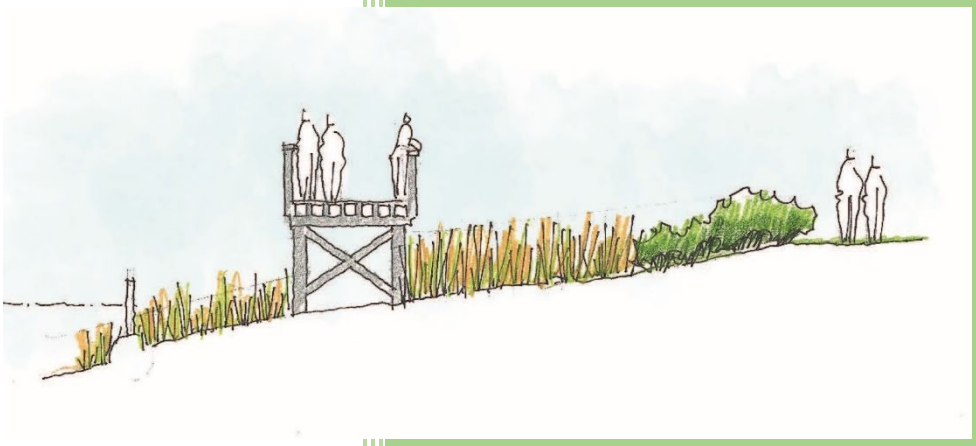

Gibson Park Resiliency Project

McAllister Marine Engineering, LLC

On behalf of the City of Revere, MA

6/30/2022

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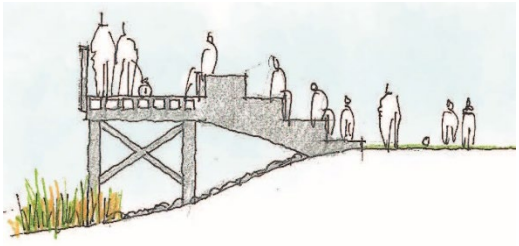
Executive Summary

The City of Revere has undertaken a significant redevelopment project to protect the Riverside Neighborhood from current and future threats from flooding and sea level rise. The Gibson Park Resiliency Project is aimed at providing nature-based resiliency measures to an area that has historically faced both tidal and storm flooding events. The 6.22-acre Gibson Park parcel includes a mix of active uses, is well maintained and has some significant public-use programming. Currently the park acts as the home of the Revere High School tennis and golf teams by providing practice facilities and a location for home tennis events. Much of the park is susceptible to flooding, rendering it unusable, or at least unpredictable, for scheduled use by community groups and youth sports. Finally, there is approximately 700 feet of Pines River frontage, with excellent views of the marsh and City of Boston. However, currently, the only access to the waterfront is through ad hoc paths, which impact the natural vegetation and are not connected to any accessible pathways.

This project was identified by residents of the Riverside neighborhood and the City of Revere as a priority issue. During the 2020 Riverfront Master Plan development process, the issues the area faces with respect to rising seas, flooding, and more intense rainfall events was increasingly evident and several conceptual strategies were developed to address those issues. The project area, which also includes the former North Shore Boatworks facility on Thayer Avenue, and the western edge of Mills Avenue, has long been subject to flooding issues, both from stormwater events and from storm surge. The Master Plan study team noted issues in the area with overtopping the sea wall, dune erosion, and accretion of sand and seawall deterioration, which mostly occurred from Boatworks site and south along Mill Avenue. The worst flooding occurs on Mills and River Avenues area of Riverside. The flooding can be so intense that it prohibits access and movement for the residents and access to their houses. At corner of Thayer, Mills Ave, and River Ave, high tide flooding occurs 8-12 times a year.

The Gibson Park project goals are to provide a more resilient, natural interface of the land and the river, provide offline subsurface stormwater storage and to create decentralized stormwater management facilities, to help alleviate flooding in the area while maintaining this parcel for optimal recreational use. In an effort to address the extreme heat concerns, the project includes a significant amount of landscaping improvements and additional vegetative plantings throughout the project area. This project will address the climate change impacts/vulnerabilities of:



- Sea Level Rise
- More intense Rainfall events
- 2060 Design Storm Events
- Design Flood Elevation

The project, because of its natural resources and its location within the Rumney Marsh Area of Critical Environmental Concern, will require environmental permitting through Massachusetts Environmental Policy Act, Massachusetts Department of Environmental Protection, the US Army Corps of Engineers, the Revere Conservation Commission, and Site Plan Review Committee.

The design phase of this project, which is being funded by a grant from the Commonwealth of Massachusetts Municipal Vulnerability Program, has been advanced to address current and future

concerns as well as providing a functional and educational space for residents and visitors to enjoy. Some of the key project features being developed are:

- **Creating offline subsurface stormwater storage underneath a multi-purpose athletic field.** This will help move stormwater away from the Riverside neighborhood and provide underground storage, particularly at the higher end of the tidal cycle and provide infiltration, helping alleviate flooding issues.
- **Decentralizing the stormwater management with raingardens and bioswales.** The redevelopment of the park features will include more localized green stormwater management practices, aiming to treat the runoff closer to its source and promote water quality treatment and recharge.
- **Creating/enhancing two areas of salt marsh along the river's edge, and restabilizing the water's edge.** The entire border between the Pines River and Gibson Park will have a stabilized sill/toe of an oyster/ribbed mussel reef structure to allow the marsh and shoreline to develop naturally to provide some protection. The marsh areas will be developed to enhance habitat and have a place to migrate up in response to rising seas.

- **Implementing a pile support marsh/water's edge walkway.** This elevated walkway will get people out over the water and the marsh and include interpretive elements to educate visitors on the importance salt marsh habitats play in protecting the shoreline and resisting climate change.
- **Park improvements, including a new multi-purpose field, pickleball courts, relocated tennis courts and more accessible walking paths.** The redeveloped park will include more diverse and accessible activities and programs for residents and visitors.
- **Expansion of park amenities to the south to include the former North Shore Boatworks property.** With the City recent acquisition of this property, additional park features such as tennis courts can be relocated to the property and the building will be transformed into a community rowing facility and public space.
- **Providing additional parking at the former Boatworks property.** In order to provide more access to the upgraded park and the community rowing facility and better control vehicle access, additional parking spaces are being provided.
- **Rebuilding the dilapidated revetment at the Boatworks property.** Along with the landscape sculpting and other softer berms, this will be a key feature in addressing rising tides and rising seas from surging into the neighborhood as is currently occurring.
- **Floating Dock system from the revetment to the Pines River.** This will provide ADA compliant access to the watersheet for rowers and kayakers carrying down their equipment.
- **Reusing excavation materials to create a vegetative berm along Mills Avenue.** By placing the excavated materials in a geotextile, placing them along the western edge of Mills Avenue, and vegetating them, this hybrid green/gray solution will better protect the neighborhood from rising sea levels and storm surge events.

Introduction

McAllister Marine Engineering (MME) is pleased to provide this Preliminary Engineering Study for the redevelopment and resiliency upgrades for the area of Gibson Park, located at Hayes Avenue in Revere, Massachusetts. This project also includes the following two components:

- The 1.187-acre North Shore Boatworks Property (hereinafter referred to as "the Boatworks Property") located adjacent to and south of the Gibson Park Property.
- An approximately 1,700-foot-long portion of the west side of Mills Avenue where a blue-gray flood berm is proposed.

MME, and its Team of sub-consultants, has been working with the City of Revere (hereinafter referred to as "the City") through funding provided by the Massachusetts Municipal Vulnerability Program (MVP) to lay out, plan and prepare preliminary designs for a redeveloped, more resilient public park facility, consistent with the City's River Front Master Plan. The City is actively seeking funding to advance the plans through the next lifecycle(s) of the project including but not limited to conducting additional surveys (e.g., topographic, environmental, etc.), preparing and submitting applicable permit application packages, completing the design, acquiring bids, providing construction oversight, etc.

Figure 1 Site Locus

Project History

The history of the Project Area, including the Gibson Park property, the Boatworks property and length of Mills Avenue was acquired through review historic topographic maps (back to 1892), historic aerial photographs (back to 1938) Sanborn fire insurance maps (southern portion of Study Area back to 1951).

- From 1892 to circa 1901, the entire study area appears to be undeveloped. One rail line transects the area from the south which eventually bends to the northwest. The property is bordered on the east by a rail line which eventually becomes North Shore Road.
- Circa 1903, the shoreline in the vicinity of the yet-to-be-developed Boatworks property appears to have been altered with a notch cut into formerly undisturbed shoreline.
- From circa 1906 through 1933, the project area appears to be similar to the configuration observed in earlier maps.
- Circa 1938 to 1939, the eastern rail line appears be in the process of converting to vehicular use. The area of the Boatworks property appears to be developed with several small structures or staged vessels and a building. The majority if the existing roadway network, including Thayer Avenue, Hayes Avenue, River Avenue and Mills Avenue are present in the southern portion of the project area.
- Circa 1944, the right of way for the North Shore Road interchange appears to be in construction. Additionally, there is a building located on the southwest corner of the Boatworks property as well as two docks extending out into the waterway to the west. The Gibson Park property appears to be vacant.
- Circa 1946, the North Shore Road interchange appears to be in in a configuration not resembling current conditions. The Gibson Park property still appears to be vacant.
- Circa 1951, the Boatworks property is labeled at a boat storage yard, is improved with a building at its southwest corner and is known a “Ruest Marine Services.” Hayes Avenue is shown as extending north of its intersection with Thayer Avenue, where it tees into an east-west trending street known as Savage Avenue. Both the northern extension of Thayer Avenue and Savage Avenue may potentially be paper streets as neither roadway is observed on the 1955 aerial photograph, associated topographic maps or 1954 Sanborn map.
- Circa 1955, the Boatworks property is nearly-fully covered by what appear to be staged boats. The Gibson Park property appears to be vacant.
- Circa 1957, the topographic map indicates that the Boatworks property is densely developed, and the Gibson Park property does not appear to be developed.
- Circa 1969, the Boatworks property appears to be in a similar configuration and the Gibson Park property does not appear to be developed. The adjacent property to the northeast appears to be utilized for the staging of vessels and at least one building.
- Circa 1971/1972, the adjacent property to the northeast appears to be utilized for the staging of vessels. A large building is present on the northern adjacent property and other areas of this property are being utilized to store boats and for marina purposes.
- Circa 1978/1985, the North Shore Road interchange appears to be in its current configuration. The Boatworks property appears to be in a similar configuration and the Gibson Park property does not appear to be developed. The northern adjacent property is improved with an on-site building, a marina and is being utilized to store boats.

- Circa 1995, the Boatworks property appears to be in a similar configuration. The Gibson Park property is developed with a baseball field, an open area where the current playground is present, a parking lot and two tennis courts with a smaller court to the north.
- Circa 2001 through 2018, the Boatworks Property appears in its recent configuration. The access trails on Gibson Park are first clearly visible in 2003. There is a second tennis court and basketball court in 2013 located to the north of the existing tennis courts. The northern extension of Thayer Avenue and the west -branch of Savage Avenue are shown in the 2012 and 2018 topographic maps. The 2015 topographic map shows a different configuration for this roadway which resemble the current access road leading to the Gibson Park Property's parking lot.

Study Area

The 6.22-acre Gibson Park property is currently improved with a mix of active public uses, is well maintained and has been subject to significant public-use programming by the City. Currently, the Park acts as the home of the Revere High School tennis and golf teams by providing practice facilities and a location for home competition tennis events. The park is also improved with a secure playground, community garden, walking trails, a golf-driving area, basketball courts, a baseball field and large areas of open-grass fields which are utilized for dog walking, picnicking, etc. Despite this, the park is still underutilized by the residents of the City. One significant limiting factor is that the park currently suffers from poor accessibility, with all south-bound traffic (there is no access to the facility from the northbound lanes) required to be routed from 1A through the adjacent Riverside neighborhood. With its remote, hard-to-access location, limited visibility and signage, and its entrance through a series of neighborhood streets, the park "*feels*" less like a community resource and has less use than other City park/recreational facilities. In addition to access issues, much of Gibson Park is susceptible to storm and tidal flooding which render it unusable, or at least unpredictable to access for scheduled use by community groups and youth sports activities. Finally, there is approximately 700 feet of Pines River frontage, with excellent views of the marsh/river shorefront and City of Boston skyline. However, currently, the only access to the waterfront is through ad hoc paths, which impact the natural vegetation and are not connected to any programmed on-site pathways or with walking/biking paths associated with adjacent properties. Further, none of the existing paths allow public access in a responsible fashion to the marshes and there are no environmental educational elements/signage associated with the area's shorefront/river assets.

Land Ownership

The Gibson Park property and the Boatworks property are currently owned by the City – the City just recently acquired the Boatworks property in Fall 2021 However, there are a mix of commercial and residential properties that that abut the project site, including those along the east side of Mills Avenue

The list of parcels, their use and size are shown below in Table 1.

Land Ownership Table of Parcels Abutting Gibson Park

Parcel ID	Address	Owner	Billing Address	City
13-192T12-2	29 THAYER AVE	THAYER AVENUE DEVELOPMENT CO, C/O WATERS & ASSOC	91 PLAISTOW RD, UNIT 202	PLAISTOW, NH 03865

13-192T11-1	HAYES AVE	ROMERO JORGE, ROMERO DORA R	32 HAYES AVE	REVERE, MA 02151
13-192T11-11	10 THAYER AVE	MERCURIO DEBORAH A	10 THAYER AVE	REVERE, MA 02151
13-192T12-1	NORTH SHORE RD	CITY OF REVERE, MAYOR'S OFFICE	281 BROADWAY	REVERE, MA 02151
14-192S-1	22 WHITIN AVE EXT	LOMBARD DBA REALTY I BARBARA A, ANGIULO DBA REALTY GENNARO JAY, ANGIULO DBA REALTY BARBARA JAY	9 VERNON ST	NAHANT, MA 01908

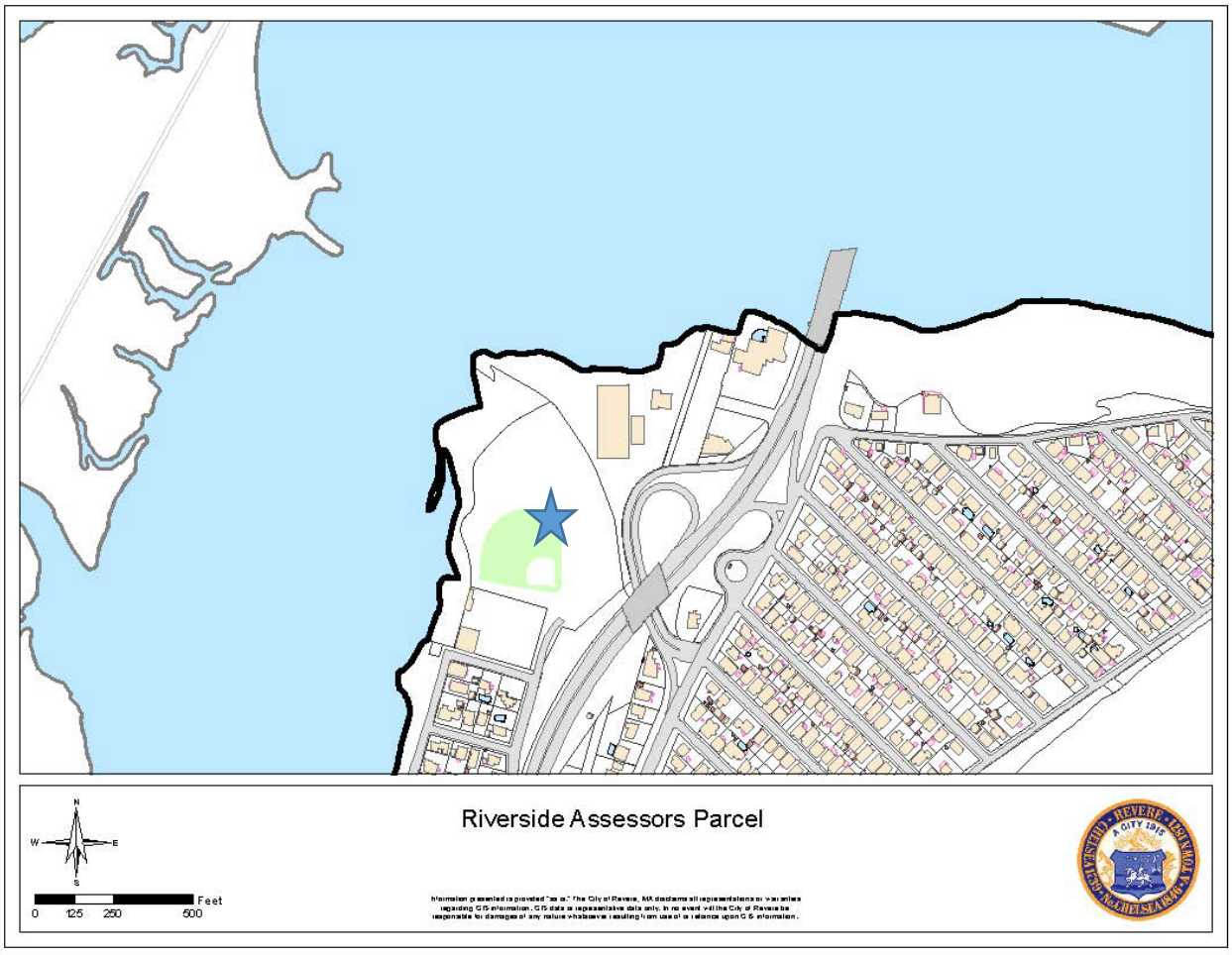


Figure 2 Assessors Map

Demographic Information

Gibson Park is located at the northern part of the Riverside neighborhood. The area is mapped as Block Group 2, Census Tract 1705.02 in Suffolk County.

The characteristics of this block group include:

- Median household income: **$35,515**, this is 41.4 % of the Massachusetts median.
- Total minority population: **20.5 %**
- Households with language isolation: **2.5 %**

In 2019, this block group had a population of 1,538 residents in 915 households.

Revere as a whole has a median household income of **$62,568** which is **72.9 %** of the Massachusetts median household income.

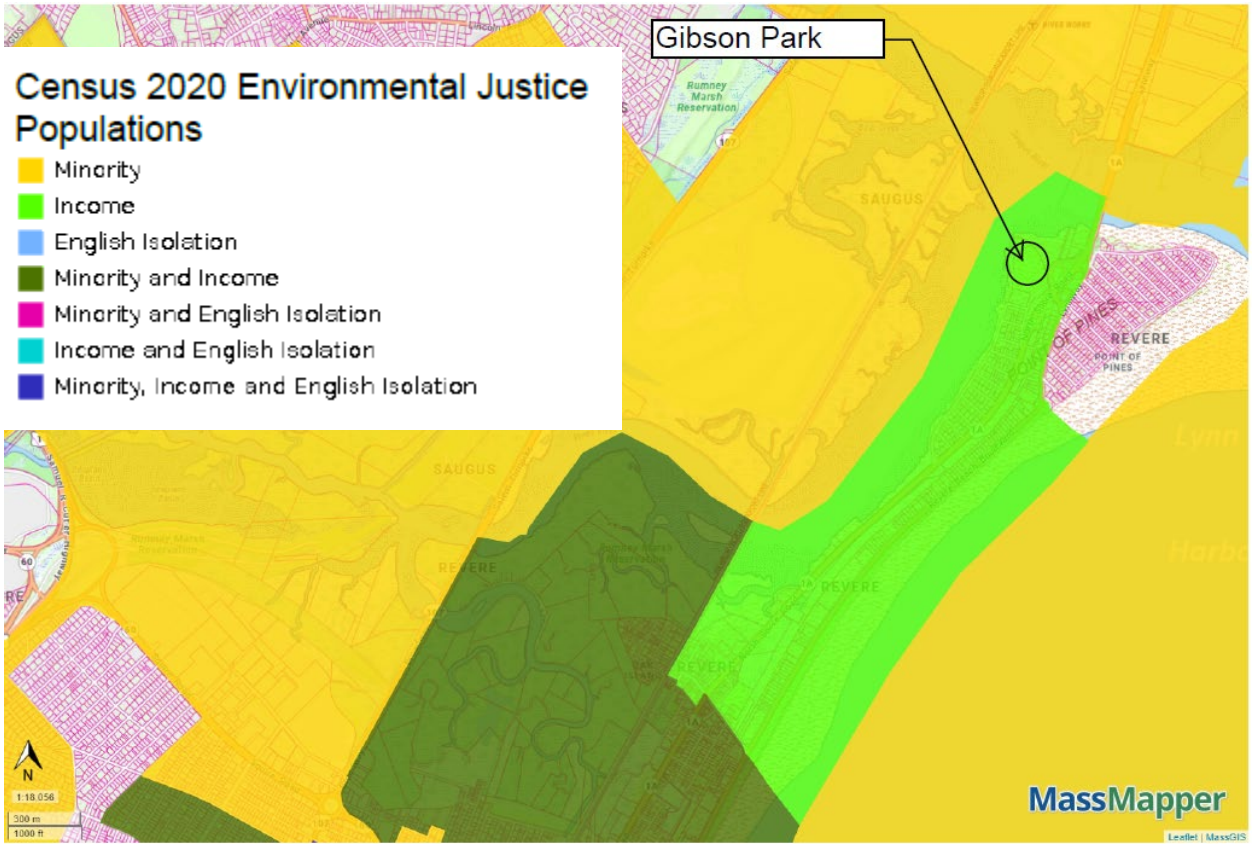


Figure 3 Environmental Justice Map

Baseline Environmental Conditions

The Gibson Park study area, which also includes the Boatworks property and approximately 1,700-feet along the west side of Mills Avenue, sits relatively low with respect to topography, with site grades elevations of approximately 6.5-feet above mean sea level (AMSL) (NAVD 88) in the parking area of the Boatworks property up to approximately elevation 10-feet AMSL at the baseball infield at Gibson Park. The elevation of the linear project component along Mills Avenue ranges from 7 feet to 8.5 feet AMSL. The highest elevations in the study area are associated with North Shore Road, Route 1A, in particular with the overpass that allows for access to the Point of Pines neighborhood from the southbound lanes of North Shore Road.

The topography within the study area is relatively flat, with grades decreasing along a gentle slope from the east to the west and northwest. The steepest portions of the overall property are the embankment located along North Shore Road. A second area of steeper terrain is located along the western portion of the Park where the upland area meets the tidal/riverfront areas of the Pines and Saugus River.

With respect to groundwater in the area - the USACE reports[1] from a regional flood study that groundwater levels are generally between mean high tide and mean low tide. This is confirmed from boring data provided from the G&J facility (an adjacent parcel) performed relatively recently by McPhail Associates. As part of this study, a groundwater monitoring well was installed in the baseball field and based on several observations, groundwater was measured around elevation 3.5 ft NAVD88 or 8.5 feet MLLW.

Soils are generally mapped by the United States Department of Agricultural National Resources Conservation Services as udorthents, wet substratum, described as "*Excavated and filled sandy and gravelly human transported material over highly-decomposed herbaceous organic material*." The soil boring data from the G&J facility indicates that this property is underlain by fill material to depths of 6-to-10-feet below the surface (bgs). The presence of some peat material (typically highly organic clay materials) was noted in one of the McPhail Associates borings which also indicated that the materials underlying the peat and fill material were dominated by marine sand deposits.

As part of the work conducted by the City, MME conducted seven soil borings across both the Gibson Park and Boatworks properties to confirm underlying soil conditions, including geotechnical characteristics and confirming site-specific depth-to-groundwater conditions. In general, the soils encountered were relatively granular in the upper portions of the profile (after penetrating through the fill materials), and siltier as depth increased. Upper profile soils are likely fill as deeper depths showed shells and marine deposits likely from the historical seabed in the area. Additionally, one groundwater monitoring well was installed, and periodic depth-to-groundwater measurements were collected to evaluate whether groundwater is tidally influenced beneath the study area. Based on initial observations, groundwater was present at a depth of approximately 6.5] feet below the ground surface and there was very little tidal influence on the groundwater table (i.e., a 0.1-foot difference observed from high tide to low tide cycles).

As discussed above, the study area has long been subject to flooding issues, both from stormwater events (e.g., flooding due to precipitation) and from storm surge (e.g., increases in the elevation of the adjacent Pine River which flood the areas) affecting the area. As part of the City's Master Plan process for the RiverFront Area), which includes this study area, it was noted that area flooding was mostly associated with river water overtopping the sea wall, dune erosion, redistribution of sand and seawall deterioration. These periodic flooding events were predominantly observed within the study area at the Boatworks property and south along Mill Avenue. In itself, and due to local topographic conditions, the majority of the Gibson Park property is not subject to significant flooding events. However, there is an area in the northern part of the parcel along an existing walking path which remains wet for some

[1] December 1989 Flood Damage Reduction Report, Saugus River and Tributaries

period following storm events. The worst periodic flooding (both associated with precipitation and storm surge events) occurs along Mill Avenue and River Avenue area of Riverside. The flooding results in flood conditions that prohibits access and movement for the residents and access to their houses. Further, during these periods of flooding, vehicle-dependent first responders are unable to access study area residents. In the vicinity of Thayer Avenue, Mills Avenue and River Avenue, storm surge/high tide flooding events currently occur on a frequency of eight-to-12 times a year with the flooding typically lasting for up to six hours per event. During the six-week duration of public meetings and interactions conducted as part of this project in November and December 2020, there were two flooding events documented with flood waters inundating both the Boatworks property and long-portions of Mills Avenue.

As part of this project, MME reviewed publicly available modeling and mapping resources of the study area to further quantify the risks associated with episodic flooding events. Almost the entire study area is mapped as a FEMA floodplain, as shown on Panel 25025C0029J, zone AE (elevation 10, NAVD 88) effective 3/16/16, and are thus highly subject to flooding. The only areas above floodplain are the ball field located on Gibson Park and North Shore Road. The Massachusetts Department of Coastal Zone Management (CZM) maps nearly the entire area (except the exceptions noted in the FEMA maps) as being subject to impacts by a Category 1 hurricane. Both of these lines of evidence support that the large majority of the study area is considered to be at high risk associated by both stormwater and storm surge flooding.

Figure 4 FEMA Floodplains

Due to the study area's well-known reputation for flooding issues, it was identified as the first priority area to be included by the Boston Region Metropolitan Planning Organization (MPO) as a pilot study for resiliency measures along sections of Route 1A in Revere. The MPO draft report describes the study area as "*natural low-lying area and close to the flood pathways of the Pines River estuary to the north and the Chelsea Creek estuary to the south. The corridor is highly vulnerable to flooding resulting from high tides, coastal storm surge, and rainstorms, and to inundation from sea level rise.* ***These hazards are expected to worsen in the future*** [emphasis added by MME]."

As part of their evaluation, the MPO study reviewed and assessed the Massachusetts Coastal Flood Risk Model's flood risk probabilities and depth of flooding for the following four scenarios: present day, 2030, 2050 and 2070. The results of this draft study indicate that the area surrounding Gibson Park property, particularly along the shoreline and the Boat works property, are highly vulnerable to flooding based on different combinations of estimates for sea level rise, heights of storm surge and tides, and wave action. It should be noted that this study did not evaluate the risks associated with precipitation events which can also result in stormwater flooding.

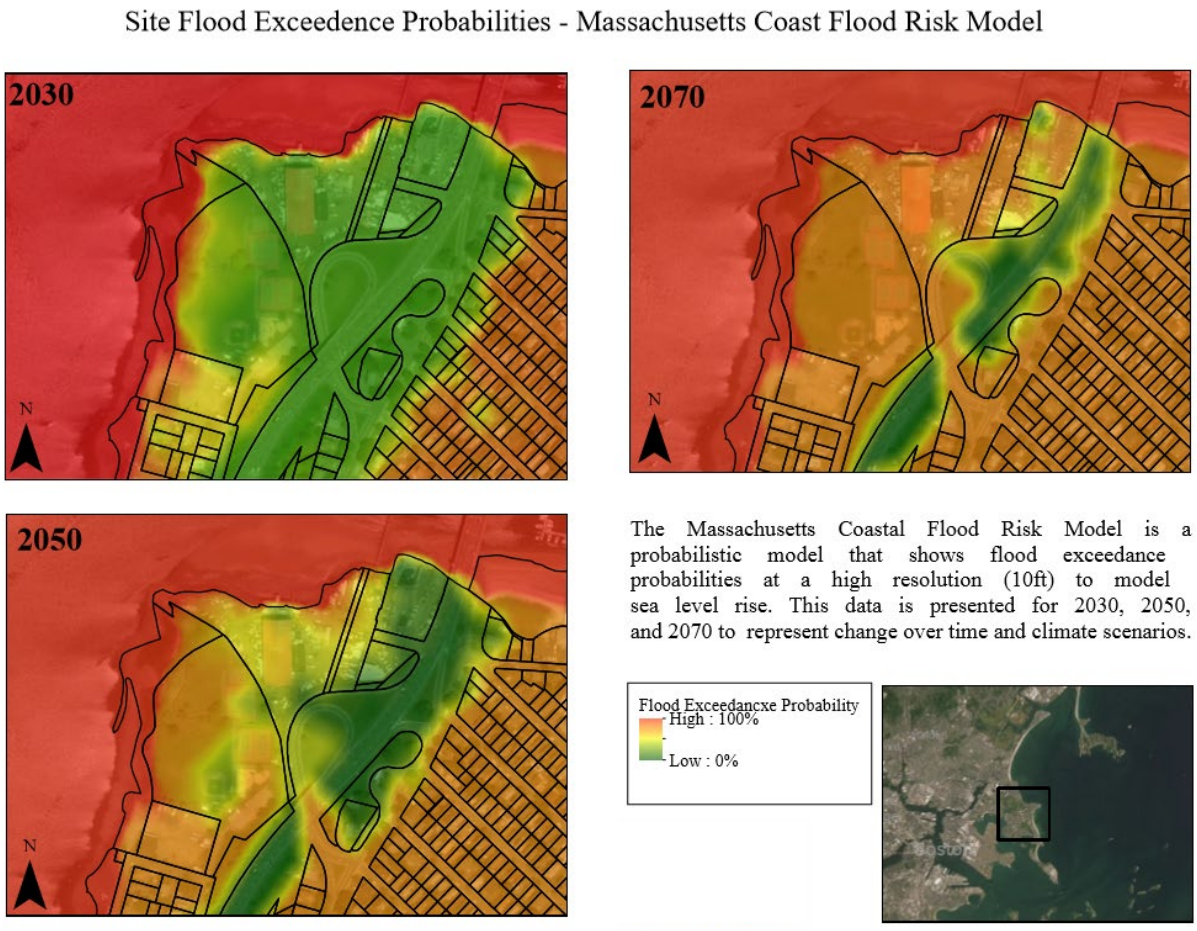


Figure 5 Site Flood Exceedance Probabilities

As part of the National Climate Assessment[2] from the U.S. Global Change Research Program, there are several trends that are anticipated to influence/exacerbate flooding conditions in the study area, most notably with respect to sea level rise and increases in frequency and amounts of precipitation associated with significant meteorological events such as hurricanes and Nor'easters. According to the assessment, sea levels will rise between one and four feet by the Year 2100. A more localized study performed by the Commonwealth of Massachusetts in 2013[3] shows scenarios that vary from 0.7 feet (a linear interpretation of historical data, and therefore least likely) to 6.6 feet (derived from ocean warming and maximum ice sheet loss). Under these sea level rise scenarios, the study area will be significantly affected and potentially flooded twice per day associated with "*normal*" high tide events versus the current periodic flooding associated with once-per-month "*king tide*" events and significant precipitation events.

In addition to sea level rise, the National Climate Assessment also noted significant rainfall events will become more frequent and more intense in nature. Since 1991, there has been a greater than 30 percent increase in the number of heavy rainfall events when compared to the period from 1901 to 1960. And the average amount of annual precipitation has increased over eight percent over the same time period. For the City and this portion of Revere, there are already large portions of the study area which are subject to more frequent significant stormwater and surge water flooding events. As sea levels continue to rise and the frequency and intensity of significant precipitation events increase over time, it is reasonable to anticipate that the study area will be subject to flooding on a nearly daily basis, unless flood-resiliency intervention measures are implemented and maintained to address impacts associated with global climate change.

[2] https://nca2014.globalchange.gov/

[3] Sea Level Rise, Understanding and Applying Trends and Future Scenarios for Analysis and Planning, MA Coastal Zone Management

Figure 6 Web Soil Survey Map

Public Stormwater Infrastructure

Knowledge of the geometry and capacity of the existing City stormwater abatement systems is a critical project component in that it will provide guidance on what currently works and does not currently work, as well as to potentially provide guidance and interconnects to flood-management intervention measure recommendation which are a result of this study.

There are two tributary drainage areas in the vicinity of the study area. It is important to note that there is only rainfall stormwater conveyance infrastructure in the study area, and there is no system capacity to store, detain and/or retain storm-surge stormwater – these three capacities are often part and parcel with any successful working-with-nature or blue-green flooding resiliency mitigation measures.

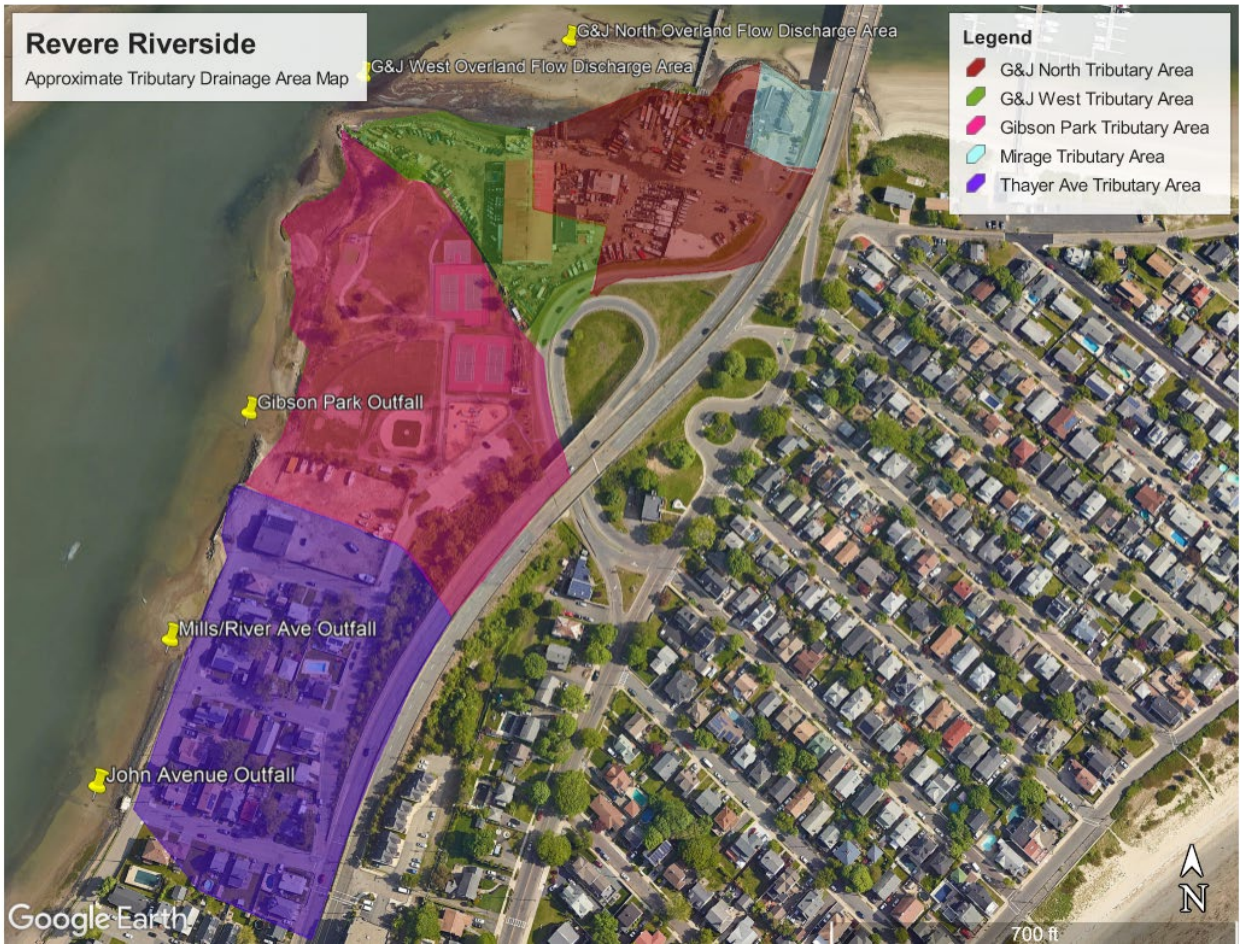


Figure 7 Drainage Tributary Areas

The Thayer Avenue drainage area is approximately 270,000 square feet (sf) (or 6.2 acres) in size and includes roadways, the North Shore Road embankment, the southern half of the Boatworks property and the residential area including the southern part of John Avenue to the north including parts of Hayes Avenue, Mills Avenue, River Avenue and Thayer Avenue. Stormwater management within this drainage area is achieved through a catch basin and pipe outfall system. The closest outfall inverts to the study area are present on Mills Avenue just north of River Avenue and at the intersection of Mill Avenue and John Avenue. The City performed upgrades to this system in 2015, including adding in-line check valves on the outfall inverts to prevent tidal incursion of the Pines River flood waters into the land-side stormwater management system. As a result, the drainage system outfalls are closed when inundated and cannot facilitate storm-related discharge at higher periods of the tidal cycle.

The Gibson Park drainage area is approximately 350,000 sf (or 8.0 acres) in size and includes some roadway and parking areas, the northern part of the Boatworks property and all of the Gibson Park property. The Gibson Park property is improved with small number of catch basins and a pipe network to a signal outfall invert located along the southwestern portion of the parcel. The outfall invert pipe appeared to be damaged at the time of this study, was not improved with a check valve and appeared to be inundated during high tides. The overall higher elevation of the property currently limits the backing up and flooding of the Gibson Park property during high-tide periods.

Watersheet Access and Infrastructure

The overall study area is surrounded by tidal waters to the west and north by the Pines and Saugus Rivers, respectively. Public access to both rivers and associated marshes is currently very limited due to the lack of shoreside boat/non-motorized vessel launching facilities and the lack of walkways through the marshes and along the shoreline. Formerly, boat launching/access was provided to customers (not the public) of the Boatworks property directly to the Pines River. This property served as a boatyard and repair facility and was improved with a marine railway which was equipped with seawall and timber bulkhead wall. The existing seawall and bulkhead are currently in disrepair and, as such, are not safe and are therefore not suitable for launching small boats and non-motorized vessels (e.g., kayaks, canoes, skulls, etc.) – the City should consider restricting ad hoc uses of the property to access the watersheet as a liability risk-minimization measure. Further, due to the deteriorated condition seawall and timber bulkhead wall, this portion of the study area is prone to storm-surge flooding.

Along the western edge of the Gibson Park property, there is a mixture of tidal salt marsh, riverbank, and coastal beach areas. There is a significant amount of phragmites (a.k.a. common reed), an invasive species that is not very hospitable to salt marsh birds and other salt marsh fauna. While there is no formal path to the watersheet from the Gibson Park property, there are a few well-worn ad hoc paths that people have taken down to the water's edge.

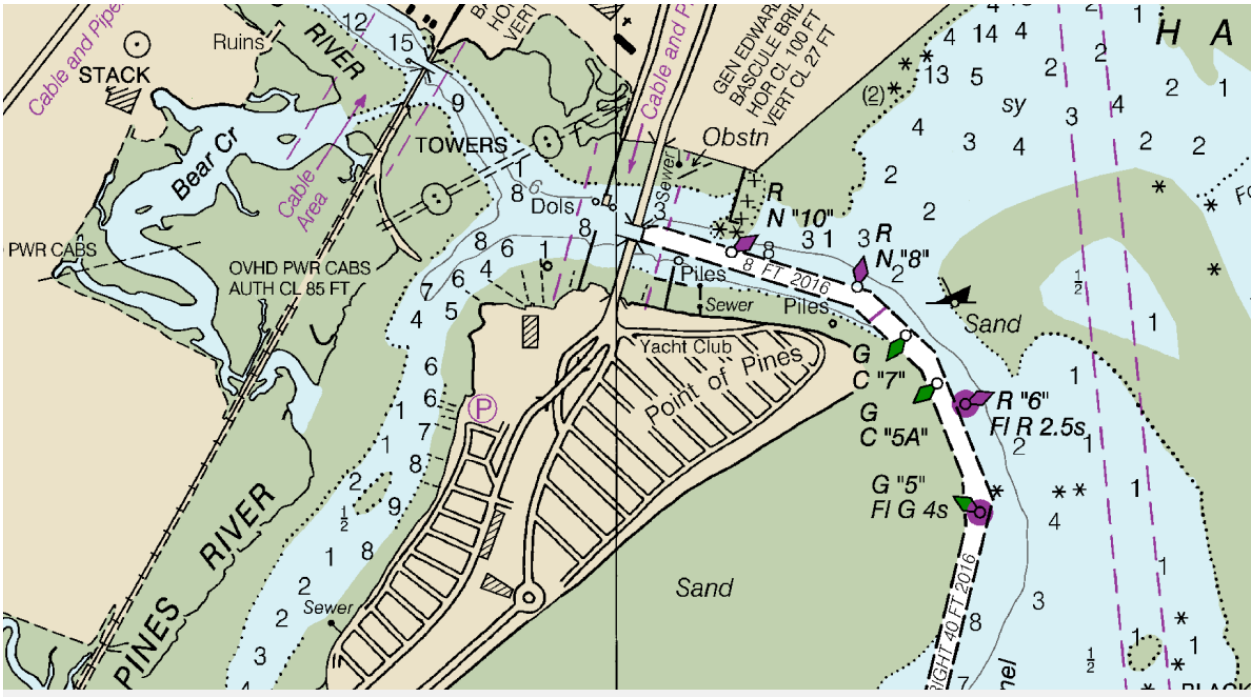


Figure 8 NOAA Navigational Chart

Some issues facing potential watersheet uses are the water depths along both banks of the Pines and Saugus Rivers. Due to high-velocity tidal currents (up to four miles per hour) and periodic storm-related surges/currents, both of these areas are subject to significant accretion of sand which result in shallower water depths. These near-shore, shallow-water conditions make it difficult for the public to launch vessels to access the watersheet, particularly at low tide. A 1989 MassDEP Environmental Notification Form (ENF) that was filed for a North Shore Boat Works project (current Boatworks property), that was

never executed, called for 7,900 cy of sediment to be dredged and disposed in the open ocean. The ENF indicted that the proposed dredging project was required to provide adequate depths to support the marina and boat works operations. As it currently stands, the permitting process for any proposed dredging program would require collection and analyses of the materials to be dredged and given the historical industrial uses that are tributary to the Pines River, it is unlikely that the sediments would still qualify for open-ocean disposal and potentially much more costly disposal options would be required. Dredging projects in Massachusetts are subject to stringent federal, state and local regulatory permitting requirements and an up-to-date assessment of present conditions (e.g., sediment quality, bathymetric conditions, costs to complete, etc.) would be required to support any such efforts.

Other Environmental Considerations

In addition to the environmental factors discussed above, there are latent environmental conditions that would need to be evaluated and factored into a redevelopment plans for the Study Area. These latent environmental conditions include subsurface soil and groundwater conditions.

Historically, vessels have been stored/staged at the Boatworks property. This results in potential risks for leaching of contaminants, such as heavy metals, volatile organic compounds, and petroleum hydrocarbons into the soils and/or groundwater and would need to be investigated and possibly remediated. As part of its due diligence efforts in obtaining the property, the City of Revere received a Phase 1 Environmental Site Assessment report from Lake Shore Environmental, LLC dated April 2, 2019. That report found no recognized environmental conditions. The report also included analytical data from 2012 soil investigation from Boston Environmental which included two hand auger soil borings, which had samples tested at various depths. The results of the laboratory analysis showed all samples were under the RCS-1 regulatory conditions under the Massachusetts Contingency Plan (MCP). The MCP is the state regulations under MGL Chapter 21E, dealing with oil and hazardous substances.

For the Gibson Park property, the primary concerns include chemical and geotechnical conditions of the fill materials underlying the property. Further, groundwater conditions, including chemical conditions, depth to water and potential tidal influences (e.g., groundwater elevations vary by tidal conditions) would require evaluation. The current plans, as discussed below, for the lineal storm-surge barrier along Mills Avenue would not require deep penetration of the ground surface. The primary environmental consideration would be the chemical nature of the materials to fill the structural geotextiles (e.g., geotubes or envirolok bags). As these materials would be acquired from on-site sources, their chemical, geotechnical and ability to support plant growth capacities are being evaluated as part of the overall project.

MME conducted sampling in 5 different locations throughout the two properties to perform some screening for environmental considerations. That data is being analyzed and will be reviewed and addressed for implementation as the design explores reuse of excavated materials.

As part of the Clean Water Act, states are required to develop and update biennially a list of waters that are impaired, commonly referred to as the 303(d) List. From the Massachusetts 303(d) List, a Total Maximum Daily Load (TMDL) has been established for the Pines and Saugus Rivers for an impairment from fecal coliform (TMDL No. 50122). The TMDL sets a target limit for fecal coliform entering into the waterbodies from the entire watershed. Therefore, any proposed redevelopment actions in the study

area would need to ensure they do not contribute potential additional fecal coliform to the waterbodies. This would be accomplished by designing, installing and operating proper waste-water control and treatment facilities in the area, if required.

The Natural Heritage and Endangered Species program run by the Commonwealth has mapped the northeastern portions of the Riverside Point of Pines area as habitat for the Common Tern; however, this critical habitat does not extend into the study area. Common Terns typically utilize sandy or gravelly areas (i.e., beaches) or salt marshes with low vegetative ground cover for nesting purposes.

Resilient Redevelopment Strategies and Considerations

Once the design team was able to confirm the underlying soil and groundwater conditions, issues associated with the study area and the scope of the proposed projects/intervention measures, the next step in the process was to evaluate strategies and interventions that have been successfully implemented in other locations to analyze their applicability for the proposed Study Area project. This represents a "*lessons learned*" work-flow component and is meant to build upon other successful projects, and just as critically, similar project components that did not work in other locations or jurisdictions.

There are resiliency strategies can be applied to different scenarios to address different concerns, and the design team identified the three most critical issues to be addressed by the project:

- **Storm Surge and Coastal Flooding:** These are king tide or storm-surge flooding events wherein the river waters overtop the land surface and cause significant flooding in the Study Area. As these events literally represent the Atlantic Ocean waters flooding, the most efficacious intervention measures are to physically raise land grade conditions to "*keep the flood waters out*."

    1. Seawalls – Seawalls are coastal protection structures, typically vertical and designed to withstand anticipated wave forces and to a height to resist over-topping from storm surge associated with a "*Design Storm*." This type of "*hard*" infrastructure is in common use across the Region and the Globe to provide targeted protection to a particular structure or area. They do not meet the strategy of living with the Norm and the Storm and do not represent use of blue-green infrastructure.
    2. Breakwaters – Breakwaters are near shore structures designed to reduce coastal erosion and diminish effects of wave action. Breakwaters can come in various shapes and materials, from solid-core and rock-lined structures to geobags filled with dredged sediment with or without a habitat-enhancement component such as an oyster reef. Breakwaters are typically permeable structures and are non-continuous in nature and as such, do not provide protection to land-side assets from still-water flooding (e.g., a breakwater can lower the erosive impacts associated with as storm event, but the area being protected will still experience flooding.

3. Revetment walls – Similar to seawalls, except with a more sloping face as opposed to a vertical seawall. They are effective in absorbing and deflecting energy and protecting shorelines.
4. Elevated Berms/Linear Structures – in this scenario, lands are re-sculpted to provide a continuous and unbroken topographic feature with sufficient elevation to keep flood waters out of the vicinity of associated land-side assets. Another alternative is to utilize sediment/soil filled geobags, geotextiles, or coir mats (non-synthetic) placed in a linear fashion along the area to be protected (e.g., Mills Avenue). Both the berms and geobags can be established with native plants to make them more visually appealing and lower their carbon footprint, as well as stabilize them from erosion.

- **Shoreline Stabilization**: depending upon the locations of various shorelines, they can be vulnerable to erosion and impacts from wave runup, especially in areas with a large, open fetch, as well as assist in controlling initial stormwaters associated with precipitation events. Many of these projects focus on re-establishing/repairing former natural wetland that were impacted or destroyed by anthropogenic activities, including re-establishing natural hydraulic conditions.
    1. Living Shorelines – Natural shoreline protection systems that are typically used in low-energy wave environments. They can include marsh sills toed in with coir logs and living reefs (for subtidal applications) that can be toed in with oyster shell bags or small stone-like structures. In some locations, re-sculpting of lands into berms to prevent storm surge flooding can resemble natural features such as maritime hammocks.
    2. Sand Mattresses – Similar to the geobag approach, sand mattresses are typically geosynthetic structures filled with sand or dredged material and laid in targeted areas along a sloped coastal embankment to prevent erosion.
    3. Concrete Mattresses – More of a "*hard*" shoreline-stabilization intervention measure, concrete mattresses consisting of interwoven articulating concrete blocks can be emplaced on an eroded coastal slope to provide erosion protection, particularly in high-energy wave environments.

- **Stormwater Precipitation Flooding:** The two aforementioned issues were related to tidal waters overtopping the adjacent lands resulting in mostly uncontrollable flooding. In this scenario, the precipitation waters from a storm event fall onto the upland surfaces and can result in flooding. This is a common event and most municipalities and states have promulgated stormwater abatement requirements to address a pre-defined "*design storm*" and, for example, a system must be designed to detain or retain rain waters associated with a two-inch fall event occurring over an eight-hour period – the actual size and duration of a design storm are a function of the local/state agency with jurisdiction. The management of flood waters resulting from a defined design storm is a critical component of this project. Example blue-green stormwater intervention measures are discussed below:

    1. Reduce Tributary Areas – Rainfall-associated flooding often occurs when runoff generated from a tributary area collects at a discharge/low point where there is not sufficient capacity to address the resultant flow/volume of a storm event. By reducing or

breaking up (potentially by land re-sculpting measures) a watershed/tributary area that contributes runoff to a discharge/low point, such low capacity "*pinch points*" are addressed, and a system has sufficient capacity to reduce the intensity of the flood event at that location. The challenge with this approach is to find and/or design discharge locations for the resultant multiple smaller tributary areas. It is critical that a newly designed stormwater abatement system does not exacerbate flooding in another area(s).

2. Detention and Retention- Rainfall-associated flooding often results when a high-intensity-rainfall event occurs and results in large volumes of runoff waters that overwhelms a stormwater abatement system. Such conditions can result in system backups which lead to localized flooding. Detention and retention stormwater system strategies aim to provide temporary storage for the runoff to collect and then slowly discharge the stormwater back along the normal intended flow course. Detention systems typically holds (or detain) the stormwater very short term (e.g., 48-to-72 hours maximum) – these types of systems are typically utilized in shallow water-table conditions and/or where the underlying geologic material are not amenable to recharging water. Retention strategies typically retain stormwater for longer periods to allow it recharge back into the subsurface. Both stormwater-management strategies provide a buffer and store stormwaters, so the conveyance network does not become overwhelmed and cause flooding. It should be noted that in the event of a storm event with exhibits a rainfall intensity and/or duration than its associated design storm, flooding can result. However, by detaining/retaining the "*first flush*" of a major precipitation event, the waters are typically treated for entrained solids, floating oils, etc. A major issue with these strategies that do not depend on blue-green techniques is that they often require large areas and can be somewhat unsightly unless aesthetic aspects are added to the design.
3. Re-sculpting and Elevating Areas – Surface stormwater flows along its lowest most-accessible path. One blue-green technique that is commonly being utilized is to re-grade/re-sculpt the existing grade/surface to create a new flow path so that the resultant runoff is directed to a new area which is away from sensitive areas or critical infrastructure. Another strategy is to raise the elevation of targeted areas/infrastructure to better protect them from flooding. This intervention strategy needs to be carefully studied, designed and executed so as to not create flooding problems elsewhere.
4. Infrastructure Upgrades/Improvements – Targeted infrastructure improvements can result in significant impacts, although care must be exercised, and a drainage area(s) must be studied to evaluate the underlying causes of flooding. Commonly implemented upgrades such as increasing the diameter of a conveyance pipe or adding in new catch basins/manholes in strategic locations can results in significant improvements in collecting and conveying water to other areas to address localized flooding conditions. The majority of stormwater abatement intervention measures require routine/periodic maintenance, as well as system-specific measures to prevent obstructions from building up, including trash racks, sedimentation structures, filters, pipe hoods, etc. Such

maintenance strategies and infrastructure are both specific to the type of stormwater abatement system, as well as its specific operational challenges (e.g., plastics removal in a watershed where plastic bottles are disposed). Such operational challenges are typically evaluated through the performance of an engineering study of the specific watershed area and should be completed in coordination with the system's operator.

5. Tidal Outfall Structures – Protection and mitigation strategies for tidal outfall structures can have a significant impact on storm-surge flooding of the associated upland areas. As an example, many areas of Queens, New York, which were topographically-protected from storm-surge flooding, experienced significant still-water flooding during Superstorm Sandy when storm-surge waters migrated through the unprotected tidal outfall structures thereby "*short circuiting*" the intervening topographically high areas – while not a dynamic event, it did result in significant damages. The primary use of tidal outfall structures is to keep water from a rising/high tide event from entering into and backing up through the subgrade piping system to impact the adjacent upland area. A second co-benefit is that these structures also serve to prevent the backflow of debris and detritus from obstructing upstream stormwater infrastructure components. There are several types of these structures including duckbills, flap gates, self-regulating tide gates and in-line check valves. Duckbills and in-line check valves are least vulnerable from being obstructed by debris. In the event that an in-line check valve does become clogged, it is typically more difficult to repair the valve. Flap gates are the most susceptible to operating challenges, and in the event that debris obstructs the opening resulting in a gate-open condition, the efficacy of the structure is negated during a storm-surge event.

Resiliency Approach

Climate adaptation and resiliency were once the realm of occasional interventions for highly at-risk and vulnerable cities such as New Orleans that typically took the form of monolithic hard-scape coastal structures – walls that cut off communities from the environment and split neighborhoods into unconnected segments - has morphed over time into strategies that focus on working with nature and building with the environment. Today, the approach to resiliency is to create resilient systems that leverage the natural landscape's ability to absorb extreme events, playing to the strength and flexibility of the environment, and resulting in more resilient outcomes through designs that work with nature. The modern approach to coastal resilience engenders a spirit of cooperation with the natural landscape – sculpting the land to take advantage of the attributes of natural systems that control water flow and surge and creating an aesthetic landscape that is both pleasant to the communities they serve as well as

provide protection from the storm and from the encroachment of water along the coastline due to climate-driven sea level changes.

Figure 9 Hurricane Surge Scenarios

Over the last several years, especially post Hurricane Katrina and Superstorm Sandy, storm resiliency practitioners have been leaning away from hard, concrete-based solutions such as flood barricade walls with associated high-volume pump systems. A relatively new concept is to "*Live with the Storm and in the Norm*." This has resulted in new design concepts that do not necessarily focus on storm-related impacts which may only occur on infrequent basis, although as discussed above, with more frequency and intensity due to global climate change. This paradigm shift in resilience and climate-adaptation responses has resulted in much less use of "*hard*" engineered intervention measures such as large concrete flood walls and structures that only provide function during a flood event and the rest of the time (the Norm), they are basically a blight on the landscape and have no co-benefits for the communities in which they are installed. Further, experience has shown that these hard infrastructure intervention measures are often poorly maintained and fail when their operation is actually required in response to a storm event. Many of design concepts and precepts were discussed and recommended in the June 30, 2021, report entitled "*Point of Pines and Riverside Area Coastal Resilience Feasibility Study*" prepared by AECOM for the City.

This paradigm shift has led many vulnerable communities and resiliency practitioners to recommend and utilize nature-based blue-green resiliency intervention measures which provide beneficial uses during Norm periods and provide flooding resiliency measures during active storm events. It should be noted that the level of protection is a direct function of the amount of available funding, as well as what impacts the public are willing to "*put up with*," to provide such protection. For instance, in 2017,

Hurricane Harvey dumped over 40-inches of precipitation of Gulf Coast communities over a very short time period. It is basically infeasible to design, construct and maintain a municipal stormwater abatement system to manage such significant stormwater events.

The following provides examples of several blue-green resiliency intervention measures, several of which are proposed for the Study Area.

- **Salt-water Marshes/Living Shorelines**: Salt-water marshes and living shorelines are one of "*nature's way*" of protecting shorelines from dynamic impacts associated with major storm events, both by buffering wave run-up energies and by helping buffer precipitation runoff. Further, marshes provide new habitat for a wide variety of flora and fauna and can provide both recreational and educational opportunities for local residents. Unfortunately, many areas of salt-marsh healthy shorelines have been impacted by anthropogenic actions, both by their removal to provide development opportunities, as well as mosquito-abatement practices which result in the short-circuiting of normal salt-marsh hydrodynamics. Restoration of salt-water marshes projects can be designed such that they can grow vertically and laterally following increasing elevations in sea levels.
- **Oyster/Shellfish Reefs**: Formerly, typical breakwaters were installed in deeper waters to protect landside assets from damage associated with highly dynamic wave runup energies from a storm event. Currently, the use of oyster/shellfish reefs has become more prevalent wherein an engineered substrate is constructed and covered by pre-cast concrete elements which are both chemically and physically amenable to foster oyster/shellfish growth. Once installed, shellfish growth can be "*kick started*" by seeding the structure with larva, or in many cases, the shellfish are naturally attracted to the substrate and grow on their own. Oyster/shellfish reefs have many advantages over typical breakwaters as they self-accrete and grow vertically in response to rising sea levels, provide water treatment (each oyster filters an estimated 50 gallons of water per day), provide habitat and shelter from predation for many species of shellfish and fin fish, to name a few.
- **Land Sculpting**: In this resiliency intervention measure, on-site materials are utilized to result in "*gentle*" topographic elevations/berms that provide protection from storm-surge impacts, but that during the Norm resemble "*normal and gentle landforms*" as opposed to constructing a concrete barrier wall. Further, the resulting low-lying areas from which materials were removed can act as a drainage/recharge area for stormwater.
- **Controlling the First Flush:** Experiences in many regions have shown that controlling the first flush, or initial rainwater volume, from a precipitation event can be very beneficial. By utilizing various techniques including large sub-grade vaults to temporary retain/store groundwater through the use of bioswales and rain gardens, the impacts of the initial part of a storm can be controlled, this is especially critical during high-tide periods where a stormwater abatement system may not be able to effectively operate. Further, the use of such systems provides primary treatment of the stormwater and improves the chemical quality thereof. This is not a new practice in the U.S., regions such as Maryland which have impermeable soils often utilize subterranean vaults underlying parking lots to manage and treat groundwater prior to discharge to a municipal stormwater abatement system. The area over these large sub-grade vaults can be improved with a wide variety of public infrastructure including parks, ball field, parking lots, to name a few.

- **Green Flood Wall Barrier Materials:** As discussed above, historically many hurricane intervention measures depended upon concrete barrier walls to protect upland assets from storm surge flooding. While use of such an intervention measure may prove warranted, industry practitioners are more and more utilizing "*softer*" materials such as geobags to provide the required protection. A well-designed geobag intervention scenario includes the planting and propagation of native plant species on the filled geobags which helps to protect them, make them more visually pleasing and decreases the carbon footprint as the plants convert CO_2 to O_2 via photosynthesis. Any such barrier intervention measure must allow access to municipal assets including roadways, beaches, vessel launching points. This can be accomplished through the use of deployable barriers such as flashboards that are deployed just ahead of a storm event or are designed to flip up from a "resting" horizontal position.
- **Sacrificial Lands:** In this scenario, at-risk lands are allowed to flood during storm events. They are designed such that there is no "*damageable*" infrastructure such as buildings, play-ground equipment, etc., but are more-commonly utilized for more passive public uses such as a grassy field. As such, minimal effort is made to protect such properties from flooding, there is little damage which requires repair post-flooding, and the land can be used for passive uses shortly after flood waters naturally recede.
- **Surface and Subsurface Conveyance**: Piping, trench drains, pump conveyance and directional galleries that move water from areas where it can build up and flood to areas where storage and discharge can be achieved.

As has become very apparent over the last few years, our climate is changing with the Earth experiencing a warming trend. The frequency and severity of storms are increasing over time and the oceans are responding to climate change with rising tides and higher water levels that result in flooding increasing areas of coastal lowlands as part of the daily tidal cycle. The City of Revere, as a coastal community with large areas low-lying landscape adjacent to the tidal waters and as a community with a long and varied-use coastline, is experiencing the brunt of impacts associated with global climate change. Each part of the World is experiencing its own impact associated with global climate change from the East Coast with storm-flooding issues to the forests and wildfires to the tundra where wildfires are prevalent, as well as the releases of methane. No part of the globe is immune to the effects of climate change.

Higher tides and coastal damage as a result of increasing storm and severe weather are affecting the City, and the trends observed over the last few years support that the situation will continue to have increasing impacts with flooding, erosion, wave and water damage, and storm surge, and waterfront habitat and infrastructure degradation becoming more prevalent. Today, the City is incorporating resilience measures into all of its planning and development efforts, and for this project specifically, the focus is on adapting strategies and interventions across its coastal lands which is resulting in forward progress toward ameliorating the effects of the encroaching ocean and storms on stormwater from rainstorms, sea level rise impacts, and storm surge to the extent possible given the

geographic/hydrologic and financial constraints.

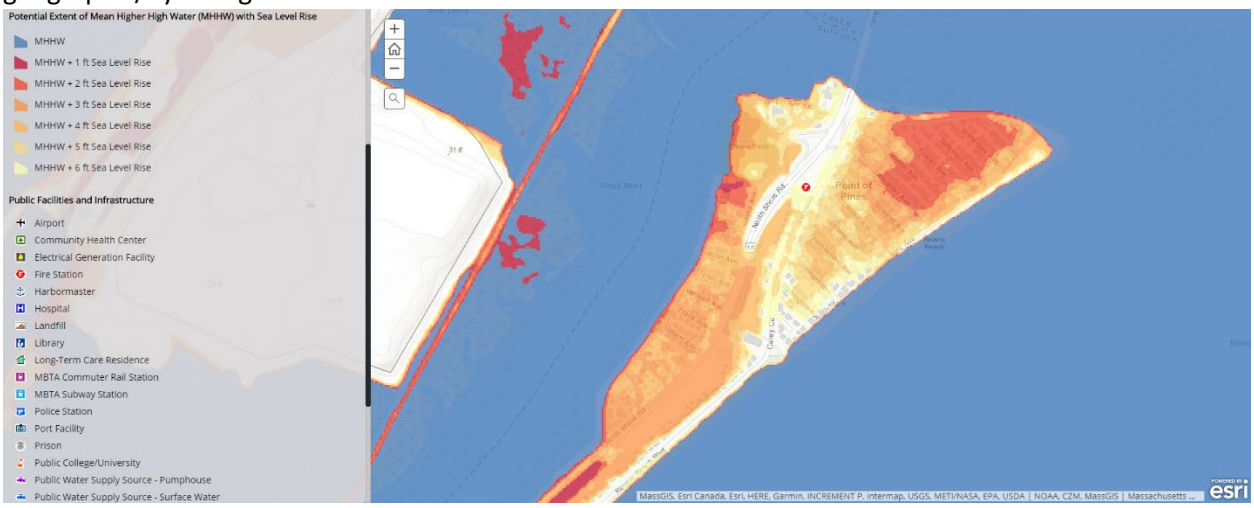


Figure 10 Sea Level Rise Projections

The successful road to a modern resiliency approach incorporates the full range of human historical experience, from early reactions to environmental events that involved retreating from the problem areas to the concept of let-it-happen-and-rebuild-with-same-after, to wall off the problem, to the modern approach that involves engineered solutions coupled with the strategy of working with nature. Nationally, the approach to resilience has evolved in part because of several extreme events. Hurricane Katrina in the Gulf and Superstorm Sandy along the mid- to north-Atlantic coast were extremely impactful and devastating to the communities affected. These events represent a wake-up call to coastal communities, and they changed the dialogue around coastal planning and development approaches. One outcome from these relatively recent extreme events was a movement to adjust the overall approach to resilience from a reactive to a proactive approach to coastal protection. One strong outcome of that resilience shift was the development of a community approach to resilience that is now imbedded in planning efforts across the range of coastal environments. An example of this approach is the coastal resilience strategy known as *Rebuild by Design*, which started as design competition for rebuilding the New Jersey, New York, and Connecticut coastal communities after the devastating effects of Superstorm Sandy and grew to create a new approach to thinking about resilient engineering that incorporates community needs across the board (http://www.rebuildbydesign.org/). One central tenant that comes out of the Rebuild by Design strategy is the concept of *building for the norm as well as the storm*. This approach engenders the concept of creating resilient interventions that protect coastal communities when there is a storm or event, while at the same time improving the utility and attractiveness of the landscape to encourage and improve community use on a daily basis when there is not a storm. The thinking around resilience shifted to working with the natural environment to create healthier, more useful, and protective interventions versus building a big concrete wall around an asset. Broad ranges of engineered solutions were developed to support resiliency efforts for all coastal situations – from urban to natural greenfield, and suburban to degraded brownfield. Many interventions were patterned after the innovative approaches taken in the Netherlands, a country that exists with nearly its entire landscape below sea level. The range of interventions and strategies that resulted from the Rebuild by Design competition, which called on the global community of coastal resiliency designers

to bring forth advanced concepts to the combat the coastal degradation issue, created a toolbox of concepts and designs that can be applied to a broad range of scenarios.

Interventions range from concepts that are applied to the direct interface between the upland and the ocean to reduce the impacts of storm surge and wave action, to concepts that create stormwater storage or conveyance that reduce the compounding effects of flooding from heavy rain events where upland water overwhelms the traditional stormwater systems of traditional engineered solutions.

A number of the modern interventions and strategies from the Rebuild by Design playbook were incorporated into the design of the resilience approach to the study area, while others were not applicable. The specific design elements associated with these strategies are included in the design basis and the design elements included in the design sections described herein.

Process. The process of determining the appropriate interventions and strategies for resilience for the study area included the following steps: assess historic conditions; assess current conditions; obtain measurements of the overall landscape; review the results of predictive models to provide context for future conditions; identify intervention types that would have the highest likelihood of success; identify the location, size, and layout of interventions that would have the highest chance of creating resilience and reducing storm impacts and impacts from daily tidal cycles; and, integrate those designs into the overall use, landscape, and aesthetic designs being developed as part of the Master Plan for the area. One key resource for this effort was the 2020 study entitled "*Point of Pines and Riverside Area Coastal Resilience Feasibility Report*" prepared by AECOM. Other data points reviewed as part of this project included the following:

- **Historic conditions**: maps and accounts of flooding over the past 20 years were identified and reviewed and formed a baseline for condition projections.
- **Current conditions**: measurements of the landscape were obtained, and a base map of existing conditions was prepared on which overlays of interventions and strategy concepts could be made.
- **Predictive models**: were prepared showing likelihood and severity of flooding and storm damage from storm scenarios that ranged from minor to severe were reviewed. A storm condition that was considered reasonable for future conditions was selected as the design storm condition.
- **Potential Intervention Measures**: were identified which would have the highest likelihood of success, including the identification of the location, size, and layout of interventions that would have the highest chance of creating resilience and reducing storm impacts and impacts from daily tidal cycles; and
- **Integration**: of those high likelihood of success designs into the overall use, landscape, and aesthetic designs being developed as part of this feasibility plan for the area was undertaken.

Environmental Resources in the Area

The area in the vicinity of the study area includes numerous environmental resources. A description of those resources and their functions is provided below. The figure below provides a listing of the resource areas identified in the vicinity of the study area which the resource protection agencies will require an evaluation of potential impacts (as part of permit application packages) and how the

proposed project components will be designed and implemented so as not to impact them and/or what mitigation measure are proposed if such impacts are unavoidable.

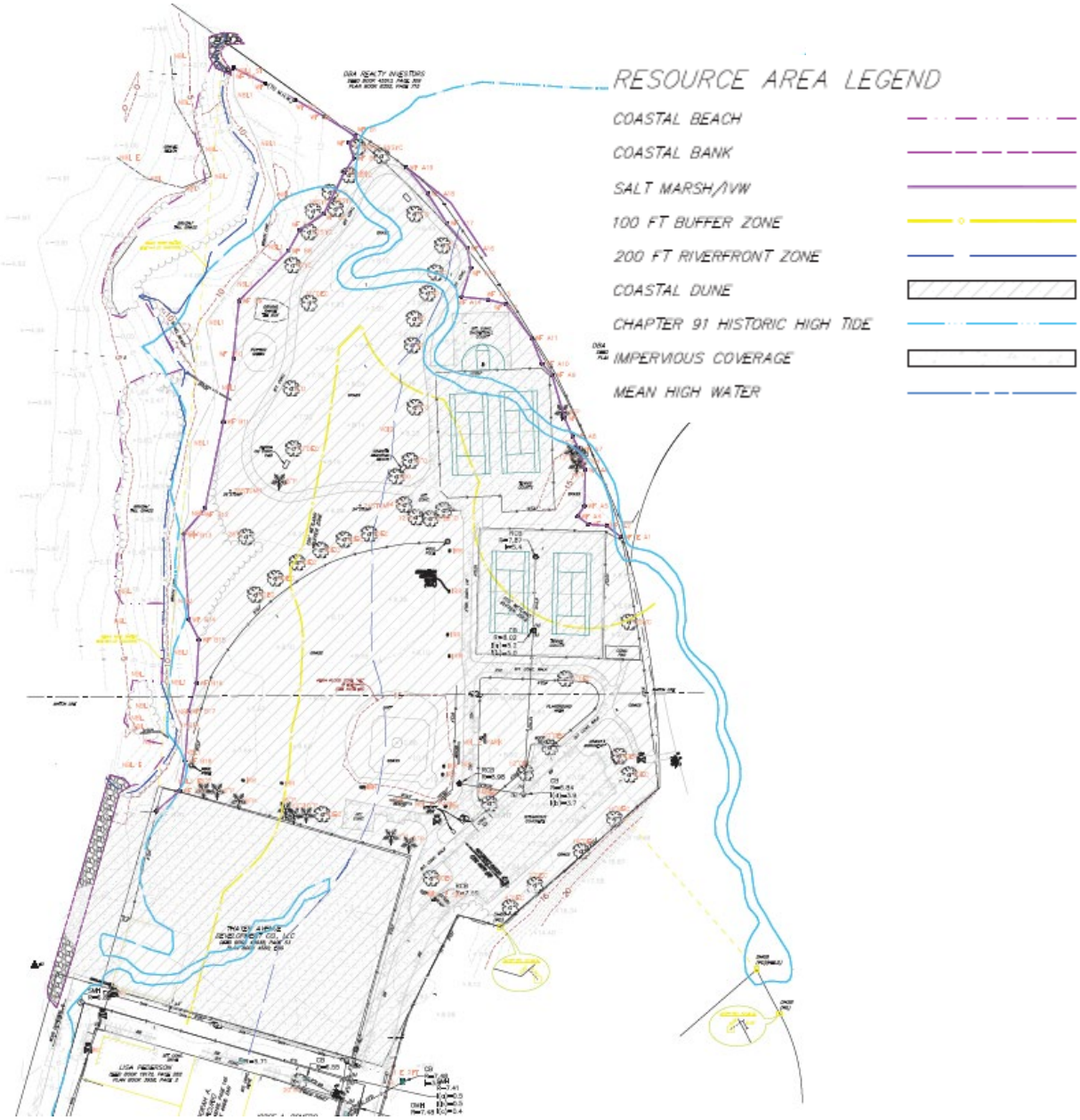


Figure 11 Environmental Resources

Area of Critical Environmental Concern

The most significant of the natural resources in the vicinity of the project is the Rumney Marsh Area of Critical Environmental Concern (ACEC),[4] as well as the Saugus and Pine Rivers. The Rumney Marsh ACEC

[4] MassDEP ACEC Regulation 301 CMR 12.00 was established in 1975 when the Massachusetts Legislature authorized and directed the Secretary of Environmental Affairs to identify and designate areas of critical environmental concern to the Commonwealth and to develop policies for their acquisition,

contains over 1,000 acres of saltmarsh, tidal flats, and shallow subtidal channels, and has been classified as a "*biologically significant estuary*" by the U.S. Fish and Wildlife Service. Because of the significant natural resource value associated with the area of Rumney Marsh, the Commonwealth has set it aside as a designated ACEC in August 1988 to protect its associated natural resources. Thus, any proposed development project will need to be cognizant of and address these resources/programs and work to complement the protections set forth in the ACEC under its approved MassDEP permits, if granted.

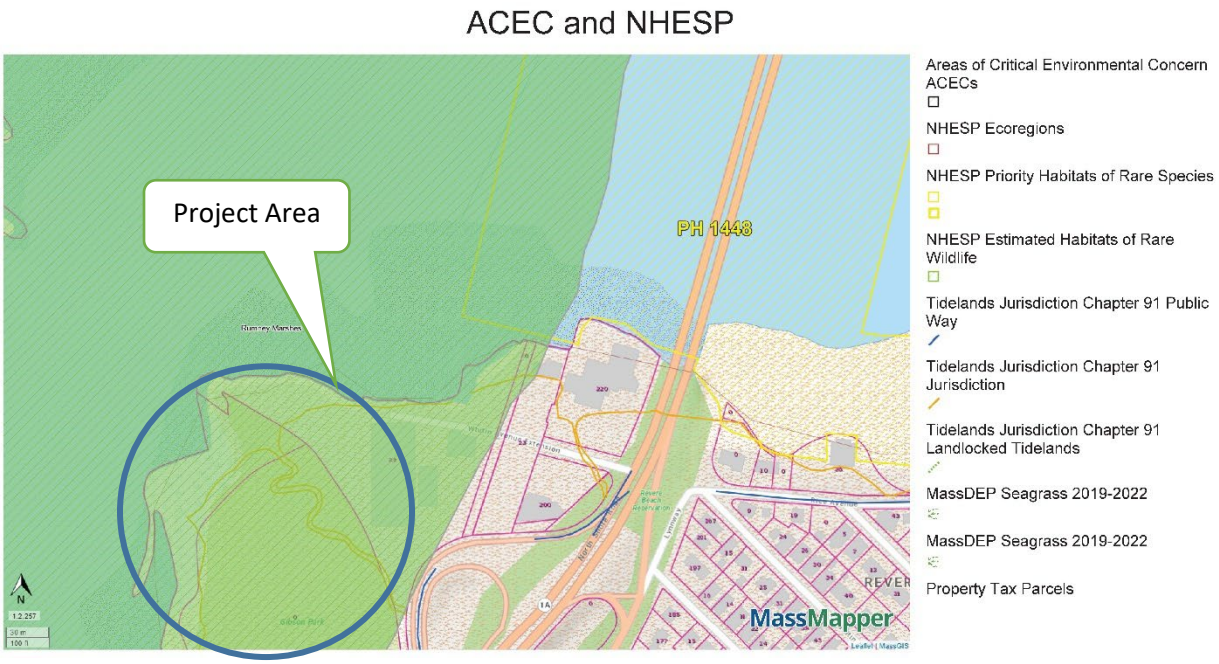


Figure 12- GIS Map Showing ACEC and NHESP Limits

Chapter 91 Regulations (310 CMR 9.00}

The Chapter 91 regulations provide the MassDEP with jurisdiction of structures located (or to be constructed) within current/historical tidelands and regulate public-access rights and use of tideland areas. According to Chapter 91:

- Areas of land that are upland of historic high-water lines are not within MassDEP jurisdiction and there are no associated landside buffer areas.
- Areas of land that are between the historic high- and low-water lines are considered private tidelands and are subject to MassDEP regulations that are designed to provide for public access to and from the water.
- Areas of land below the historic low-water lines are considered Commonwealth Tidelands and are subject to broader public rights for the use and enjoyment of the water.
- Public pier projects with either water-dependent uses or accessory to water-dependent uses, are specifically encouraged by the Chapter 91 regulations.

protection and use. An ACEC is a place in Massachusetts that receives special recognition because of the quality, uniqueness, and significance of its natural and cultural resources.

FEMA/Flood Plain

The landside of the entire study area (with the possible exception of a small portion of its southeastern corner associated with the existing baseball field) is mapped as FEMA 100-year floodplain, as shown on Panels 25009C0528G and 25009C0529G, Zone AE (elevation 10, NAVD 88), effective 7/16/14. The Massachusetts Department of Coastal Zone Management maps the entire area as being subject to impact by a Category 1 Hurricane. Any structure built within the 100-year floodplain is required to conform to the Massachusetts State Building Code standards for work within these areas (780 CMR 3107.0: Flood-resistant Construction).

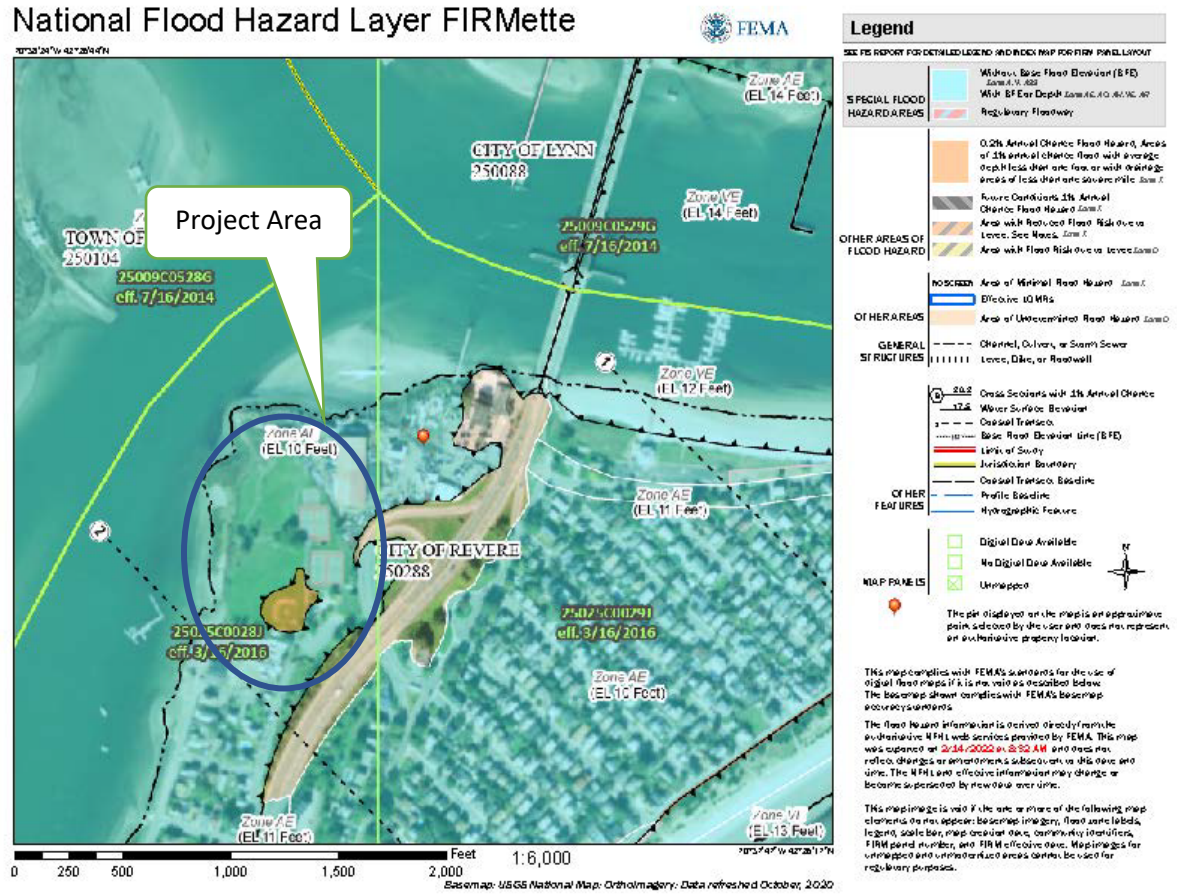


Figure 13- FEMA Floodplain Map

The following provides various Commonwealth-identified resource areas/designations.

Land Under the Ocean (310 CMR 10.25)

Nearshore areas of Land Under Ocean (LUO) are likely to be significant resources to provide storm-damage prevention, flood control and protection of wildlife habitat and, where they are present, shellfish. Nearshore areas of LUO can help reduce storm damage and flooding by buffering wave energy through the formation of offshore bars or by supplying sediments to adjacent beaches.

Coastal Beach (310 CMR 10.27)

Coastal Beaches (CBs) will likely play a key role in storm-damage prevention, flood control and the protection of marine fisheries similar to LUO. They may also be significant to the protection of Land

Containing Shellfish (LCS) when shellfish are present. CBs may reduce wave energy, and natural beaches provide sediment to LUO (which serves as a buffer to storm waves). The CB at the subject property would be classified primarily as a tidal flats. Tidal flats are typically significant to marine fisheries, LCS and the protection of wildlife habitat.

Land Containing Shellfish (310 CMR 10.34)

LCS is significant to the protection of marine fisheries when such lands have been identified and mapped by the Local Conservation Commission, the local shellfish constable, the MassDEP and the Massachusetts Division of Marine Fisheries (DMF).

Fish Runs (310 CMR 10.35)

A Fish Run (FR) is defined as an area within estuaries, ponds, streams, creeks, rivers lakes, or coastal waters which is spawning or feeding grounds or passageways for anadromous or catadromous fish, and which have identified by the DMF or has been mapped on the Coastal Atlas of the Coastal Zone Management Program. (310 CMR 10.35). A review of the FRs mapped by MassGIS indicate the Saugus River is a FR.

Land Subject to Coastal Storm Flowage (310 CMR 10.04)

This resource area is significant to flood control and storm damage prevention but has no function for protection of marine fisheries, Land Subject to Coastal Storm Flowage (LSCSF) extends to elevation 10 feet (NAVD88) and includes nearly all of the lands within the study area.

Riverfront Area ((310 CMR 10. 58 (6) (i))

Riverfront Area is defined at 310 CMR 10.58(2)(a)(3) as *the area of land between a river's mean annual high-water line measured horizontally outward from the river and a parallel line located 200 feet away.* The 200-foot Riverfront Area extends from the MHW line associated with Pines River and includes Coastal Beach, Coastal Bank, Barrier Beach (in turn, Coastal Dune), Salt Marsh, mature trees, manicured lawn, paved areas and public roadways, and existing athletic fields.

Natural Heritage and Endangered Species (321 CMR 10.00)

The Massachusetts Endangered Species Act and its implementing regulations are intended to protect rare species and their habitats by prohibiting the "*take*" of any plant or animal species listed as Endangered, Threatened or Special Concern. The regulations establish procedures for the listing and protection of rare plants and animals and outlines project review filing requirements for projects or activities that are located within a Priority Habitat of Rare Species. The northeastern portions of the Riverside Point of Pines area as habitat for the Common Tern; however, this critical habitat does not extend into the study area.

Project Goals and Considerations

The redevelopment and upgrade of the infrastructure (both naturally occurring and anthropogenic features) in the study area can be judged as to their level of respective success by evaluating both the project goals and project considerations/limitations. MME understands that the primary City goals for this project include the following:

1. **Serving the Community** – Providing full access and programing to the Gibson Park and Boatworks properties for a wide variety of traditional active public uses including playground, tennis, basketball, soccer, baseball and pickle ball; passive uses such as free-form playing, walking, dog-walking, etc.; educational opportunities including safe access to the wetlands; connecting adjacent properties for walking and biking; recreational fisherfolk, birdwatchers and other passive-type users; and, water-dependent recreational/sustainable opportunities such as rowing and kayaking.
2. **Resiliency** – Planning for future sea level rise and more intense and frequent storm events associated with global climate change. Potential impacts to be addressed include flooding associated with river-flooding from storm surges and high-tide events; and flooding associated with rain-fall events. It should be noted that portions of the study area are already subject to relatively frequent flooding events associated with both modalities and it is anticipated that both types of flooding events will become more frequent and/or intense over the next several years.

In addition to meeting the primary project goals, potential future layouts, facility uses, and flooding abatement intervention measures need to be gauged against certain considerations and limitations that will affect the viability of a project component, these include:

1. **Permitting Difficulty** – Factoring in the local, state and federal coastal and natural resources of the area, understanding how permitting can add risks, costs and timeline extensions to a project.
2. **Construction Costs Considerations** – The project funding will likely come from a mixture of grants, loans, and local matches, and thus any potential project elements will need to have a justifiable benefit-cost balance to provide to potential funding sources and associated audits. Due to the conceptual nature of these layouts and lack of detailed design information, we have only provided relative cost considerations for the different elements, and a more detailed construction cost estimate will be conducted in future efforts.
3. **Operations and Maintenance Costs** – Considering the lifecycle of the proposed upgrades, the project should not pose undo or burdensome operations and maintenance (O&M) activities. As with construction costs, this issue will require a benefit cost analyses to illustrate the short- and long-term benefits associated with the selected project design.

One of the primary goals of the City for the overall Gibson Park project is to provide a resiliency-based redevelopment of the Gibson Park property, the Boatworks property and the Mills Avenue alignment, especially focusing on utilizing nature-based, blue green/gray intervention measures. The nature-based, blue green/gray aspects of the project will include establishing new salt marsh, a stabilized vegetated berm and new living shorelines along the Pines River. A second public-access/educational project component included installing an elevated boardwalk through and above the marsh areas west of Gibson Park which leads south to a community rowing/kayak launching facility to be built at the Boatworks portion of the subject property. The elevated boardwalk will have “bump outs” and seating areas to stop along with the way for users to rest, take in the views and read in the interpretive educational signage explaining features of the project. The community rowing facility will have a set of dock floats extending into the Pines River which will be the terminus of the walkway.

Gibson Park Layout Alternatives Analyses

Redevelopment Options

As discussed above and throughout this Design Report, the proposed project is very complicated and includes several distinct but inter-related components including the following:

- Use of blue-green techniques to store the first several inches of stormwater associated with a rainfall event including a retention system, bioswales, rain gardens, pervious materials, etc.
- Use of nature-based, living shoreline components, as well as selected "*normal*" sea-wall components to protect the Study Area from flooding associated with storm-surge and/or high-tide flooding associated with the adjacent Pines River waters.
- Use of nature-based, living shoreline components to protect the existing shoreline of the Gibson Park Property, as well as to stimulate the growth of healthy saltmarsh beds and reefs both in the short term and in response to rising sea levels associated with global climate change.
- Part and parcel with providing resiliency measures, many of the intervention measures include adding public amenities to the Gibson Park and Boatworks properties such as a multi-use athletic field, a walkway, a community boating center, etc.

The interdependencies between project components results in critical evaluation criteria associated with this alternatives analyses. For instance, if the study area is not provided protection associated with Pine River flood waters, the proposed land-side stormwater abatement system for rainfall events would be of limited effectiveness as any such system would be quickly overwhelmed by river-associated flood waters. Another example includes that without the installation of the stormwater detention system in Gibson Park, the proposed multi-use athletic field would likely not be constructed. Therefore, the following alternatives analyses evaluates the overall project components at a high level and then evaluates individual intervention measures on a more granular scale.

Overall Project

In this alternative, the City takes no actions to provide any improvements to any of the infrastructure in the Study Area. Following the Do Nothing alternative, this section of the Design Report provides an alternatives analyses for smaller-scale design components. There are multiple aspects of this project that provide benefits and could be developed in a multiple manners. The project activities for which we evaluated multiple options include:

- The living shoreline components
- The salt marsh
- The elevated walkway
- The berm/seawall along Mills Avenue
- The stormwater conveyance along Thayer Avenue
- The stormwater conveyance system to the subsurface chamber system
- Ball retention along the edge of field

Do Nothing

There would be no actions taken with respect to resiliency or public amenities for the residents of the area. While this is not a realistic option, most planning efforts include this alternative due to state and federal permitting requirements.

Community

This option would result in a large portion of the community being subject to more frequent and intense flooding events. Further, there would be no upgrades to either Gibson Park or Boatworks properties. This would like result in the Boatworks property continuing to being an under-developed blighted property in the neighborhood and the Gibson Park facility being one of the most underutilized public park facilities in the City that in a decade may be lost to shoreline erosion.

Resiliency

There will be no resiliency aspects associated with the Do Nothing alternative and the flooding issues experienced by the neighborhood would continue and likely become more frequent and intense over the next few years and decades.

Permitting

As no actions would be conducted, there would be no permitting issues. The only minor exception could potentially be associated with the existing Chapter 91 license for the infrastructure associated with the Boatworks property.

Construction Costs

There will be no infrastructure actions associated with the Do Nothing alternative; and therefore, no construction costs. However, the City and neighborhood residents would likely accrue additional costs associated with "*preventable*" flooding events in the form of stormwater removal, building materials damage (e.g., mold, repairs, replacements, etc.) and loss of tax-ratables as local residents are forced to leave the City to live in higher and drier locations.

Operations and Maintenance

There will be no infrastructure actions associated with the Do Nothing alternative; and therefore O&M costs.

Living Shoreline Concept – Protection of the western riverbank slope

Living shorelines are a great nature-based solution to stabilize a bank slope, reduce wave energy and reduce erosion. As part of this process, we evaluated several different options for provide a sill or "toe" for the living shoreline, including:

1. Riprap/stone – A natural material, whose weight and angularity provide the toe and when sized appropriately are affecting at reducing wave energy. The rip-rap stone feature does not provide much habitat benefit and will not self-accrete to work with rising sea levels.
2. Oyster/Ribbed Mussel Reef – Shellfish beds are a natural part of a low marsh area and are effective at reducing wave energy, stabilizing a slope and will naturally self-accrete to rise with rising sea levels.
3. Coir Logs – Typically comprised on native materials like coconut husks, coir logs are staked in place at the toe of the marsh. Coir logs provide temporary stabilization for the plantings to establish, however they do naturally degrade over time and therefore could leave the shoreline

susceptible to storm events with high wave energy that could degrade/erode a newly established marsh. Furthermore, the coir logs do not provide a solution for rising sea levels.

During our research and pre-application project meetings, resource-protection regulators expressed concerns regarding the use of oysters associated with the living reef nature-based solution. Their primary concern was that the study area is within an Impaired Shellfish Area and the harvesting of any shellfish for human consumption purposes is prohibited. This alternative includes the use of ribbed muscles which are not edible and would protect the public from harvesting and consuming tainted shellfish in the form of oysters. Both options (using oysters or ribbed mussels) would result in similar levels of shore-line protection, as the shellfish established themselves along the sill of the shoreline, help reduce wave energy, filter water, and self-propagate to grow/accrete with rising sea levels.

Community

The living shoreline options would not alter the Community's use of the shoreline of the Pine River. It is anticipated that the use of most options would provide more-suitable habitat for recreational fin fishing opportunities, with the exception of the rip/rap stone option. Further, the oyster/ribbed mussels options would provide similar levels of educational opportunities for area residents to understand the importance of healthy, local reef-type habitats and how they protect our shorelines.

Resiliency

As both the oyster and muscle reef options would require similar substate and both options would provide ongoing shoreline protect as they would self-accrete (e.g., grow vertically) in response to sea-level rise, both of these alternatives would provide similar levels of resiliency. The rip rap/stone option would provide stability and resiliency, but for a shorter term, as eventually rising seas would overtop the stone and make the marsh vulnerable again. Similarly, the coir logs, after decomposing, will provide no additional structural support to the slope and not protect the slope as sea level rises.

One significant co-benefit of living reefs is that when established, the organisms filter water which results in over improvements to surface-water quality conditions. Oysters typically filter approximately 50 gallons of water each per day and ribbed muscles only filter 15 gallons of water each per day.

Impacted stormwater is one of the primary mechanisms resulting in closure of shellfish beds for human consumption. The proposed project stormwater intervention measures will provide significant pre-treatment of stormwater to the adjacent surface waters which could potentially "*open up*" the shellfish beds for harvesting for human consumption purposes in the future. Further, the use of high-filtering volume oysters versus ribbed muscles could more quickly accelerate the general improvement of surface-water quality conditions in the vicinity of the study area.

Permitting

The use of natural materials will be a keep component of permitting the shoreline sill. The rip rap/stone and coir logs are natural materials and likely to meet less scrutiny. The reef discussed, which are designed to mimic the composition of oyster shells, are considered a bio-engineered product and would likely meet some scrutiny to review historic data and performance.

Due to the designation of the study area as a Conditionally Prohibited Shellfish Area, the propagation and ongoing presence of edible oysters would prove to be a challenge for the regulatory community. Although living oyster reefs have been successfully permitted and constructed in Massachusetts (in the

vicinity of Boston Harbor which is in a different CZM territory than the study area) and elsewhere, it would be less challenging to permit a living reef which utilizes ribbed muscles as it takes out the risk of human consumption. This option could also prove to be both catalytic and implementable in other areas of the Commonwealth and East Coast.

Construction Costs

It is anticipated that the coir logs would have the least cost implications, followed by the rip/rap stone option, and then the shellfish reef options being slightly more.

Operations and Maintenance

For the shellfish reef options there would be no ongoing O&M issues or costs with either option once the substrate and any seeding has been completed. The rip rap/stone option would not have much O&M costs in the beginning, however as sea levels rise, they would either need to be redressed or removed. The coir logs similarly would have little initial O&M costs, unless there are significant storms that occur early in the project, damaging the coir logs and effecting the shoreline. Over time O&M costs for the coir logs option will increase as they will provide less and less protection for the shoreline.

Salt Marsh Concept 1 – Expand Existing Salt Marsh Habitats

At the outset of the project, we understood that salt marsh enhancement and creation would be a critical aspect of enhancing our resiliency. The question became to what extent and what footprint, so we looked at three different scenarios

1. Developing salt marsh the entire shoreline of Gibson Park – This would transfer some coastal beach areas to salt marsh
2. Expanding the salt marsh in the two areas where it currently is present by creating more low marsh and much more high marsh - This would involve significant “dredging” (excavation below MHW) and could impact currently healthy marsh habitat.
3. Expanding the salt marsh in the two areas where it currently exists by removing invasives and creating more surface-water flushing (chosen alternative)- This would involve little dredging and only works in areas of invasive phragmites.

Community

Enhancing and restoring salt marsh will have minor impacts on the Community’s use of the shoreline of the Pines River. All of the options would provide similar levels of educational opportunities for area residents to understand the importance of healthy, local salt marsh habitats and how they protect our shorelines.

Resiliency

Salt marshes serves as a critical component of resiliency as they mitigate storm surge, provide flood storage and can reduce and prevent erosion of the shoreline. All the three of the concepts would contribute greatly to the overall resiliency of the site.

Permitting

Salt marsh is protected resource area and will need to be created and enhanced in accordance with the governing regulations. Each of the three options analyzed have differing regulatory needs. The first option, the entire Gibson shoreline, would create the transfer from one resource area (coastal beach) to another (salt marsh) and may not be reviewed kindly as the project area would lose the benefits of the

coastal beach. The second option involves much greater amounts of dredging and impact to the low salt marsh, which is healthy and propagating, so the added benefits of the salt marsh expansion may not outweigh the impacts in some regulatory manners. The third option will still require "dredging" to expand the salt marsh, but it's all done in areas currently above MHW and overgrown with invasive Phragmites, so while there is an existing resource area in this footprint, it provides less functions and values than a healthy salt marsh would.

Construction Costs

Options 1 and 2 would generally be higher in costs as the work would occur lower in the topographic profile and thus be influenced by tides and water, making it slower and more difficult to execute. The third option would be slightly easier as the work is occurring in an area above MWH, meaning it would not be tidally affected.

Operations and Maintenance

The ongoing O&M costs for all of the options would be associated with monitoring the health of the marsh and ensuring that invasives don't re-establish.

Mills Avenue Alignment Berm Concept – Storm Surge Protection

High tide events and storm surge from storms frequently overtop the roadway along Mills Avenue and inundate the neighborhood, making it impassable, causing property damage, and potentially creating public safety issues. In order to protect the Mills Ave area in the shorter term (as the longer-term plan based on a previous MVP study is to install a seawall barrier), the project anticipates using a berm up to a targeted height along the edge of Mills Ave. For this option we explored two options:

1. Use of interlocking, concrete Jersey Barriers
2. Soil filled vegetated berms (consisting of soil-filled geobags, geotextiles or similar)

In both options, concrete-walled access points would be installed along the alignment to provide access for residents to the shoreline. The access points would be improved with infrastructure such as flash boards or deployable barriers that the City would need to install in anticipation of a significant storm and/or high-tide event.

Community

This jersey barrier option would result in a three-to-four-foot-tall concrete wall for Mills Avenue residents to look out on 24-hours a day. While views of the more distant views, such as the Boston skyline, would remain unimpeded, it is believed that the recommended vegetated berms would provide the community with a more aesthetically pleasing view shed.

Resiliency

The concrete Jersey Barrier alternative would provide similar levels of resiliency protection associated with Pine River flood waters, as do the recommended vegetated berms, presuming that the barriers could be installed in an interlocking manner with rubber joints. The City could also take decarbonization credit for the berms due to their use of vegetation while the concrete Jersey Barriers would not factor into this equation. However, it should be noted that federal, state and local grant opportunities for blue-green, nature-based resiliency intervention measures would likely not be available associated with the concrete Jersey Barrier option. Furthermore, while wave action isn't a major concern along the banks of

the Pines River, the sloped vegetated berm would have less wave deflection impacts when compared against the mostly vertical concrete structures.

Permitting

The installation of either vegetated berms or concrete Jersey barriers would likely require acquisition of permits from the appropriate regulatory agencies; however, the two strategies would address different performance standards within these resource areas. As noted above, wave deflection would be a regulatory concern associated with the Jersey Barriers, not to mention the use of concrete would act as a seawall, whereas the vegetated berm is more of a nature-based, bio-engineered solution. There may potentially be challenges with the installation and use of concrete elements along the shoreline. It is anticipated that similar permitting challenges associated with the vegetated berms will be encountered as they typically made from synthetic materials which the regulators would not want discharged to the adjacent surface waters.

Construction Costs

The costs to construct the vegetated berm option are on the order of $150 per linear foot. This includes the costs to install granite curbing of the base of the eastern-face of the berm to protect its length from snowplow operations. The costs to install a similarly configured system utilizing concrete Jersey Barriers is $110 per foot. This is the option preferred by the City DPW due to their extensive experience with utilizing concrete Jersey Barriers within the City. The higher costs of the vegetated berm would likely be offset by the availability of grant funds for the use of blue-green, nature-based resiliency measures.

Operations and Maintenance

The concrete Jersey Barrier alternative would have less O&M costs as, other than relacing failed or damaged units, there are little to no O&M requirements versus the proposed vegetated berm which would require some level of vegetation maintenance by the City. Snow management would be an issue with both options and a designated snow storage area(s) would need to be designated.

Saltmarsh Walkway Concept – Provide an Alignment to connect the Community

As the Rumney Marshes ACEC Salt Marsh Restoration Plan encourages and stresses the need for public education and public access as a keystone for successful protection of the marsh, this project is anticipating installing an elevated walkway overlooking the salt marsh. We looked at three options for the salt marsh:

1. Straight down from the Gibson Point project over the existing low marsh – The existing low marsh appears healthy and there are concerns about shading and impacts from installing the walkway through that area.
2. Down from Gibson Point over an area populated by invasives and where the new marsh is proposed – In the upper elevations, the park is populated by common reed/phragmites that distort the viewshed and don't provide good wetland functions and values. he raised walkway would be routed a bit further inland and to the east from the shoreline in areas dominated by existing phragmite beds which are considered as "*low value*" wetlands when compared to saltmarshes.
3. Upland from the bank away from the Salt marsh – While this option would have the least amount of impact on the marsh, it would also have the least impact on the educational opportunities and engaging the public.

Figure 14 Conceptual Rendering of Walkway Through Marsh

In the recommended scenario, the raised walkway would be routed through, and over existing salt marsh habitat located to the west of Gibson Park to maximize the public enjoyment of the area, as well as to provide educational opportunities. Upon completion of the raised walkway, an abatement program would be conducted to remove or control the phragmites and to re-establish native saltmarsh habitat, as such, existing saltmarsh habitats would not be impacted during construction.

Community

The first two options would meet all City program elements involving allowing access to the saltmarsh habitats to area residents, as well as integrating the program elements of the projects within the area. It would also meet program educational components, including a discussion/signage of how the non-native phragmites were successfully addressed. The third option would provide very little public education benefits as the walkway would be too far set back, similar to the existing condition.

Resiliency

The walkway structure would be constructed at the same elevation in all the alternatives. As such, there are no differences in resiliency measures or effectiveness. The elevated structure and the mostly north/south orientation of the structure would create less shading which will help the salt marsh vegetation better establish underneath.

Permitting

The resource-protection regulators would prefer not to have any structures constructed within any wetland. However, as the raised walkway is a critical component in integrating all of the proposed projects in the study area and promoting the benefits of nature-based solutions and the importance of resource areas, it is highly recommended that this project component be fully pursued during the design and permitting project phases. It is anticipated that a project constructed within low value, phragmite-rich wetlands would be more easily permitted than the proposed alternative of constructing the raised walkway in the existing saltmarsh.

Construction Costs

Realigning the raised walkway a bit further inland will slightly reduce the project construction costs as there will be less influence of the tides on work schedules. As such, we anticipate costs to be most for option 1, then option 2, and with option 3 as the least costly to implement.

Operations and Maintenance

Realigning the raised walkway would not result in any additional O&M costs or activities for the City over the originally proposed alignment.

Thayer Avenue Stormwater Management System Concept– Stormwater Conveyance

In order to move the stormwater away from the Riverside Neighborhood and into the subsurface storage system under the field, we looked at two different options,

1. Using a sub-surface trench drain system
2. Using a standard catch-basin/drainage pipe system

The trench drain suggested would run along Mills Avenue from the street end at the Rumney Marsh to the Mills Avenue intersection with Hayes Avenue. The trench drain, could be designed similar to the typical French-drain systems used to dewater around housing and other building structures, would be located along the northern edge of Mills Avenue along the noted segment of the street.

It is anticipated that a four-by-four-foot trench drain running the length of this segment of the street would be about 250-feet long and could have as much as 4,000 cf of storage capacity, retaining and moving almost 30,000 gallons of water at a time. The trench drain would require the design of a covering feature – either a steel or concrete mesh set of plates or a hood structure that would decrease the likelihood that debris and sediment would infiltrate the system. Similar to a catch basin and pipe system, a sump or multiple sumps would be required to allow for debris cleanout during regular maintenance.

The trench drain system would interface with the pump and water movement system currently envisioned for the property near the Mills and Hayes Avenue intersection.

This type of system is common in this portion of New England, as a photo of a similar system from Swampscott, MA are shown below.

Figure 15 - Photo of Trench Drain in Swampscott, MA

The catch basin and pipe system would be comprised of Class V Reinforced Concrete Pipe. This pipe is the strongest of all concrete pipe, (class III is typically used) and would allow for shallower cover depths, to keep the conveyance system higher up and away from the groundwater table. The catch basins

would be located in targeted low points along the re-graded roadway and be equipped with a deep sump and outlet hood to capture sediment and debris and prevent materials from entering into the system and potentially damaging the pumps or clogging up the recharge chambers.

Community

Both options would meet all City program elements involving a stormwater conveyance system for the study area, moving the water away from the Riverside neighborhood and to the subsurface storage system.

Resiliency

Both options will provide resiliency, each benefits will depend on the size and slope installed as that will dictate the conveyance and storage capacity. Prior to selecting the final design, MME recommends that this and the following alternative stormwater BMP be presented to the City's DPW and engineering team for evaluation.

Permitting

We do not anticipate any differing options for permitting as a result of each conveyance option.

Construction Costs

The catch basin and pipe system is likely to have a lower cost, roughly $150-$200/lf as the materials are readily available and because of the shallow profile of the pipe trench. The trench drain would likely have a higher cost due to wider excavation, but mostly because the materials are not readily used and may require custom fabrication.

Operations and Maintenance

The catch basin and pipe network would be easier to maintain for the City DPW as that is consistent with the infrastructure the typically maintain throughout the City and would primarily involve cleaning out the catch basins. The trench drain would be a little more intensive for maintenance as the cleaning/sediment removal is required the full length of the trench, and leave/debris management will relatively often in the fall.

Stormwater Conveyance to Field Concept– Storm Surge Chamber versus the Use of Alternative Drainage Systems

During high intensity storm events, the stormwater runoff will arrive very fast and will be difficult to convey to the field and keep from backing up into the neighborhood. As part of this design, we evaluated two different options:

1. Use of a storm surge chambers and multiple design flow pumps
2. Use of Alternative Drainage Systems

The first option would have a series of storm surge chambers that would feed a dual duplex pump system. The dual duplex pumping system would have a pair of pumps designed for low flow events and another pair designed for high flow events. The storm surge chambers would act similar to a wastewater surge tank at a sport stadium or other place that may see periodic very high flow events. The surge chambers will provide a buffer and storage capacity to allow the pumps to work without backing up in the system and flooding the neighborhood.

This alternative drainage system is based on the passive water movement systems of historic engineering systems. Similar to the Archimedes Screw concept, a turning pathway that elevates water through a passive piping system. The water-movement system could be powered by generators or through passive hydropower from the forces of moving water. Additional design analysis would be required to determine the site-specific best solution. The advantages of this type of system are that it does not rely on pumps that could clog or otherwise not function fully properly during power outages or storm stress situations. The specific design considered for this site should take into consideration the type of power that may be available and the potential that the power could be interrupted during storm events. See examples below:

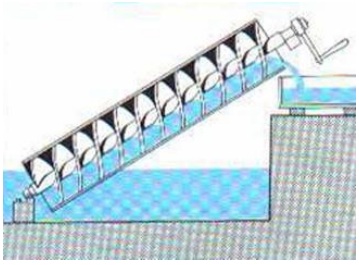


Figure 16 Archimedes Screw Concept for moving water. Handle would be replaced by motorized mechanical system or passive energy transfer system (falling water energy transfer mechanism).

(Source:https://www.renewablesfirst.co.uk/hydropower/hydropower-learning-centre/archimedean-screw-hydro-turbine/).

Figure 17- Modern Application of the Archimedes Screw Concept (Water World, CA)

(Source :

https://www.math.nyu.edu/~crorres/Archimedes/Screw/Applications.html)

Community

Both of these options would meet all City program elements involving a stormwater management and conveyance system for the study area.

Resiliency

While neither of these options alone are very resilient, they both contribute to the overall resiliency of the site and area. The biggest difference between the two options with respect to resiliency is that if the storm events become more powerful, it is more straightforward to upgrade to a higher capacity pump system than to upgrade the Archimedes screw.

Permitting

We don't believe either of these options would have different permitting requirements and scrutiny and both would be reviewed in the total context of the stormwater management system.

Construction Costs

At this early stage of the project, it is very difficult to gauge the level of costs for implementation of these options. The storm surge tanks would require materials and excavation; however, they are compatible and consistent materials with what else is being proposed throughout the project. The pumps will be relatively expensive, however there are multiple pump manufacturers that could possibly provide cost-effective alternatives that could meet the design pump curves. For the Archimedes screw option, this is a relatively rare item, making it more difficult or probably longer to procure, with less competition. Furthermore, the installation is not a common practice and thus likely to be more costly than the known and experienced pump and chamber system.

Operations and Maintenance

This Archimedes screw alternative may result in greater O&M challenges as it is a system not in common use in the City. In addition, having only one screw would make the system susceptible should there be an issue. Pump maintenance is a common practice in the City, there is already a stormwater pump station at the nearby Point of Pines. The duplex pumping system allows for the system to still function while one of the pumps is offline for maintenance as well.

Design Alternative - Passive Ball Retention System along Marsh Side of the Multi-use Field.

During pre-application discussions with regulators, it was revealed that there is some level of concern concerning the elevated walkway/seating system contemplated for the marsh-side edge of the multi-use field at the Park. Once of the purposes of the elevated walkway in this area is to keep out-of-play balls from going into the water in the salt marsh and adjacent river waters. To evaluate this design, we looked at 3 alternatives:

1. No barrier from the field to the marsh
2. A solid bench along the edge of the elevated walkway to provide seating and prevent balls from passing.
3. A deployable netting system along the edge of the field.

A simple alternative that is used in a number of fields and ski areas in the New England area where adjacent features such as ponds, rivers, marshes and even streets limit the amount of free area for out-of-bounds ball movement is the high-net system. Quite simply, a high-net system uses a net wall to confine balls and other objects that are blown by the wind or kicked or thrown toward the edge of play area. A high-net system could be used instead of or in concert with the elevated path/bleacher steps system currently envisioned – thereby reducing the need for height of the path/bleacher steps and thus reducing the shadow impact of that structure.

Figure 18 -Photo of High-Net of ball capture, soccer field in New England. High Net is the black nearly transparent net system suspended from poles at this soccer field in central MA.

(Photo: S. Manoog, June 20, 2022)

Community

Option 1 would not provide benefits to the community and result in the likely loss of balls into the marsh/river, as well as damage to the marsh/river. Option 2 would provide good community benefits by providing seating along the ballfield and prevent balls from entering the marsh/river. The third option would meet all City program elements in allowing for full use of the proposed multi-use field while protecting users by keeping their out-of-play balls from running into the salt marsh and adjacent river waters.

Resiliency

Option 1 would not have any resiliency benefits. Option 2, the solid structure, could have negative impacts on the growth of vegetation along the slope, thereby reducing resiliency benefits. The use of a high-net ball capture net would keep park users from entering and damaging the adjacent salt marsh, thereby protecting them and maintaining the resiliency benefits.

Permitting

Option 1 of no ball-catch barrier would not likely have permitting implications; however, the regulators may be concerned about unauthorized, uncontrolled access into the resource areas to try to retrieve balls. Option 2 would likely have more regulatory scrutiny as the solid structure would have shading effects and could impact the health of the vegetation along the slope down to the shoreline. The high-net ball capture net would be any more difficult to permit than the other options.

Construction Costs

Option 2, of the solid bench structures would be the most expensive to implement, with the high-net ball capture system only marginally more expensive to implement when compared to the no barrier option 1.

Operations and Maintenance

The no ball barrier option wouldn't have direct O&M implications but would likely result in the more O&M to maintain the marsh and slope. The option 2 solid bench structure would be maintained consistent with

the elevated walkway but would also likely result in slope and shoreline maintenance because of the impacts to the vegetation. The high net ball capture alternative would likely require O&M services from the City to ensure its long-term functionality and make sure the netting doesn't get ripped or clumped together.

Option/Concept Ranking Matrix

Using the decision parameters discussed above, MME evaluated the potential options against those parameters with a ranking of zero to five. Zero would indicate the least desirable outcome and five would indicate the most desirable.

Alternatives Analyses Ranking Matrix							
Project Component	**Concepts Analyzed**	**Community**	**Resiliency**	**Permitting**	**Cost**	**O&M**	**Total Score**
Do Nothing	Project No Action Alternative	0	0	5	1	5	11
Living Shoreline	Rip rap and stone	2	2	3	4	3	14
	Oyster/Ribbed Musssels	4	5	2	3	4	18
	Coir Logs	2	1	4	5	2	14
Salt Marsh	Entire Shoreline	5	5	2	2	3	17
	Two areas with more low marsh	4	4	3	3	3	17
	Two areas removing phragmites	4	4	4	4	4	20
Mills Avenue Alignment Berm	Utilize Vegetated Berm	4	4	3	4	3	18
	Utilize Concrete Jersey Barriers	2	3	2	4	4	15
Saltmarsh Walkway	Through Low Marsh	5	3	1	2	3	14
	Removal of Invasives and new high marsh	5	4	3	3	3	18
	Upland and away from marsh	2	2	5	4	3	16
Thayer Avenue Stormwater Abatement System	Trench Drain	3	3	3	2	2	13
	Catch Basin and Pipe	3	3	3	3	4	16
Thayer Avenue Stormwater Abatement System	Storm Surge Chambers with Pumps	3	4	3	4	4	18
	Use of Archimedes-screw System	3	2	3	2	2	12
Ball Capture System Along Edge	No barrier	1	N/A	5	5	3	14
	Solid bench along the edge	5	N/A	2	2	3	12
	Deployable Netting	4	N/A	4	4	3	15
Qualitative Ranking Criteria: 0 = lowest score, 5 = highest score							
	Recommended Option						

Based on this ranking matrix, the following provides MME's recommended project alternatives:

- **No Action Alternative:** This low ranking reflects the complete lack of community and resiliency benefits for this alternative. As no work would be conducted, there would be no permitting required and there would be no O&M costs. The low ranking for cost was assigned associated with induced costs associated with preventable damages if no actions are taken.
- **Living Shoreline:** The use of ribbed muscles alternative scored slightly higher than the use of riprap/stone or coir logs, as they are more resilient and provide better educational and community benefits.
- **Salt Marsh:** Expanding salt marsh in the targeted areas where the invasive phragmites are predominant is the chosen option, as it provides resiliency and community benefits, while not being overly burdensome for permitting and maintenance considerations.
- **Mills Avenue Alignment Berm:** The use of vegetated berms scored slightly higher as this option will be more aesthetically pleasing to the community. The costs were assigned the same score as the use of contrate Jersey Barriers would be lower; however, it is anticipated that the higher costs associated with the vegetated berm would be offset by the availability of funding through resiliency grants.

- **Saltmarsh Walkway:** The rerouting of the walkway through areas of low-quality, phragmites wetlands, followed post construction with abatement of the phragmites was selected due to permitting issues and higher educational opportunities wherein the public would learn more about wetlands and the presence/abatement of invasive species.
- **Thayer Avenue Stormwater Conveyance:** The catch basin and pipe network ranked slightly better than the trench drain as the construction costs would be cheaper and the maintenance consideration consistent with what they City is already performing.
- **Stormwater Conveyance to the Field**: The use of the storm surge chambers and dual duplex pumping system was chosen due to its availability , interchangeability with differencing conditions and known maintenance considerations.
- **Ball Capture System:** The high net system is the preferred alternative as it has low implementation costs, but prevents balls and thus people from entering in the resource areas.

Permitting Considerations

The richness of the study area's and region's natural resources requires that any proposed project include components and steps that need to be implemented to ensure that the natural resources are protected, and that any development is performed in a responsible manner, both during short-term construction phases and long-term operational phases. There are several federal, state and local governing regulations that would apply to the project and would need to be considered as a development program is developed.

Some of the natural resources in the area include the Rumney Marsh Area of ACEC, as well as the Saugus and Pine Rivers. Thus, any development regime will need to be cognizant of these resources and work to complement the protections set forth in the ACEC.

The other primary sensitive resources in the study area are the Saugus and Pines Rivers, both of which are tidal rivers which fall under the jurisdiction of the Massachusetts Wetland Protection Act, the Rivers Act, and the Public Waterfront Act, commonly referred to as the Chapter 91 Program. This program is the oldest of its kind in the Nation and was formally established in 1866. It is intended to protect and promoted the public use of tidelands and other waterways for the general public. The program is tasked with ensuring the development within current and historical tidelands are protective of and preserve public rights and workplace rights over the waterfront areas.

Another notable permitting and review program is the local Site Plan Review (SPR) which under the purview of the City of Revere through a combined effort of several municipal departments. The purpose of the SPR process is to ensure responsible development within the City that conforms to accepted standards and regulations, is congruous with the surrounding neighborhoods and environments, and can be supported by existing resources and infrastructure in an area.

The discussion above highlights some of the most notable regulations that would affect development in the study area; however, in order to bring a project through design to implementation and operation, there will be a series of local, state, and federal permitting programs that will require conformance. The full extent of the permit requirements will not be fully known until the approximately 30 percent project design is completed. The Project Team has already held one pre-application meeting with several of the

resource-protection regulators which provided extremely useful feedback contributing to the preliminary design phase of the project.

A list of the potential permits, their governing agency, regulations and why the permits may be required is presented in the table below:

Agency	Permit	Regulations	Comments
Local			
Revere Conservation Commission	Order of Conditions under the Local Wetland Bylaw	310 CMR 10.000	Required for any disturbance in tidal wetlands or within 200 feet of a riverfront
Revere Zoning Board of Appeals and/or City Council	Special permit	Revere Zoning Ordinance	Will be required if any of the proposed structures, signage or features of the Project do not comply with the zoning by-law,
Revere Department of Public Works	Water and/or Sewer Connection Permits		Required to connect into municipal sewer or water service
Revere Site Plan Review Committee	Site Plan Review	Zoning Ordinance Chapter 17.17	Site Plan Review is required for all new construction projects over 1,000 gross square feet of building area.
State			
MA DEP	Order of Conditions-Wetland Protection Act	310 CMR 10.00	Required for any disturbance in tidal wetlands or within 200 feet of a Riverfront
MA DEP	401 Water Quality Certification	314 CMR 9.00	Should dredging or activities which could impact surface-water quality occur within the River.
MA DEP	Chapter 91 License	310 CMR 9.00	For dredging or structures that could occur between current and/or historical high- and low-tidelands both public and private. .
MA DEP	Uniform Hazardous Waste Manifest	31 CMR 30 and MGL 21E	Handling, transporting and disposing of hazardous materials should they be encountered during the project

MA Environmental Policy Act (MEPA)	Environmental Notification Form, Draft Environmental Impact Report, Final Environmental Impact Report	301 CMR 11.00	Should any of the review thresholds under Section 11.03 be triggered, such as state-listed endangered species present, alterations requiring a variance under the Wetland Protection Act, alterations of bank or salt marsh above thresholds
MEPA	Environmental Notification Form, Draft Environmental Impact Report, Final Environmental Impact Report	301 CMR 12.00	Work within a designated ACEC
MEPA	Environmental Notification Form, Draft Environmental Impact Report, Final Environmental Impact Report	950 CMR 71.00	Work affecting historical properties and places as identified by the Massachusetts Historical Commission
Federal			
U.S. Army Corps of Engineers (ACE)	Clean Water Act 404 Permit	33 USC 1251, 33 CRF 322	For discharge of dredged or fill material into waters of the United States
U.S. ACE	Rivers and Harbors Act of 1899 Section 10	33 USC 401-413, 33 CFR 323	For work, including structures, seaward of the annual high-water line in navigable waters of the United States
Federal Emergency Management Agency	Floodplain determination	Executive Order No. 149	The National Flood Insurance Program is administered in Massachusetts by the Departments of Conservation and Recreation. Requires review by applicable state agencies for projects within the Floodplain
U.S. Fish and Wildlife	Incidental Take Permit	50 CFR 17.00	Any project that "*takes*" federally defined endangered or threatened species
U.S. Environmental Protection Agency (EPA)	Permit under the National Pollutant Discharge Elimination System (NPDES) program	40 CFR 122	Construction activities disturbing greater than one acre of land will require coverage and authorization to discharge stormwater under the NPDES program administered through the EPA

Connection to the Surrounding Areas

The vicinity surrounding the Study Area has historically been relatively isolated, accessible only from southbound traffic on Route 1A and with no real connection to the properties and development to the north. That status is changing and the area surrounding the subject property will look very different in the coming years. The primary off-site project in development at this time, which is located on the northern adjacent property to the Gibson Park property, is the Gibson Point Project which is a fully-amenitized 291-unit multifamily, ground-up development located on the current G&J Towing site, the former infrastructure of which has now been demolished. This development project, along with the housing units it will provide, will also include numerous exterior amenities to enhance the overall livability of the area including outdoor gaming and landscaped areas, a potential kayak launch, and a wraparound boardwalk out to Gibson Point.

Gibson Park and the G/J Towing site are completely disconnected as a result of the location of the sweeping Route 1A southbound ramp that divides these two sites from the Point of Pines and to a small extent, the Riverside neighborhood. Gibson Park is only safely accessible to motorists through the contiguous Riverside neighborhood; while access from the adjacent Point of Pines neighborhood is more complicated. In addition, the G/J Towing site has no direct access from Revere to the south and only one point of access from the north via the Whitin Road Extension, which is expected to be eliminated when the new General Edwards Bridge is constructed.

From the collaborative consultation among transportation and development representatives of the City of Revere, and civil and traffic engineers from MassDOT and Redgate teams (the developers of Gibson Point), the option emerged of a reconfigured southbound on/off-ramp network that would incorporate small-radius traffic roundabout. That combination would provide multi-modal northbound and southbound links from all of Revere to every element of the RiverFront district (which includes Gibson Park and Gibson Point), while correspondingly reducing adverse traffic impacts on the Riverside community.

This approach has the additional advantage of recovering a large portion of the now inaccessible infield of the current loop ramps system for community use; and most importantly, all these transportation improvements can be made before the new bridge is funded, designed and constructed. This plan is preliminary and will need to be refined, designed, permitted and funded.

One factor that will affect all of the potential redevelopment options in the Study Area is the planned replacement of the General Edwards (GE) Bridge which brings Route 1A/North Shore Road across the Saugus River in between Revere and Lynn. MassDOT is undertaking a study to evaluate potential future improvements including the replacement for the GE Bridge – which includes raising the elevation and eliminating the draw bridge that is currently utilized to provide free navigation for vessel traffic.

The rebuilding of the GE Bridge will require changes to the ramp interchanges (north and southbound) and other street access points to meet new roadway grades. The higher profile of the planned new fixed-span bridge would result in a more southerly "*landing point*" for traffic in Revere.

On the negative side (which would be more temporary impacts) would be the noise, traffic and activities associated with the construction/replacement of the bridge. Since the project is still in the early stages

of study and planning, there are few details of its design; however, there is the potential for temporary bridges to divert traffic, which could bring it closer to the study area and significant barge and heavy equipment traffic within the Saugus River itself, all of which would temporarily take away from the passive recreational attributes of the proposed project components.

Since the GE Bridge replacement project is still in its early stages, it provides an opportunity and is important that the City remain active in the planning and understanding of how the bridge-replacement project will be developed to better plan for and mitigate impacts from the project components proposed for the Subject Property and the surrounding area.

Another project under consideration and design by the City includes the refurbishment of a dilapidated pier located to the north of the subject property, which is a former railroad bridge trestle. Potential uses of this pier include fishing, bird watching and other passive uses. The City is also considering utilizing the pier for other water-dependent uses such as supporting chartered fishing vessel and ferry service operations. These types of future operations would require the pier and the Gibson Park project to be fully integrated so as to provide for parking and user access at and through the Gibson Park property to support higher-use water dependent uses.

The combination of the City's Gibson Park project (including the Gibson Park facility, the Boatworks project and the Mills Avenue alignment), the Gibson Point project and the Pier project will result in a wonderful and fully integrated redevelopment project for the residents of the Riverside neighborhood, while also providing resiliency protection from ever increasing storm-surge and rain-fall flooding events. The Gibson Park project is the keystone to the City's vision for the area by providing walkways, a fishing/nature pier, a destination/launching point for a 1/3-mile riverwalk passing amongst two tidal rivers re-established salt marshes which will allow the public to connect with recreational opportunities and the Riverside neighborhood.

Design Components

The project includes many significant design components, all aimed at addressing the various issues and project goals set forth for this project. The methodology of how they were developed is discussed later, and the list below provides details on the key components that will be implemented at Gibson Park.

Subsurface Storage/Infiltration Chambers

The project includes four different subsurface storage chamber systems designed to retain/detain/infiltrate runoff as conditions dictate. The total system provides over 92,000 cf of storage which is over 2.1 acre-feet of storage.

Subsurface Chamber System (SCS) 1 - Three rows of four Cultec C4HD Chambers – This system, installed on six inches of crushed stone and surrounded on all sides by 12 inches of crushed stone, provides 427.5 cf of storage volume. The primary catchment area contributing to this best management practice (BMP) is the Boatworks property/Future Community Boating Building. The BMP is equipped with an overflow for larger storm events that will allow it to connect into the reconstructed outfall pipe at the southern end of Gibson Park.

SCS-2 – Eight rows of eight Cultec C4HD Chambers –This system, installed on six inches of crushed stone and surrounded on all sides by 12 inches of crushed stone, provides 2,060.8 cf of storage volume. The

primary catchment area contributing to this BMP is the new parking area servicing the former Boatworks property and the relocated tennis courts. Pretreatment is provided through the raingardens at the edge of the parking and court.

SCS-3 – Eight rows of 10 Cultec Recharge R-180 Chambers - This system, installed on six inches of crushed stone and surrounded on all sides by 12 inches of crushed stone, provides 3,054.7 cf of storage volume. These systems serve as a retention buffer for the pump system for the large rainfall events and will not provide any recharge/groundwater infiltration due to their lower profile. The primary catchment area contributing to this BMP is the re-graded and re-piped drainage network along Mills and Thayer Avenues.

SCS-4 - 64 rows of 35 Cultec Recharge R-180 Chambers - This system, installed on six inches of crushed stone and surrounded on all sides by 12 inches of crushed stone, provides 86,697.9 cf of storage volume. This system located underneath the multipurpose field, is intended to provide offline storage of major rainfall events during the higher end of the tidal cycles and also to provide groundwater recharge. Due to the ability to service the area with gravity, the system will be serviced by the dual duplex stormwater pump system.

Dual Duplex Stormwater Pump system

The Riverside neighborhood sits at a lower topographic elevation than Gibson Park and given the need for subsurface collection and conveyance infrastructure to move runoff from the neighborhood and to provide offline storage system, gravity will not work for stormwater conveyance purposes as the system would eventually run into the groundwater table. In order to convey stormwater effectively and efficiently to the SCS-4 chambers through the various storm system components, the proposed Gibson Park system is designed with dual duplex pump system. This includes low flow pumps with a target pump rate of 100 gallons per minute (gpm) at eight feet of total dynamic head, and high flow pumps with a target pump rate of 1,000 gpm at eight feet of total dynamic head. The system is designed as a duplex system, meaning there will be two of each pump type, allowing the pumps to alternate use which will reduce pump fatigue and provide a backup in the form of double pump capacity.

Raingardens

Raingardens function as soil and plant-based filtration devices that remove pollutants through a variety of physical, biological, and chemical treatment processes. The Raingardens included in this design will utilize a bioretention system consisting of a soil bed planted with native vegetation, all located above an underdrain gravel layer. Stormwater runoff entering the Raingarden system is filtered through the hardwood bark mulch layer and then the bioretention soil mixture before being collected and then conveyed downstream by the underdrain system. Runoff storage depths above the planting bed surface are less than six inches. Bioretention systems are used to remove a wide range of pollutants, such as suspended solids, nutrients, metals, hydrocarbons, and bacteria from stormwater runoff. They will also reduce the peak runoff rates and increase stormwater infiltration when designed as a multi-stage, multi-function facility.[5]

As part of this project, raingardens are being implemented in three areas including: 1) the southeastern corner of the Boatworks property, which is over 1,500 sf of surface area; 2) in the northwestern corner

[5] New Jersey Stormwater Best Management Practices Manual, February 2004, Chapter 9.1, “Standard for Bioretention Systems.”

of the Boatworks property's parking area, which is over 390 sf of surface area; and 3) to the west of the relocated tennis courts, which is over 1,300 sf of surface area.

Bioswales

Simultaneously functioning as a means of stormwater conveyance, as well as a means of providing water-quality treatment, bioswales are proposed for installation throughout the project area. The proposed bioswales will increase hydraulic retention time and promote recharge and filtering of stormwater prior to release to the main treatment BMPs. Because of the shape, planting and mulch associated with these landscaped beds, they will retain runoff for longer periods of time. These are intended to act as pre-treatment stormwater BMPs and will allow for settlement of suspended solids prior to discharge.

The largest bioswale for this project will be installed to the east of Hayes Avenue and the existing parking area. These bioswales will convey stormwater runoff away from the impervious areas, providing filtering and infiltration. The bioswales are equipped with overflow grates for larger storm events that would overwhelm the bioswales – note that even in this case, the bioswales would provide pretreatment of early-event/first flush stormwater runoff.

As noted in other parts of this report, native vegetation is proposed within the park including within the raingardens and the bioswales. Proposed plantings include American Beachgrass, Big Bluestem, Purple Love Grass, Switchgrass, Saltmarsh Cordgrass, Little Bluestem, Pink Tickseed, Showy Aster and Sweet Goldenrod. The mixed planting will provide bank stabilization, seasonal color, texture and fragrance throughout the year as well as habitat and food sources for pollinators and wildlife.

Enhanced/Restored/Created Salt Marsh

Salt marshes are coastal wetlands that are constantly flooded and drained by salt water brought in by the tides. These intertidal habitats are essential for healthy fisheries, coastlines, and communities—and they are an integral part of the Commonwealth's and City's economy and culture. They also provide essential food, refuge, and/or nursery habitat for more than 75 percent of fisheries species, including shrimp, blue crab, and many finfish. Salt marshes also protect shorelines from erosion by buffering wave action and trapping sediments. They reduce flooding by slowing and absorbing rainwater and protect water quality by filtering runoff, and by metabolizing excess nutrients.

This project includes salt marsh work in two areas, in the north near the Gibson Point Project and to the south near the Boatworks property revetment. In the north, the project proposes creating/restoring 9,200 sf of low marsh area and 14,000 sf of high marsh/marsh migration area. This work will be accomplished by removing invasive phragmites and regrading to allow for better flushing and more movement of water. The southern salt marsh area included 2,700 of restored high marsh and marsh migration area through phragmites removal, regrading, and planting with native vegetation.

Living Shoreline Creation

A living shoreline is a protected, stabilized coastal edge constructed with natural materials such as plants, sand, or rock. Unlike a concrete seawall or other hard structure, which impede the growth of plants and animals, living shorelines promote vegetation and shellfish growth over time. These

shorelines are resilient against storms and with the reef sill, protect from erosion and allow sediments to collect behind the sill, which allows for the shorelines to grow vertically in response to rising sea levels.

This project proposes to install 250 linear feet of shoreline sill near the northern salt marsh and 110 linear feet of shoreline sill for the southern salt marsh. The living shoreline sill will be constructed through the implementation of a proprietary substrates, specifically designed and fabricated for the development of a living shoreline. The proprietary materials, provided by GROW Oyster Reefs, LLC, include reef tiles which are biomimetic calcium carbonate aquatic ecosystem restoration substrates that can jumpstart and protect the living shorelines by attenuating wave energy, restoring the seabed, balancing pH and sequestering carbon. These materials are composed of naturally occurring materials and do not merely represent dumping concrete elements into the waters.

GROW Oyster Reefs' biomimetic reef substrates are modular and mimic nature in their form, material, and performance. Their complex configuration and enhanced surface characteristics provide a haven for the embryonic oyster, supporting the oysters' reef-building capacities. This project does not propose seeding with oysters, rather with ribbed mussels, per our conversation with the Division of Marine Fisheries, and as discussed in the Alternatives Analyses. They are fabricated using a proprietary $CaCO_3$ concrete mix, 85% calcium carbonate, formulated to closely resemble the mature oyster/mussel shell, producing an attractive chemical environment for shellfish growth; providing a porous infrastructure with interstitial spaces at many scales, designed to facilitate the long-term recruitment and survival of embryonic shellfish, and the rapid recruitment of non-reef building organisms from crabs to young fish, protecting the shellfish from larger predators.

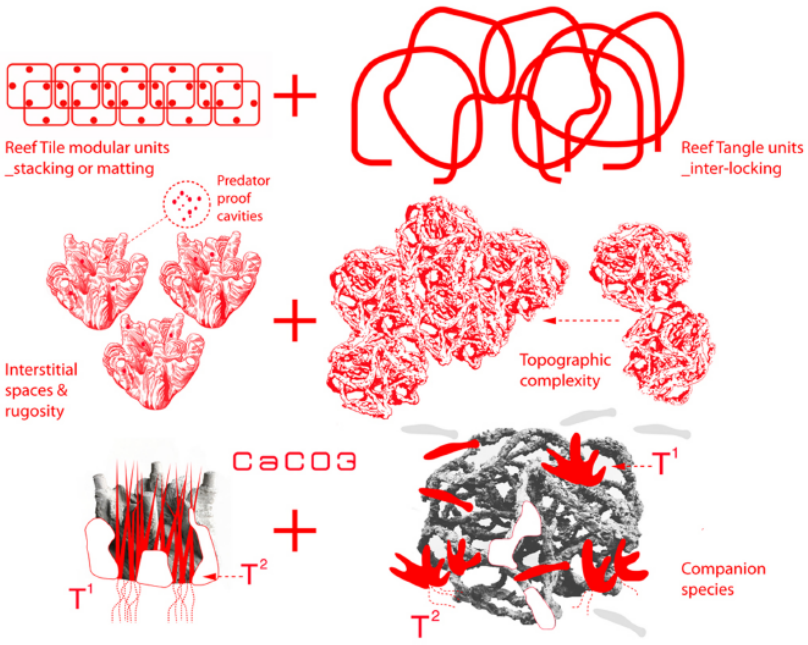


Figure 19 GROW Oyster Reef Products

GROW Oyster Reefs' products provide complex interstitial spaces and surface indentations that protect the shellfish and allow them to thrive by slowing the water flow through the substrate and dampening wave energy. Carefully configured cavities reduce the volume and embodied energy of the concrete form and provide an array of niches for compatible species of sea creatures and plants. Co-designing with shellfish, GROW concrete reef substrates are based on the principle that a kinship can be facilitated that allows the substrate to be used as a catalyst for the construction of a reef form that is responsive to the hydrodynamic and topographic context, stimulating the shellfishes' innate reef-building capabilities, allowing the organisms to form the self-healing, connective complexity of a native reef.

GROW reef building materials provide suitably scaled openings, designed into the substrate, facilitating the inclusion of seagrasses and other marine plants. This results in increased wave attenuation and biodiversity, results in a hybrid "*blue carbon*" vegetated marine habitat, provides for localized mass burial of excess organic carbon and plays an important role in mitigating the build-up of atmospheric CO_2.,

Removal of Invasive Species

Portions of the study area, particularly along the northern shoreline, are dominated by common reed, *Phragmites australis*. This reed, often referred to as Phragmites or Phrag, is widely regarded as an indicator of disturbance and subsequent impairment of ecological functions and values. The robust growth form of common reed crowds out virtually all other plant species and diminishes the habitat value of an area. In many instances, a dense mat of rhizomes and dead and decaying plant material builds up, raising the level of the marsh surface, further restricting tidal flow and freshwater run off, and increasing the areal extent of common reed onto the marsh surface.

This project involves a significant amount of Phragmites removal, down through its root zone, along with post-construction monitoring to ensure that the phragmites do not re-establish. The areas where the phragmites are being removed will be replanted with native, coastal species.

Expanded Parking

The expansion of Gibson Park and the development of the former Boatworks property allows for the creation of an additional 21 parking spaces for Gibson Park, bringing the total parking available to 56 parking spaces available at the park, including 4 accessible spaces, two at Gibson Park and two at the Boatworks.

Relocated and Improved Park Features

The repurposed park will retain some of its most popular features including playground, tennis courts and a community garden, and will also add in new public amenities such as the multi-purpose field, pickleball courts, high mast lighting (to allow for more nighttime sports activities), and expanded walking paths with educational signage.

The proposed park layout will improve public access to the Riverfront by creating pedestrian and bicycle connections with the adjacent Riverside and Point of Pines neighborhoods. Proposed pathways throughout Gibson Park create a third of a mile loop connecting the numerous sports fields and open space amenities. Waterfront walks, boardwalks and overlooks over new salt marshes offer views of the Saugus River, Rumney Marsh and downtown Boston skyline in the distance and access with a future public pier which extends out into the Saugus River near the 1A bridge.

Native vegetation is proposed within the park and on the vegetated slopes along the water's edge. Proposed plantings include American Beachgrass, Big Bluestem, Purple Love Grass, Switchgrass, Saltmarsh Cordgrass, Little Bluestem, Pink Tickseed, Showy Aster and Sweet Goldenrod. The mixed planting will provide bank stabilization, seasonal color, texture and fragrance throughout the year as well as habitat and food sources for pollinators and wildlife.

Elevated Walkway

The project includes over 900 linear feet of elevated, pile supported timber walkway that will allow residents and visitors access out over the marsh, while protecting from unauthorized access and creating a connection to the neighboring properties. Once fully built out, the walkway will be a vital corridor creating over 1/3 mile of waterfront/riverside walking paths connecting the Riverside neighborhood to the north of Gibson Point where the Saugus River flows and potentially a redeveloped municipal pier could exist.

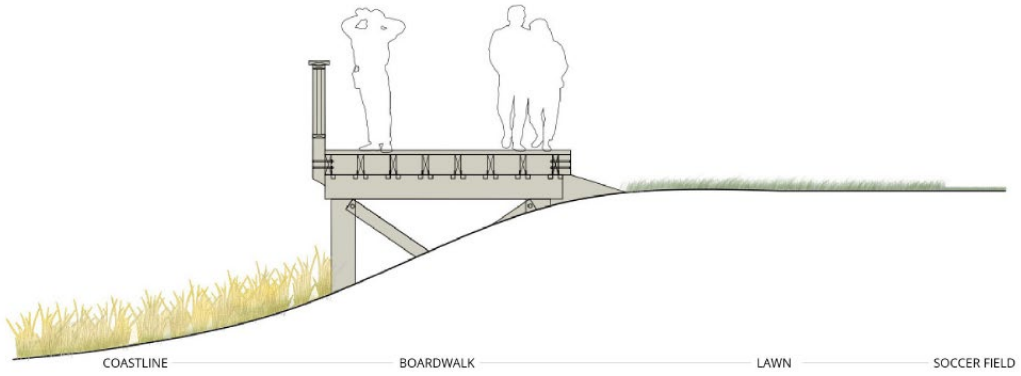


Figure 20 Rendering of Walkway along edge of Field

Rebuilt Revetment Wall

The former Boatworks property currently has several shoreline structures that are in disrepair, including a timber bulkhead and a rip-rap revetment. Those dilapidated structures provide very little flood-water protection and are often overtopped or bypassed and allow an easy pathway for storm surge waters to enter into the neighborhood. As part of this project, the revetment wall spanning the length of the parcel will be rebuilt to provide better protection for the neighborhood and connect topographically with the other flood/storm surge protection features being developed in this project at Gibson Park and along Mills Avenue alignment.

Gangway and Floating Dock

The City has envisioned the former Boatworks building will be redeveloped into a community boating facility focused on rowing and kayaking activities. In order to provide water access for people carrying their non-motorized "vessels" down to the water, the project includes a gangway down to a floating dock system in the Pines River that will extend out far enough to avoid bottoming out, as much as feasible (to be verified by a bathymetric survey).

Mills Avenue and Thayer Avenue Drainage Infrastructure

In order to convey stormwater runoff away from the Riverside neighborhood, this project includes the upgrade of selected components of the existing stormwater management infrastructure and re-grading portions of Thayer Avenue. These infrastructure upgrades include the installation of two deep-sump catch basins, two drain manholes, and 200 linear foot 12-inch diameter Class V Reinforced Concrete Pipe (RCP) pipe.

In an effort to minimize the disturbance to the Riverside neighborhood, most of the infrastructure work is limited to the northern part of Mills Avenue and Thayer Avenue. The existing infrastructure on Hayes Avenue and further to the south will remain in place and continue to function; however, the upgraded infrastructure in Hayes Avenue will be equipped with a "*relief valve*" for the associated infrastructure. The relief valve will function to allow excess stormwater and/or high-tide waters, to be conveyed through the pipe and manhole network into the new infrastructure feeding the pump chamber, thereby limiting the potential for surface ponding associated with overtaxed stormwater infrastructure.

Standby Generator

As the stormwater management system is intended to function during extreme storm events to dissipate and mitigate flooding issues, there is a real potential that the system could fail due to a temporary loss of power. In order to maintain system operationality, the project includes the installation of a standby generator to power the pumps. The generator will be a 100KW/125KVA 120/240, single phase, 30 kW diesel-fueled generator enclosed in a sound-attenuated, weatherproof enclosure.

Upgraded Lighting

As part of the park improvement upgrades, additional lighting is being installed to allow for activities in expanded hours in a safe manner. The project includes 13, dark sky compliant poles/fixtures provided by Musco Lighting, a leader in sports-field lighting.

Vegetated Storm Surge Protection Berm

In order for the stormwater/precipitation management system to function as intended, it is absolutely critical that storm surge waters from the Pines River be kept out of the system to the maximum extent feasible. The rebuilt revetment wall at the Boatworks property and the grading modifications at Gibson Park will keep storm surge/high tides out of the northern portion of the study area; however, the relative shallow profile of the shoreline of Mills Avenue alignment results in an easy pathway into the neighborhood for those high-tide and storm-surge waters. While the original MVP study for the study area recommended an upgraded sea wall to provide the projection, that is a major undertaking in terms of design, permitting and construction, and will take and minimum several years to complete. As a shorter-term measure (e.g., to provide a 10-year horizon protection), this project is proposing a beneficial reuse of materials excavated from Gibson Park to be placed within geotextile bags in a berm formation and vegetated. The target elevation of this vegetated berm will be elevation 11 NAVD (16.2 MLLW) , approximately three feet higher than current grade, and will protect up to the projected 2030 MC-FRM 10-year storm event. This berm will be vegetated with native, coastal flora with deep roots to reinforce the berm. This berm will in part replace the existing wooden post and guardrail system and would require new granite curbing along the edge of Mills Avenue to protect the berm during snow-removal operations by the City. In order to maintain current access points, small, concrete wingwall

access points will be constructed to create a rectangular geometry that would allow the City DPW to use either flashboards or deployable barriers in advance of a storm/high tide event.

Figure 21- Existing View down Mills Ave and Rendering of Vegetated Berm

Design Methodology and Governing Standards

The following provides MMC's design strategies and methodologies as well as thew regulatory/governing standards including, federal, state and local jurisdictions.

Proposed Resiliency and Flooding Interventions for the Project Study Area

The location, topography and hydraulics of the study area leaves it very vulnerable to natural, weather-related events such as storm surge, heavy rainfall events and tidally-influenced flood events – all of which are anticipated to occur much more common in response to global climate change. While the original MVP study focused on a wider, more large-scale strategy to make this portion of the City more resilient, there are several smaller-scale strategies which would effectively increase the resiliency of the study area. The intervention measures included in this design report will provide several years of protection from anticipated impacts (e.g., sea-level rise, increase storm intensities, etc.) and can be implemented more rapidly than the larger-scale MVP strategies.

In a light of a regional approach being developed and the desire not to negatively affect other parts of the City just to protect the study area, the design team has developed targeted interventions to reduce the impact of extreme events, ameliorate existing flooding conditions, and promote natural features best equipped to provide a resilient shoreline located adjacent to the western boundary of the Riverfront neighborhood including Gibson Park, the Boatworks property and the Mills Avenue alignment. These resiliency and flood improvements strategies are as follows:

Decreasing the Tributary Area to the Riverside Neighborhood/Study Area

In order to allow southbound vehicles to access the Point of Pines neighborhood (an adjacent neighborhood to the study area), North Shore Road was elevated to the east of Gibson Park and slopes down into the Riverside neighborhood at John Avenue . South of the underpass, there is a large

embankment that slopes down to meet the grade level at Hayes Avenue. While this embankment is vegetated and does not contribute runoff as an impervious (paved) area would, it still represents approximately 14,000 sf of tributary drainage area to the Riverside neighborhood and the study area. One of the stormwater intervention measures proposed as part of this study is to remove the North Shore Road stormwater flow from the study area's tributary area by installing a bioswale along the base of the existing roadway embankment. The bioswale would be designed to direct stormwater flow to the north towards new infrastructure that will be installed on the Gibson Park Property. A bioswale (also commonly referred to as a vegetated drainage swale) is a vegetated, low-lying feature that provides a natural feel to stormwater management and provides some water-quality treatment, in addition to its runoff conveyance capabilities. Further, the vegetation increases the amount of evapotranspiration (water taken up by the plants and evaporated off) which further reduces the amount of stormwater which must be addressed by the remainder of the system. By removing this 14,000 sf of tributary area associated with North Shore Road, the drainage tributary to the northern part of the Riverside neighborhood and the study area is reduced by six percent.

Tide Gates and Backflow Prevention

The outfalls in and around the study area are tidally influenced, meaning that at higher ends of the tide cycle, the inverts of the outfalls are submerged. This results in the following: 1) the outfalls do not work as there is no differential "*head*" driver; and 2) they can actually act as conduits to flood associated upland areas. In 2015, the City upgraded some of the outfalls in the Riverside neighborhood with in-line check valves to prevent the high-tide waters from rising back up through the stormwater abatement system. During meetings associated with the public-outreach process, neighborhood residents raised issues regarding the performance of these check valves that will need to be investigated by the City. The outfalls pipe(s) for the Gibson Park property network appears to be partially crushed and/or the inverts are not equipped with tide gates. As such, there are currently no tidal controls protecting the stormwater outfall inverts in a large portion of the study area.

As part of the City's overall stormwater management strategy, the inverts of all outfalls will need to be verified to ensure the presence and functionality of tidal/backflow controls. This is a critical work-flow component as the uplands stormwater management systems are not designed for, nor do they have the capacity, to handle tidal flood waters flowing into the areas via the invert(s). A second work-flow component will be to work with City engineers to evaluate what type of tidal controls have worked well, have not performed to expectations or have proven to require excessive maintenance.

Installing a Pump Station

The relatively low-topographic profile of the study area, particularly in the southern part near the intersection of Thayer and Mills Avenues, results in a challenge to efficiently and effectively move storm-related water (versus tidal/storm surge waters) away from areas that currently experience inundation to new stormwater management structures to be installed on the Gibson Park property. The Project team are proposing to take advantage of the existing topographically low area of the Boatworks property to install a stormwater pump chamber. The installation of the system in an existing topographically low-lying area avoids the requirement to create shallow-sloped conveyance structures that could result in maintenance challenges, could experience operation issues or failures, and would be more cost effective

and have a higher possibility of issues or failure. Use of stormwater pumping stations is a proven flood intervention measure and the City has over 30 such systems in service, with the closest one located near Rice Avenue in the Point of Pines neighborhood.

Providing Subsurface, Off-line Storage Capacity

One of the primary issues in developing the stormwater management strategy in coastal Massachusetts communities is addressing runoff during the higher ends of the tide cycle in adjacent surface waters when the outfalls cannot discharge, whether or not if that are equipped with a tidal gate. In order to address this issue, a state-of-the-art stormwater intervention system has been designed to provide off-line subsurface storage of stormwater runoff underneath the multi-use fields. This system will detain, and possibly infiltrate, the runoff waters during the higher end of the tidal cycle and then continue to recharge in the subsurface, as well as discharge into the Pines River as the tidal cycle enters lower phases. This controlling of stormwater to coincide with the tidal cycles of the Pines River will significantly reduce the potential for flooding in the study area.

The subsurface storage chambers would be installed on top of a bed of crushed stone (typically 6-inch minus). The chambers are commercially available in various sizes, configurations, and materials, from plastic to concrete. Massachusetts stormwater regulations typically require recharge a targeted volume based on the underlying soils, which for this project is 0.35 inches per tributary impervious area. That provides well over two acre-feet of recharge area, far exceeding the requirements.

Moving and Managing Stormwater Away from the Riverside Neighborhood

The proposed subsurface, stormwater storage system will provide a significant amount of flood-storage capacity and relief to both the Gibson Park property and the northern part of the Riverside neighborhood in the vicinity of both the Boatworks property and the Mills Avenue alignment. However, there is the challenge of how to convey the stormwater from the neighborhood to the storage system which will be located on the Gibson Park property. The existing stormwater infrastructure in the neighborhood consists of a classic catch basin-to-pipe-to-manhole-to-outfall network. The outfall inverts, which discharge to the Pines River, are located at the intersection of Mills Avenue and John Avenue, and to the north of the intersection of Mills Avenue and River Avenue. The inverts for both of these outfalls are located at an elevation below the high-tide line and are submerged during the higher end of the tidal cycle. As such, during periods of high tide, rainfall runoff accumulates in the catch basins and pipe network and have nowhere to discharge (as the inverts are underwater) which results in system backups. These backups result in flooding of the streets once the storage capacity of the pipes is exhausted. Installing new infrastructure to redirect the runoff directly to the pump chamber (which will convey stormwater to the storage field) would be very costly, disruptive, and require excavating/repairing the majority of the streets in the northern part of the neighborhood. Also, at the lower end of the tide cycle, the existing network has sufficient capacity to address a design storm and does require upgrading. Therefore, to provide additional capacity only during periods when stormwater flooding is a risk, the Project team is proposing to install a "*relief valve*" in the existing catch basin and pipe network. This strategy would take advantage of the existence of a second underutilized system consisting of a catch basin located along the southeastern end of Thayer Avenue. This second system is essentially the second-in-line of the catch basin and pipe network that collects runoff from the neighborhood and ultimately discharges to an outfall located at the extension of John Avenue at Mills

Avenue. The proposed "*relief valve*" would include tapping into the second system catch basin and installing a new pipe outlet at an elevation above the invert of the existing outlet pipe – this would allow the second system to operate independently during normal times. The outfall of the new, higher-elevation invert pipe would eventually convey the stormwater to the off-line storage chambers located on the Gibson Park property. This intervention measure would allow the second system to be utilized to its maximal capacity and if storm/tidal conditions result in overloading the system, the excess stormwater would discharge into the pipe chamber, which would then, in turn, be conveyed to the system located on the Gibson Park property. This solution minimizes disturbance to the neighborhood roadways, fully utilizes the existing stormwater network, and provides a mechanism for runoff generated during high-tide periods to be conveyed to and addressed by to the subsurface, off-line storage area.

Reducing Impervious Areas and Promoting Recharge Through Pervious Surfaces

Another effective stormwater management strategy is to reduce the amount of surface runoff that is generated during stormwater events. Impervious areas, such as asphalt pavement, hard-packed gravel and concrete, have very little capacity to store and retain water and result in the most amount of surface runoff during a rainfall event – further, as they are not vegetated, there is no associated evapotranspiration. Reducing the amount of these impervious and hard-packed gravel areas will reduce the volume and velocity of runoff generated from these surfaces and result in infiltration of a portion of the resultant runoff.

The entire Boatworks site, from years of boat work and heavy equipment traffic, is dominated by hard packed gravel that acts as an impervious surface. This project proposes to convert over 36,000 sf of impervious area to vegetated permeable surface, representing a 29% reduction in the total impervious area coverage for the project study area (both the Boatworks and Gibson Park site). This will significantly reduce the amount of surface runoff generated from each storm event.

Providing Water-quality Treatment for Stormwater Runoff

While most of the strategies and interventions discussed thus far have dealt with addressing flooding or stormwater volume issues, water-quality issues associated with runoff should also be considered and addressed. Between storm events, nutrients, oils and sediments can build up, particularly on impermeable roadways and parking lots. The "*first flush*" (i.e., first surface waters associated with a precipitation event) of runoff from impervious surfaces can have a deleterious effects associated with entrained contaminants on the waterways to which they discharge. Typically, surface waters associated with later portions of a storm event are much "*cleaner*" and do not contain entrained contaminants. Water-quality treatment strategies can be designed to capture and control contaminants in the runoff associated with the first flush of a precipitation event prior to discharge into an associated waterway. Selected treatment strategies proposed as part of this project include the implementation of a bioswale along the bottom of the embankment from North Shore Road along Hayes Avenue and several raingardens strategically placed throughout the Study Area. The off-line storage area to be installed underneath the multi-purpose athletic field also provides first-flush, stormwater treatment.

Bioswales, or grassed channel biofilter swales, are stormwater treatment and conveyance best management practices (BMPs) that provide longer hydraulic residence time than typical drainage channels. The longer hydraulic residence time allows for sediment to settle out prior to discharge to the final treatment BMP (such as a raingarden).

Raingardens are a bioretention technique that effectively utilize soils, plants, and microbes to treat stormwater. These are typically shallow depressions (i.e., six-to-nine-inches deep) to allow for some ponding in low lying sculpted areas that are filled with a specific soil media (sandy with some mulch and organic material), that are then mulched and planted. They are aesthetically pleasing, appearing as a planting bed, but function as the soil media and the plant roots treat and uptake nutrients present in the runoff. According to the MA DEP Stormwater Policy,[6] they are effective at removing at up to 90 percent of total suspended solids (with pretreatment) 30 to 50 percent total nitrogen, 30 to 90 percent total phosphorus, and 40 to 90 percent metals. The treated groundwater is then typically addressed by evapotranspiration, recharge and/or discharge.

Sculpting the Landscape

Storm surge from the Pines and Saugus Rivers also contributes a significant amount water and flooding to the study area. Erecting a seawall would be an effective solution to minimize storm-surge and high-tide related flooding. This is a large-scale intervention strategy that will be explored as part of the MVP and other regional planning process. A smaller-scale effective strategy proposed as part of this project includes performing targeted landscape sculpting including raising some areas and lowering others to result in a continuous "*high topographic area*" to prevent flooding of river waters associated with storm surges and/or high-tide periods. Raising the elevation of selected continuous areas would provide protection to associated upland areas, while lowering other areas would create new salt marsh which could provide storm-surge storage in a manageable manner. This strategy would provide some targeted protection, while providing a net-zero fill on a small scale, and; therefore, would not result in flooding of other nearby vulnerable areas.

Expanding and Developing Salt Marsh and Living Shorelines

Salt marshes are a type of naturally occurring, coastal wetlands formed along tidal channels, behind barrier beach and dune systems, and in other low-lying areas subjected to tidal inundation. Salt marshes provide beneficial habitat for many species of fish, shellfish, birds, plants and other species. For Master Planning purposes, salt marshes provide a significant storm-surge flood protection benefit. Salt marshes are known to help control flooding, protect shorelines from storm damage, improve water quality in coastal waters by filtering out sediment and nutrients, and provide recreational and educational opportunities. According to the Rumney Marsh ACEC Salt Marsh Restoration Plan (SRMP)[7] "*Salt marshes help mitigate these impacts by storing and attenuating storm flows, thereby promoting sediment deposition, stabilizing and protecting shorelines, and maintaining nutrient and carbon exchange*."

[6] 2008 MA DEP Stormwater Policy, Volume 2 Chapter 2, Pages 23-35

[7] Massachusetts Wetland Restoration Program and MA DEM ACEC Program ,May 2002

This project proposes to protect, expand and create new salt marsh areas along the waterfront throughout the study area. The increased salt marsh area will create improved flood-storage and storm-surge benefits, and be consistent with many of the goals of the Rumney Marsh ACEC SRMP, including:

- Continue efforts to discover as yet unknown (or previously unidentified) salt marsh restoration opportunities which could provide further ecological benefits to the ACEC.
- Use projects to educate the community regarding wetlands and wetland restoration.
- Increase noninvasive public access to the ACEC.
- Protect existing salt marsh from encroaching development.
- Protect existing salt marsh from new and existing sources of pollution.

Another strategy being proposed as part of this Project is to create more living shoreline components where possible along the shoreline of the study area. Living shorelines are essentially more natural "*softer*" shoreline interventions in lieu of harder ones such as concrete seawalls and steel bulkheads. These strategies, when designed and sited correctly, can provide a stable shoreline and/or slope transition from the waterway to the upland that is natural and can have other ecological benefits such as habitat creation/preservation or sediment retention. Some of the shoreline areas along the Pines River, which is not subject to heavy wave action (relative to other coastal locations), are good candidates for these living shoreline intervention measures.

Proposed Waterfront Infrastructure Improvements for the Project Study Area

In an effort to expand public access to the water and wetlands eco-spaces, there are improvements proposed as part of this Project, as well as several other interventions and improvements that will create a better connection for area residents to the watersheet.

As discussed in other sections of this Project, the Boatworks property is being fully incorporated into the Gibson Park study area and will provide additional parking, recreational and stormwater management spaces for the overall RiverFront area. The western portion of the Boatworks property has been selected as the portion of the property which will be subject to this waterfront infrastructure redevelopment project. The existing on-site building structure has not been formally evaluated to date; however, based solely on brief visual inspections, upgrades and improvements will be needed to provide a more solid structural and resilient facility. Based upon initial discussions with the City and a feasibility study conducted in the winter of 2022, the adaptive re-use for the storage and use of non-motorized crafts such as skull and kayaks appear to be a good option for the structure. Design of such a sustainable-use facility would be conducted under a separate contract.

Under the envisioned redevelopment scenario, the existing revetment wall that is currently in a state of disrepair will be rebuilt, most likely with additional rip rap and stone, although use of greener materials will be evaluated. Based upon initial planning efforts, the revetment wall would be rebuilt to a height of 11-feet amsl to provide storm-surge protection for the Boatworks property up to original elevation, and to match surrounding elevations that will be protective of river-water flooding associated with storm surges and/or high-tide events. This is the current design elevation height for the entire project including the Gibson Park property and the Mills Avenue alignment.

A landing pad, gangway and floating docks, which would be used for the community rowing programs, would be installed at the southwestern portion of the Boatworks property. The gangway would extend out to the floating docks that would sit in a minimum of 18 inches of water even at the lower end of the tide cycle. The floating docks would be oriented parallel to shore to allow for easier launching of the sculls directly into the river.

Those two infrastructure projects would greatly improve public access to the watersheet, promote healthy outdoor recreational opportunities, and reconnect the area to its natural resources. They would also be fully resilient and sustainable in nature.

Mills Avenue Storm Surge Berm

As discussed throughout this Project, there are two primary modalities of flooding addressed in this plan including: 1) uplands flooding associated with rainfall/precipitation events; and 2) river-water flooding associated with storm-surge and high-tide events. It is infeasible to address river-water flooding with traditional rain-water stormwater management systems such as pumping and temporarily storing flood waters as storm-surge and high-tide flooding events have the "*entire Atlantic Ocean behind it*." Further, even the blue-green rainfall intervention measures recommended above would quickly become overwhelmed and be rendered ineffective in the event that storm-surge/high-tide waters were to flood the study area.

The need to protect the study area from storm-surge/high-tide waters is well understood and addressed in this Project and takes full advantage of the relatively large area of the Gibson Park property and existing, all be it degraded, infrastructure on the Boatworks property. The use of re-sculpted berms throughout the Gibson Park property and sea wall at Boatworks property have been designed to provide a continuous minimum 11-foot AMSL topographic high to protect these portions of the study area from being flooded. The concept of continuity of the topographic high is critical to provide flood protection as flood waters will find low-lying areas, if any, and result in uncontrollable flooding.

Based upon observations made during storms and high-tide events, a major vulnerable portion of the study area is the alignment along the west side of Mills Avenue which forms the western border of the Riverside neighborhood. Currently, the road surface at elevations ranging from approximately seven to nine feet AMSL is the only barrier to flood waters from the adjacent Pines River. It is a common-place occurrence for storm-surge and tidal waters to overtop the road surface which results in serious flooding along several hundred feet of the neighborhood along Mills Avenue.

To address this flooding issue, the Project takes advantage of the linear relatively flat-lying area along the western side of Mills Avenue and the adjacent rocky coastal beach. It is proposed that geotextile bags, such as those produced by Envirolok , which are geotextile bags made of porous, weather-resistant geotextiles filled with a sand or other compatible materials, be installed. These items are often utilized to form a reinforced coastal shoreline structure such dunes or berms and are common components of living shorelines approach to coastal management. This design includes to following components:

- Filling the geotextile bags with materials excavated as part of the Gibson Park property project (this is a very sustainable project component as the excavated materials will be re-used as part of the project).
- Installing the geotextile bags in a continuous linear geometry along the western edge of Mills Avenue. The height of the top of the filled bags would be a 11-feet AMSL, consistent with the MC-FRM 2030 1- year storm event design scenario,
- Native, low-lying, deep-rooted and low-maintenance plantings would be established on the exposed surfaces of the geotextiles to help further stabilize them, as well as making them more aesthetically pleasing.
- To provide access to the adjacent beaches for neighborhood residents, concrete-walled accessways would be installed at selected locations along the run of the geotextiles. The accessways would be equipped with flash board of other deployable mechanisms that would be deployed by the City in anticipation of a storm and/or king, high-tide event, thereby maintaining the integrity and continuity of the berm.
- The eastern edge of the vegetated berm system would be protected by either a guardrail system and/or vertical curbing along the edge of Mills Avenue to project the structures from damage associated with winter-time snow plowing operations.

The length of Mills Avenue which would be required to provide a protection height of 11.3-feet AMSL is currently under design. It should be noted that this berm actually represents an interim flooding protection measure in advance of and in anticipation of higher and likely more-rigorous measures which will likely be recommended as part of a future design and study process.

Consistency with the Rumney Marshes Salt Marsh Restoration Plan

As this project lies within the Rumney Marshes ACEC, the project team reviewed the *"Rumney Marshes Area of Critical Environmental Concern, Salt Marsh Restoration Plan (SRMP),"* from May 2002, issued by the Commonwealth of Massachusetts, Executive Office of Environmental Affairs .

As the SRMP states: "*The Rumney Marshes ACEC is ecologically diverse with salt marsh, tidal flats, subtidal channels and abutting upland. An extraordinary variety of birds use the area, including five state-listed endangered, threatened, or species of special concern according to the Massachusetts Natural Heritage and Endangered Species Program. The marshes also provide habitat for commercial fish and shellfish; a filtering system for improved water quality; and recreational, educational and scenic resources. The extensive holdings of the Metropolitan District Commission (MDC) in both Rumney Marsh and Belle Isle Marsh offer public access to the marshes and uplands for hiking, nature study, boating, and fishing for area residents and visitors. The recent opening of the Bear Creek Wildlife Sanctuary in Saugus further enhances public access to the ACEC and its salt marshes.*

The salt marshes are vitally important to the surrounding human population in their capacity to prevent flood damage by providing floodwater storage. This capacity is lost when marshes are filled. Most of the ACEC lies within the 100-year floodplain of East Boston, Winthrop, Revere, Saugus, and Lynn. Protection and enhancement of the floodplain is vital to these communities for coastal flood control.

Despite the tremendous ecological value of Rumney Marsh and Belle Isle Marsh and their uniqueness as large natural areas within a highly developed and urbanized region, the ACEC suffers from a host of problems which diminishes values and impairs vital ecological functions. Threats include:

- *loss of habitats,*
- *increase in invasive plant species and loss of native salt marsh plants,*
- *impaired water quality,*
- *flooding,*
- *increase in mosquitoes,*
- *increased risk of fire, and*
- *loss of recreational and educational opportunities, open space, and scenic quality."*

The Gibson Park Resiliency project responds positively and proactively to most of these threats and does not negatively affect any of them. Namely, the proposed project:

- Counteracts the loss of habitat by restoring and expanding salt marsh habitat on site.
- Counteracts the increase in invasive plant species and loss of native salt marsh plants, by targeting removal of invasive phragmites that have established along the edge, planting native salt marsh species as part of the marsh creation/enhancement, and implementing a program of monitoring post-construction.
- Counteracting impaired water quality, by providing water quality treatment for all impervious runoff, promoting recharge into the groundwater table and only discharging treatment settled runoff.

- Counteracting flooding by creating more salt marsh, providing stormwater storage for the higher ends of the tidal cycles, and implementing significant infrastructure to mitigate the effects of flooding.
- The project does not have any negative effect related to an increase in mosquitoes,
- The project does not have any negative effect related to increased risk of fire, and
- Counteracting loss of recreational and educational opportunities, open space, and scenic quality by redeveloping the park as a blue green water park with recreational (multiple sports) and educational opportunities such as interpretive signs, and an elevated boardwalk through the marsh and looking out across the Pines River to allow for more appreciation of the scenic qualities of the area.

The SRMP further goes on to discuss issues with invasive species: *"Historically, vegetated tidal wetlands of the ACEC area were dominated by either Spartina alterniflora (regularly flooded low marsh) or S. patens (irregularly flooded high marsh). This pattern remains in less disturbed portions of the marsh, but extensive areas of former salt marsh are now dominated by invasive plant species, most notably common reed, Phragmites australis…*

Its presence in wetlands, and Rumney Marsh in particular, is widely regarded as an indicator of disturbance and subsequent impairment of ecological functions and values. At disturbed sites, common reed frequently forms dense monotypic stands ranging up to four meters (12 feet) tall. The robust growth form of common reed crowds out virtually all other plant species, diminishing the habitat value of the area. In many instances, a dense mat of rhizomes and dead and decaying plant material builds up, raising the level of the marsh surface, further restricting tidal flow and freshwater run off and increasing the areal extent of common reed onto the marsh surface."

As the yellow outlined area on the figure below indicate, there is significant growth of invasive Phragmites in Gibson Park. As part of the Project, the City proposed to remove the invasive species, including the rhizome mat, and replacing it with native vegetation, and performing post implementation monitoring to track the health of the vegetation and remove invasives that try to reestablish.

Figure 22 Areas of Phragmites Domination

With respect to Water Quality, the SRMP states: "*The most effective method of controlling bacterial pollution, and other pollutants such as suspended solids, is to keep them from entering the system in the first place. Though great improvements have been made in addressing the sources of water pollution, some inputs will likely always remain. These are best treated near the source, in the higher sections of the watershed, with a combination of stormwater treatment Best Management Practices (BMPs), such as proprietary treatment systems, constructed treatment wetlands, and detention basins. "*

The Gibson Park Resiliency project includes multiple water-quality treatment aspects, most notably with a series of treatment stormwater BMPs including bioswales, raingardens, and infiltration chambers to control and treat nutrients and pollutants carried from stormwater prior to entering into the watershed. Furthermore, as an additional water-quality function, the project includes a living shoreline that will be seeded with Ribbed Mussels. According to the EPA, ribbed mussels (included in our one of our living shoreline project components) can filter up to 15 gallons per day of estuarine water and can remove a significant amount of nitrogen[8], which is well needed in the Saugus and Pines Rivers.

With respect to access and getting the public involved with the salt marsh and the ACEC, the SRMP states: "*In order to appreciate and understand salt marshes people must be able to see them and directly access them. Views of marshes in urbanized areas are often obscured by tall, dense stands of*

[8] Ribbed Mussels Could Help Improve Urban Water Quality | NOAA Fisheries

common reed. Direct access to a marsh can be precluded by lack of parking, landowner restrictions, safety concerns, or unawareness of the presence of the marsh.

Salt marsh restoration projects that are on public land are deemed to have high potential for enhanced public access, particularly when the jurisdictional agency's primary mission is open space protection, such as the MDC or a municipal parks department. The prospect of providing a designated parking area, visible access points, boardwalks, formal programming, and interpretative signage will further enhance access and appreciation. In addition, restoration projects that control stands of tall common reed, will increase visual appreciation for the marsh, along with addressing concerns about security and illegal dumping."

Public access and appreciation of the salt marsh is one of the key features of the Gibson Park Resiliency project. The project adds parking along the former Boatworks property, removes dense stands of common reed, and creates a boardwalk through the restored marsh in order to increase the connection to the public and provides educational components about the importance of salt marsh. One of the key features of the elevated boardwalk is that is traverses through the restored/enhanced marsh area to the north. The project team debated the positioning of this but given that it is elevated and oriented most north south, the shading effects have been minimized and the educational and access benefits of getting the public safely, and in a controlled manner out over the salt marsh will be more effective and impactful than having the boardwalk pass further landward of the marsh area.

Conclusion

The Gibson Park Resiliency project is designed with three types of goals in mind, these being:

1. Creating Resiliency – Providing resiliency to the Neighborhood and the Park itself. In this coastal environmental bordering an area of critical environmental concern, the project will create new salt marsh, living shorelines and provide resiliency from storm surge flooding.
2. Serving the Community – Allowing for activities for all users of the community. The redeveloped park will include a multi-use field that can be set up to serve many different activities and age groups, as well as have resilient walking paths that can provide a connection with the environment to residents in the area.
3. Addressing Historic High Tide Flooding – One of the key takeaways for this project is that it will provide a solution for the historic high tide flooding that occurs in the northern end of the Riverside neighborhood. By providing offline, subsurface storage below the multi-use fields, the project provides a storage place to move water away from the neighborhood when it currently does not have an outlet during the higher ends of the tide cycle. Our strategy will allow the temporary storage of stormwater during the higher ends of the tide cycle and allow for a controlled release as the tide recedes, while also promoting groundwater recharge.

The proposed Gibson Park Resiliency park offers the City to utilize living with nature, blue-green infrastructure to provide several years of protection from increased storm events, storm flooding and high tidal flooding associated with global climate change. The project includes stormwater measures including bioswales, rain gardens, off-line storage, vegetated berms, salt marshes sea

walls, and pervious surfaces, as well as upgrading existing City systems. The project also includes multiple living shoreline components, as well as public access and education components including a walks way, and multi-use sports field and a non-motorized vessel facility.

The proposed project will result in reinvigorating the Gibson Park facility itself for the City residents and visitors.

Project Team

This project resulted from a collaborative effort of multiple disciplines providing valuable input to this process. The key contributors to this report/design effort include:

- The City of Revere
- The Commonwealth of Massachusetts' Municipal Vulnerability Program
- McAllister Marine Engineering, LLC
- Copley Wolf Design Group
- LEC Environmental Consultants, Inc.
- Hancock Associates
- Petersen Engineering

Background Research

In an effort to review and understand the underlying conditions in the project area and develop appropriate strategies for this project, the consultant team reviewed a variety of sources, including the following:

Arrowstreet "Revere Riverfront Masterplan – Final Report," January 2021,

AECOM "Point of Pines and Riverside Area Coastal Resilience Feasibility Report"_June_30, 2021

Collins Engineers, Inc. "29 Thayer Ave Waterfront Access Study – Preliminary Planning Report" January 27, 2021

MassGIS- MassMapper The Online Data Viewer – Commonwealth of Massachusetts, https://maps.massgis.digital.mass.gov/MassMapper/MassMapper.html

MassGIS – MORIS https://maps.massgis.digital.mass.gov/MassMapper/MassMapper-CZM-MORIS.htmlMapper

City of Revere GIS, https://www.revere.org/gis

FEMA Flood Rate Insurance Maps, Panels 25025C0028J (3/16/2016), 25025C0029J (3/16/2016) and 25009C0529G (7/16/14)

Rumney Marsh Area of Critical Environmental Concern Salt Marsh Restoration Plan, Massachusetts Wetland Restoration Program and MA DEM ACEC Program ,May 2002

Commonwealth of Massachusetts- Sea Level Rise, Understanding and Applying Trends and Future Scenarios for Analysis and Planning, MA Coastal Zone Management, 2013

Massachusetts Coastal Flood Risk Model, Executive Office of Energy and Environmental Affairs

USDA, Natural Resources Conservation Services, Web Soil Survey, National Cooperative Soil Survey

AECOM " City of Revere, Massachusetts, Municipal Vulnerability Preparedness, Summary of Findings Report" June 2019

Scientific Investigations Map 3402, Quadrangle 137- Lynn, Surficial Materials Map of the Lynn Quadrangle, Massachusetts, 2018, compiled by Byron D. Stone and Mary L. DiGiacomo-Cohen, US Department of the Interior, US Geological Survey, in cooperation with the Commonwealth of Massachusetts, Massachusetts Geological Survey and Executive Office for Administration and Finance

Attachments

Project Design Plans – "Gibson Park Resilience and Recreational Restoration Project " prepared by McAllister Marine Engineering, LLC, dated June 30, 2022

Site Renderings – Copley Wolff Design Group

Wetland Resource Analysis Report - prepared by LEC Environmental , June 30, 2022

Other materials generated during this process but not attached to this report:

- Gibson Park Resiliency Project – Draft Operations and Maintenance Manual
- Gibson Park Sampling and Analysis Plan
- Gibson Park Boring Logs
- Gibson Park Stormwater Report