COASTAL RESILIENCE SOLUTIONS FOR EAST BOSTON AND CHARLESTOWN

FINAL REPORT

October 2017

Mayor Martin J. Walsh

GREENOVATE CITY of BOSTON

MASSACHUSETTS OFFICE OF COASTAL ZONE MANAGEMENT

Barr Foundation

BOSTON Green Ribbon COMMISSION

October 2017

Dear Neighbors,

Climate change is here. It's happening now. This year, we saw its effect in Texas, Florida, Puerto Rico, and across our country and world. In Boston, we are seeing more frequent flooding on our waterfront, hotter summers, stronger rains, and unpredictable weather. It's more important than ever that we work together to make sure our city is ready for the changes ahead.

When we released the *Climate Ready Boston* report in December 2016, we weren't writing a plan that would sit on a shelf. In less than a year, we've made climate resiliency central to all our major planning efforts, including *Imagine Boston 2030*, *GoBoston 2030*, and *Resilient Boston*.

East Boston and Charlestown face specific risks because of sea-level rise and coastal flooding. This report, which was created with the support of the Commonwealth of Massachusetts and the Barr Foundation, helps us understand these risks and how we will address them. We've developed immediate measures we can take, and longer-term standards we can work towards to make sure our City is stronger, safer, and more equitable because we're ready for climate change.

Climate resiliency means many things. It's about protecting public health and safety in our neighborhoods, and using the best available information to do so. It's about focusing on our infrastructure and how our systems work together to make our city more resilient. It's about working with our neighboring municipalities, because climate change knows no borders. We're making sure that any action we take has many benefits for our residents, and that residents are always included in the planning process.

This report shows how we're doing this, and in the coming years we'll bring these types of solutions to other neighborhoods across the city. We look forward to continuing to work with you in your neighborhoods.

Sincerely,

Martin J. Walsh, Mayor of Boston

Attendees at the Charlestown Open House provide feedback and develop their own solutions to protect the neighborhood.

PROJECT TEAM

Austin Blackmon, Chief of Environment, Energy and Open Space
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Dalia Munenzon, Urban Designer
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Woods Hole Group
Kirk Bosma, Senior Coastal Engineer and Flood Risk Modeler

Community and Steering Committee members participate in a climate resilience walking tour of the East Boston waterfront, organized by The Neighborhood of Affordable Housing.

ACKNOWLEDGEMENTS

The City of Boston wishes to acknowledge the many partners and community stakeholders who supported this project. Without their participation, this project would not have been possible.

A Steering Committee composed of the following partners oversaw the project:

- Boston Environment Department
- Boston Planning and Development Agency
- Boston Parks and Recreation Department
- Boston Public Works Department
- Boston Transportation Department
- *Imagine Boston 2030*
- Mayor's Office of Neighborhood Services
- Mayor's Office of Resilience and Racial Equity
- Boston Water and Sewer Commission
- MA Office of Coastal Zone Management
- Massachusetts Department of Transportation
- Massachusetts Port Authority
- Massachusetts Bay Transit Authority
- City of Cambridge
- City of Somerville
- Green Ribbon Commission
- UMass Boston School of the Environment
- Neighborhood of Affordable Housing

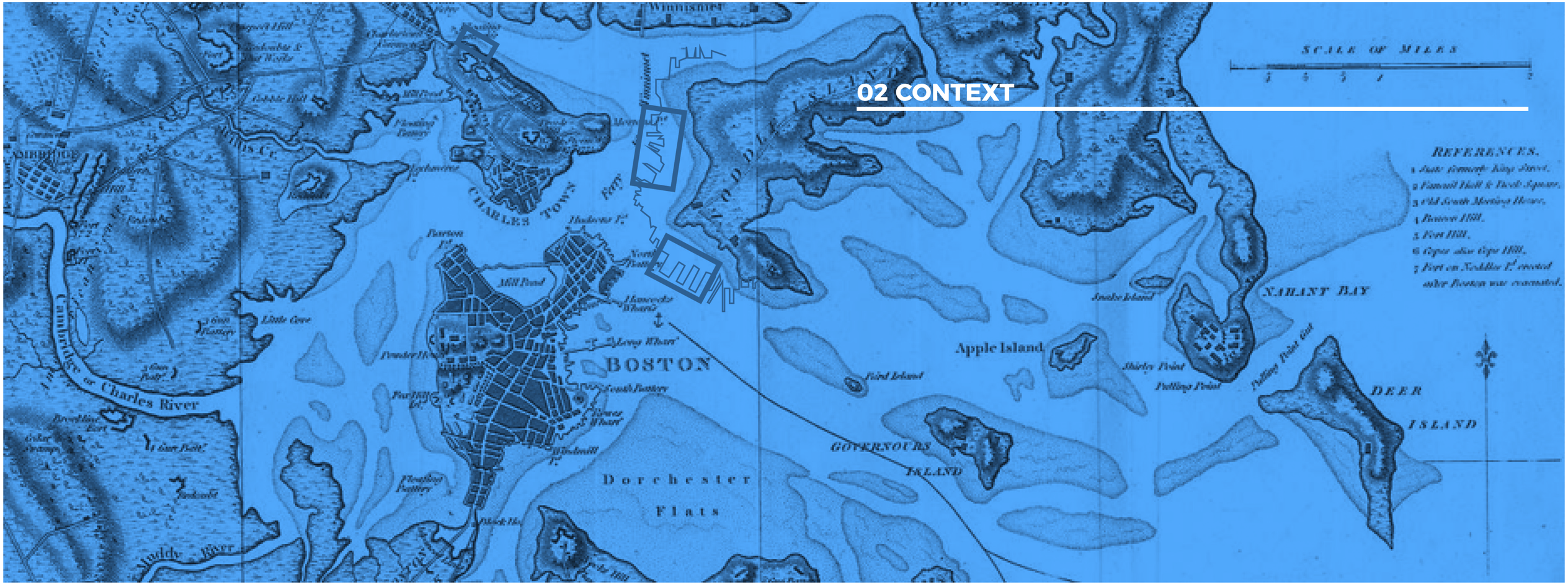
The following organizations helped us engage with their stakeholder communities:

- Neighborhood of Affordable Housing
- Green Ribbon Commission
- Boston Harbor NOW
- Harborkeepers
- The John Flatley Company
- East Boston Harborwalk Group
- Greenway Council
- Friends of the Charlestown Navy Yard
- Harbor View Neighborhood Association
- Eagle Hill Neighborhood Association
- Orient Heights Neighborhood Association
- Jeffries Point Neighborhood Association

The City of Boston would like to thank the Commonwealth of Massachusetts Executive Office of Energy and Environmental Affairs and the Barr Foundation for their generous support.

CONTENTS

02 CONTEXT


Winnisimet
CHARLES TOWN
BOSTON
Dorchester Flats
Charles River
Apple Island
Snake Island
NAHANT BAY
DEER ISLAND
GOVERNOURS ISLAND
Pullings Point
Shirley Point
Muddy River
SCALE OF MILES
REFERENCES.

CONTEXT

Coastal Resilience Solutions for East Boston and Charlestown presents near- and long-term strategies for protecting East Boston and Charlestown from sea level rise and coastal flooding. The project was led by the City of Boston Environment Department and the Boston Planning & Development Agency. It was funded with a Community Coastal Resilience Grant from the Massachusetts Office of Coastal Zone Management and a grant from the Barr Foundation, with support from the City and the Neighborhood of Affordable Housing - an East Boston community organization. A separate Executive Summary accompanies this report.

Coastal Resilience Solutions for East Boston and Charlestown is the first neighborhood coastal resilience plan from *Climate Ready Boston*, the City of Boston's ongoing initiative to adapt to climate change. *Climate Ready Boston* is an integral part of the City's comprehensive planning efforts, including *Imagine Boston* 2030, Boston's first city-wide comprehensive plan in 50 years.

Imagine Boston provides an overall direction for the City's long-term planning and development, bringing together plans for housing, education, transportation, racial equity, climate preparedness, and more. One of its four overarching goals is to "promote a healthy environment and adapt to climate change." *Imagine Boston* also focuses the City's efforts on creating a waterfront for future generations. Well-planned redevelopment of Boston's waterfront could help protect the city from sea level rise (SLR) and coastal storms, while supporting other goals related to open space, mobility, affordable housing, economic growth, and natural resources.

Climate Ready Boston was a major step in integrating climate preparedness into all aspects of city planning, review, and regulation, as outlined in the *Greenovate Boston 2014 Climate Action Plan Update*. Boston's Climate Action Plan sets the goals for both reducing greenhouse gas emissions and preparing for the impacts of climate change.

The 2016 *Climate Ready Boston* report set the foundation for the City's ongoing climate preparedness activities. The report included:

- Updated projections of climate change in Boston;
- More detailed vulnerability assessment of the city and specific focus areas; and
- Principles, strategies, and initiatives to achieve the City's climate preparedness goals.

WHY EAST BOSTON AND CHARLESTOWN?

- *These study areas were selected as the first because they are currently at risk from 1% annual chance coastal flooding, have high concentrations of vulnerable residents and critical infrastructure, and are affected by relatively narrow and well-defined flood pathways. Other vulnerable areas will be studied as part of future similar initiatives.*

Climate Ready Boston's vulnerability assessment identified East Boston and Charlestown as two of the neighborhoods most vulnerable to sea level rise and coastal flooding. *Climate Ready Boston* recommended that the City "prioritize and study the feasibility of district-scale flood protection" for these and six other focus areas (Initiative 5.3), and "develop local climate resilience plans in vulnerable areas to support district-scale climate adaptation" (Initiative 4.1).

Coastal Resilience Solutions for East Boston and Charlestown focuses on two vulnerable study areas:

- East Boston's Jeffries Point, Maverick, Central Square, and Lower Eagle Hill; and
- Charlestown's Sullivan Square, the Neck, and Rutherford Avenue, plus areas of Somerville and Cambridge.

These study areas were selected as the first because they are currently at risk from 1% annual chance coastal flooding, have high concentrations of vulnerable residents and critical infrastructure, and are affected by relatively narrow and well-defined flood pathways. Other vulnerable areas will be studied as part of similar future initiatives.

SEA LEVEL RISE SCENARIOS

Climate Ready Boston selected three sea level rise scenarios (9 inch, 21 inch, and 36 inch) that are likely to occur within the century to focus the discussion on how Boston will adapt to climate change. The actual sea level rise Boston experiences will be driven by many factors, including global carbon emissions.

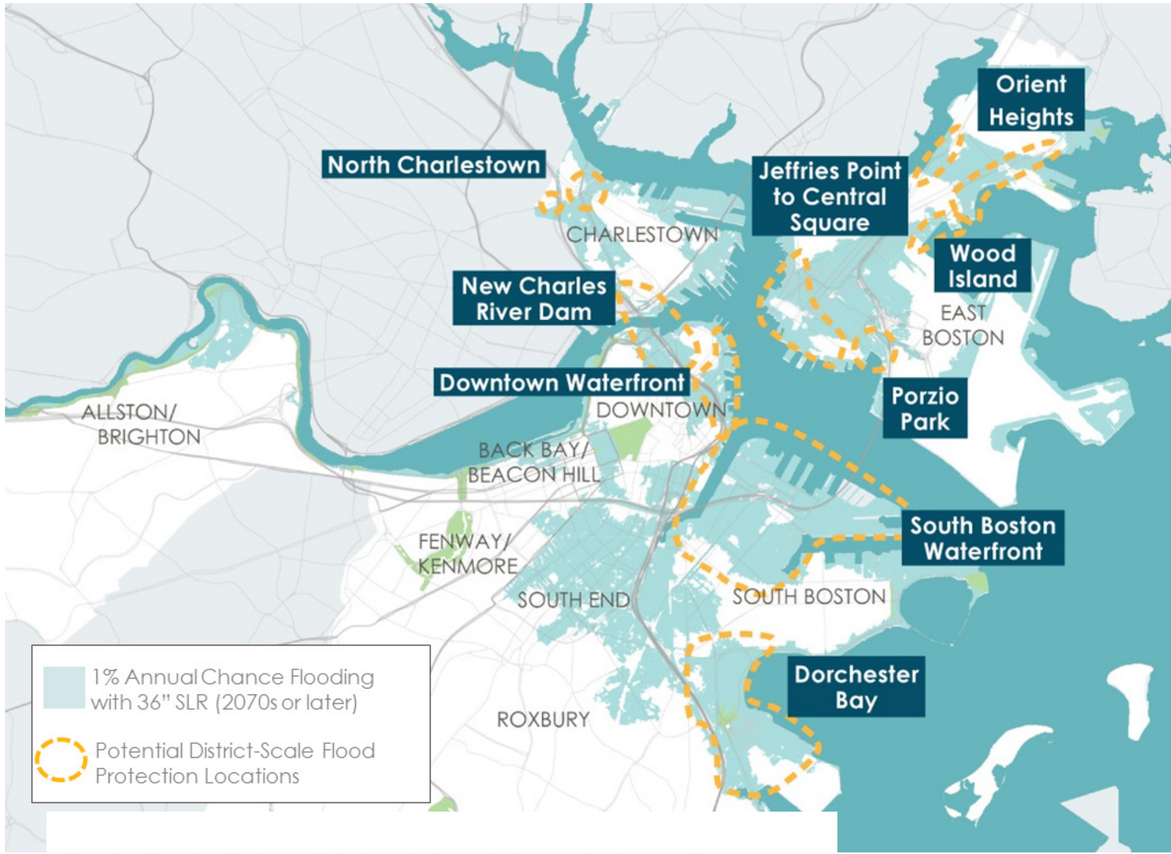
Climate models show that sea level rise in the near and intermediate term is largely locked in due to carbon emissions that have already occurred. By 2050, possibly by 2030, at least nine inches of sea level rise are likely, even if there is a major reduction in emissions. At least twenty-one inches of sea level rise is possible by 2050.

The highest sea level rise considered in the Climate Ready Boston vulnerability analysis, 36 inches, has a one-sixth chance of being exceeded by 2070, if emissions remain at the current level, and a 1-in-20 chance with a moderate reduction in emissions. The three scenarios were intended for conducting a high-level assessment of flood risk and were not intended for detailed planning and development of regulations.

The Boston Planning and Development Agency now requires developers to evaluate the vulnerability of new projects to 40 inches of sea-level rise through its "Climate Change Resiliency and Preparedness Checklist". This level is derived from the Boston Harbor Flood Risk Model (BH-FRM) and is equivalent to the Climate Ready Boston data. However, to be consistent with Climate Ready Boston, this report refers to the long-term scenario as "36 inches" of sea level rise.

See Climate Ready Boston for more details on sea level rise probabilities. The data in that report show how sea level will continue to rise for more than 100 years.

1) The sea level rise (SLR) numbers and probability analysis in the CRB report were established to align the Boston Research Advisory Group (BRAG) projections, data from Boston Water and Sewer Commission on stormwater flooding, and data on SLR conditions from the MassDOT-FHWA Boston Harbor Flood Risk Model (BH-FRM). Actual sea level rise value is 3.2 feet above 2013 tide levels with an additional 2.5 inches to account for subsidence.



Climate Ready Boston identifies nine areas for flood protection interventions based on a city-wide vulnerability assessment. Image Credit: Climate Ready Boston.

PROJECT OVERVIEW

Coastal Resilience Solutions for East Boston and Charlestown involved extensive technical, design, and stakeholder engagement efforts. Technical reviews were carried out early in the project to understand coastal flooding risks with greater specificity. The *Climate Ready Boston* vulnerability assessment, latest flood models, development plans, and conditions on the ground were analyzed to identify critical locations where practical measures could reduce district-scale coastal flood risks.

Through iterative design and stakeholder engagement, potential flood protection strategies for critical locations were identified, evaluated, and developed. A set of evaluation criteria, established with input from stakeholders, guided the design process towards feasible, effective, and flexible solutions that achieve multiple benefits over long time horizons. Recommendations and roadmaps for implementing near- and long-term actions were further defined through ongoing analysis and community engagement. Costs and phasing plans in this report are estimates and recommendations only, and should not be used for detailed planning.

Stakeholder engagement activities included:

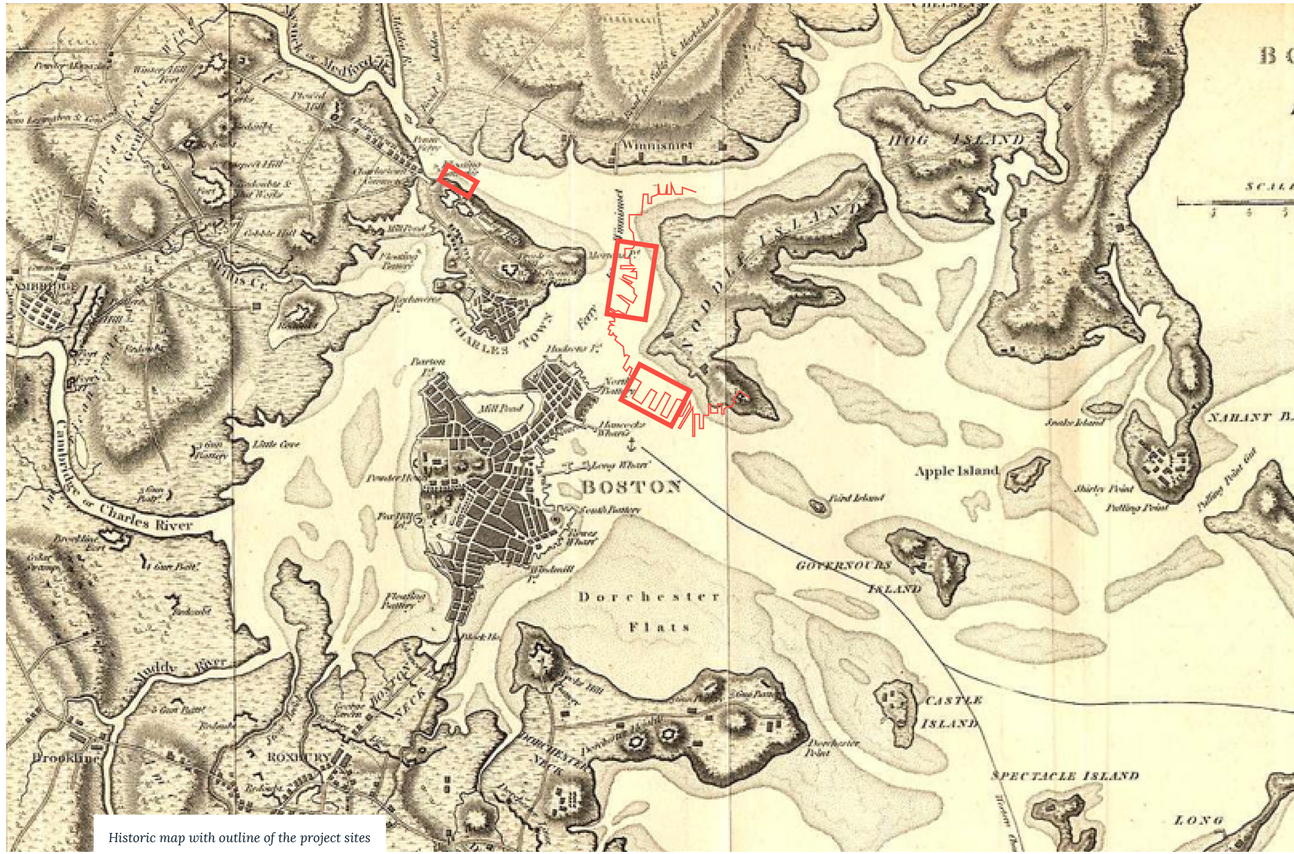
- More than two dozen public outreach and community engagement activities with neighborhood residents, community civic associations, interest groups, and local media to build awareness, answer questions, and gather input.
- Three community open houses to educate residents about flood risks, engage them in the decision-making process, and share resources on preparedness actions they can take.
- Over 50 interviews and follow-up meetings with a broad set of City departments, State and regional agencies, non-profit organizations, and private property owners to understanding their interests, identify potential strategies and partnerships, and inform recommendations.
- Coordination with other planning processes, such as *Imagine Boston 2030*, development project reviews, and the Rutherford Avenue redesign project.

PERCENT ANNUAL CHANCE

A "1 percent annual chance flood" has a 1 in 100 chance of being equaled or exceeded in any given year and is the primary coastal flood hazard delineated in FEMA flood maps. Though the chance of occurrence each year may seem relatively low, a 1 percent annual chance event could occur multiple times in a given year, decade, or century. These events have close to a one in three chance of occurring at least once during a 30-year period.

Climate Ready Boston uses a 1 percent annual chance flood nomenclature rather than the "100-year" flood, in order to limit confusion related to the possible time horizon of an event occurring. The "100-year flood event" terminology is sometimes misinterpreted to imply that 100-year events will occur only once every 100 years, which is incorrect.

A "0.1 percent annual chance flood" has a 1 in 1,000 chance of occurring in any given year. It is also referred to as the "1,000-year flood." It is 10 time less likely to occur than a 1 percent annual chance flood.



Historic map with outline of the project sites

A diverse group of stakeholders were engaged during the project to raise awareness, answer questions, and collect feedback.

CITY DEPARTMENTS AND AGENCIES

- Environment
- Planning and Development Agency
- Water and Sewer Commission
- Parks and Recreation
- Transportation
- Public Works
- Neighborhood Services
- Budget
- Law
- *Imagine Boston 2030*

PRIVATE SECTOR

- Flatley Company
- East Boston Harborwalk Group

STATE AND REGIONAL PARTNERS

- Office of Coastal Zone Management
- Department of Transportation
- Massachusetts Bay Transit Authority
- Massachusetts Port Authority
- City of Cambridge
- City of Somerville

NON-PROFIT

- Neighborhood of Affordable Housing
- UMass Boston School for the Environment
- Green Ribbon Commission
- Boston Harbor NOW
- Trustees of Reservations

ELECTED OFFICIALS

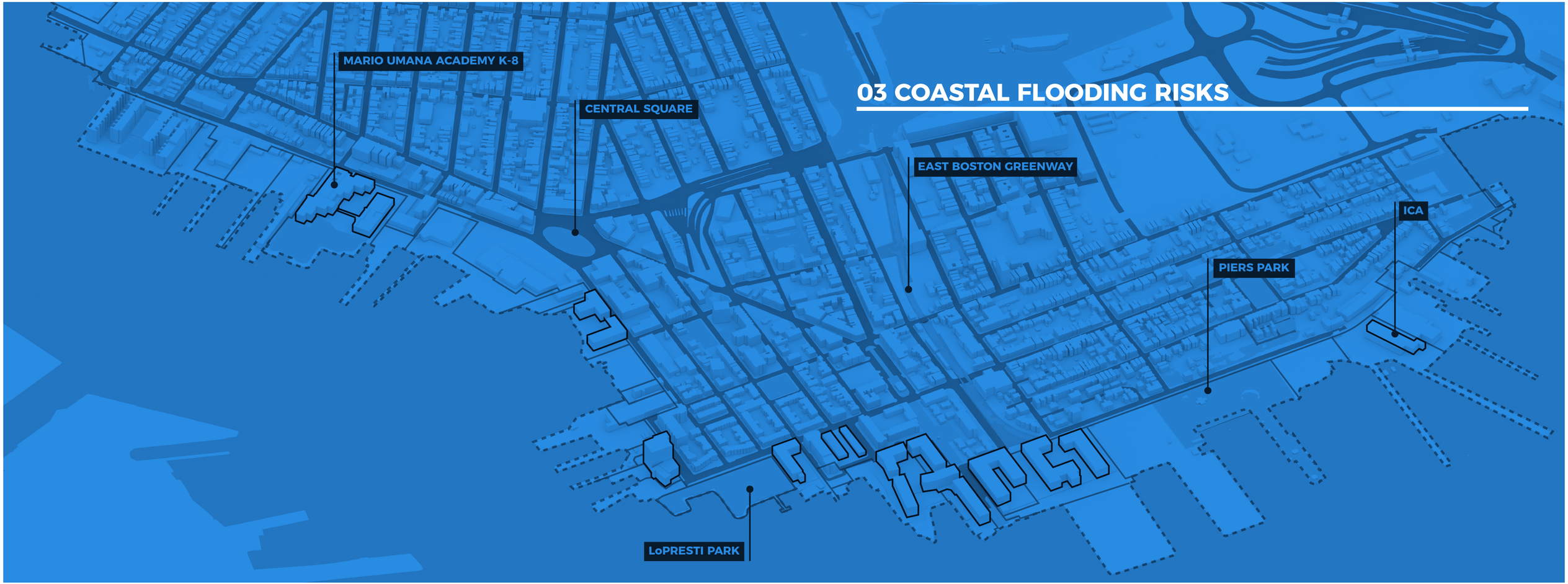
- City Councilor Salvatore LaMattina
- State Representative Adrian Madaro
- US Congressman Michael Capuano

CIVIC ASSOCIATIONS

- Greenway Council
- Friends of the Charlestown Navy Yard
- Harbor View Neighborhood Association
- Eagle Hill Neighborhood Association
- Orient Heights Neighborhood Association
- Jeffries Point Neighborhood Association

East Boston residents 'build a berm' at the Marine Fair.

03 COASTAL FLOODING RISKS



COASTAL FLOODING RISKS

East Boston and Charlestown were historically islands and peninsulas, surrounded by tidelands. As the city's population and economy grew, the neighborhoods expanded by filling in the tidelands. These areas have developed and redeveloped, many times over. They now house critical infrastructure and a mix of residential, commercial, community service, and industrial land uses.

Tidelands were filled high enough to be safe from past tides and flood levels. But flood levels will be higher in the future, as a result of sea level rise. That puts filled tidelands and other low-lying areas at growing risk of coastal flooding.

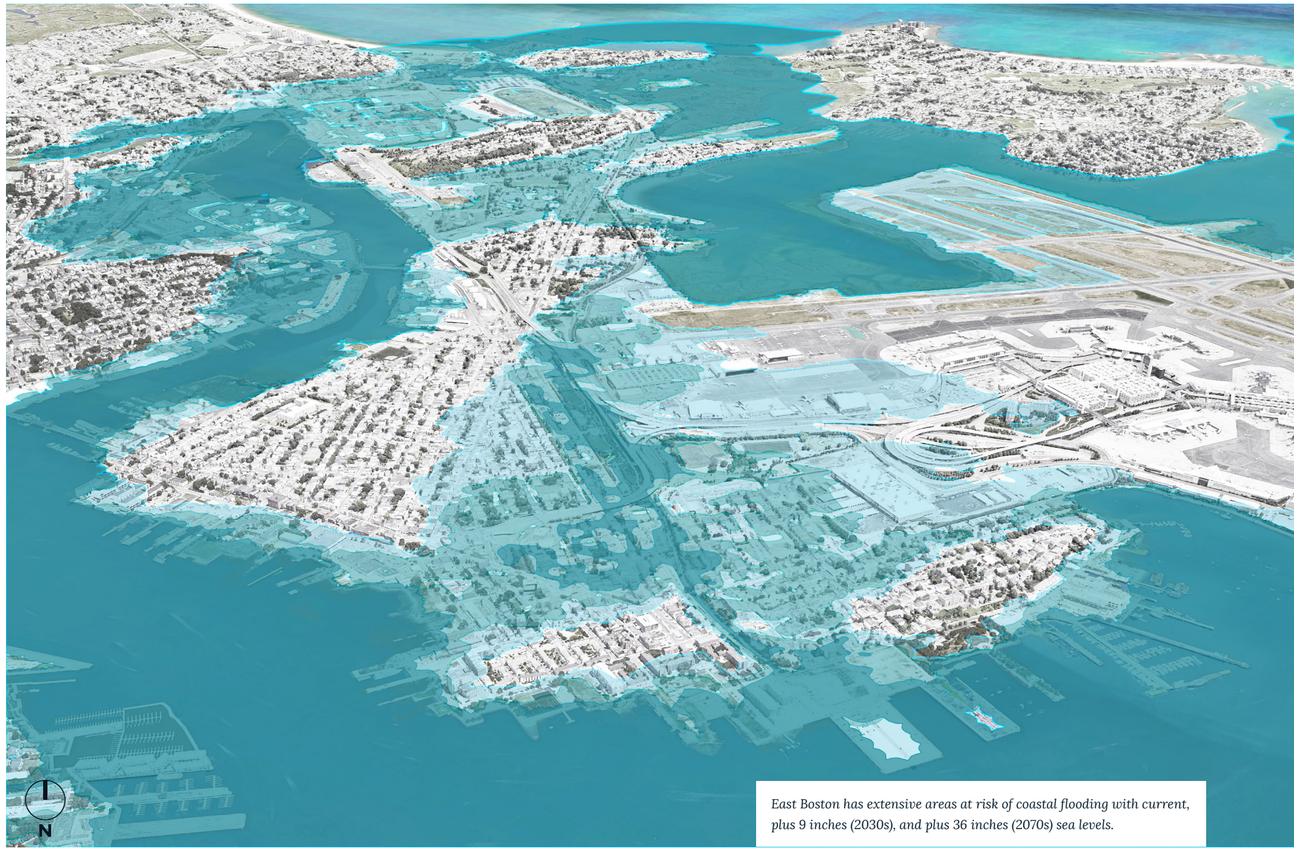
Climate Ready Boston projections indicate that Boston's sea levels will probably rise (from 2000 levels) by at least 9 inches by 2030, 21 inches by as soon as 2050, and 36 inches by as soon as 2070.

Nine inches may seem small, but it will make the current 1% annual chance flood in the East Boston and Charlestown study areas four to five times more likely than it is today. And with sea levels 36 inches higher, the current 1% annual chance flood will occur during the highest tides of the month.

In both study areas, large inland areas are at risk of flooding through low-lying pathways that originate at the waterfront. Flood pathways in East Boston and Charlestown were identified using the Boston Harbor Flood Risk Model developed by the Massachusetts Department of Transportation. To gain a deeper understanding of when and where these flood pathways would form, high resolution data from the model was collected and the movement of flooding through the neighborhoods was analyzed down to the property and street level.

While the depth and extent of flooding in these areas increase over time, the flood pathways remain relatively narrow and well-defined. These findings were used to develop near- and long-term measures to block flood pathways and extend flood protection to vulnerable waterfront areas as sea levels rise and coastal flood risks grow. Targeted solutions at these locations can prevent coastal flooding in large portions of the study areas. However, detailed solutions and analysis for flood pathways that develop in the mid-to-late century were not included in the scope of this project.

Boston's sea levels will probably rise by at least 9 inches by 2030, 21 inches by as soon as 2050, and 36 inches by as soon as 2070.



East Boston has extensive areas at risk of coastal flooding with current, plus 9 inches (2030s), and plus 36 inches (2070s) sea levels.

WE ASKED EAST BOSTON RESIDENTS WHAT CONCERNED THEM MOST ABOUT COASTAL FLOODING AND SEA LEVEL RISE.

“I live in the Orient Heights neighborhood, but enjoy the **parks and retail** *down on the point.”*

“I am most concerned about **severe coastal flooding** *affecting Sumner/Callahan tunnels and the Blue Line tunnel, potentially cutting East Boston off from mainland.”*

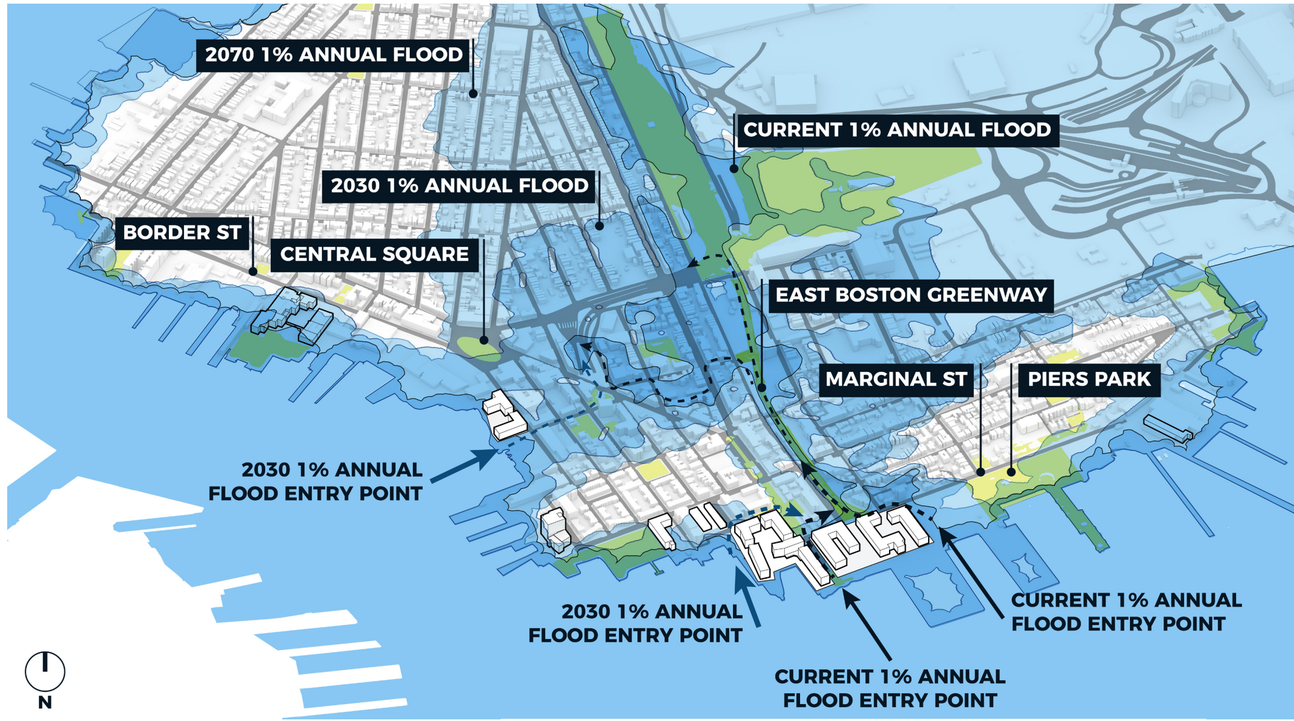
EAST BOSTON

POTENTIAL IMPACTS

Out of all Boston neighborhoods, East Boston has the most population, buildings, and land area at risk from coastal flooding, and most of it is residential. The East Boston study area includes much of Jeffries Point, Maverick, Central Square, and Lower Eagle Hill. Flooding of the study area would impact:

- Socially vulnerable residents.
- Dense residential development.
- A Main Streets commercial district.
- East Boston’s only supermarket.
- Police and fire stations.
- Schools.
- Subway and highway tunnels.
- Airport circulation roads.
- Combined stormwater and sewer systems.

The impacts would be felt well beyond this area if it flooded, largely due to the disruption of regional transportation systems.



The gradations of blue in the map show how the 1% annual chance flood extent changes as sea levels rise. The colors do not indicate depth of flooding. The arrows show the flood entry points and pathways with current sea levels, 9 inches of sea level rise (2030s), and 36 inches of sea level rise (2070s).

Annual Chance Flood Depths At The Greenway Entrance

Data source: Boston Harbor Flood Risk Model.

FEMA uses the 1% annual chance as a standard to assess flood risks and solutions. This table highlights how the 1% annual chance flood depth will increase with 9 inches and 36 inches of SLR.

		FLOOD DEPTH (FEET ABOVE EXISTING GROUND)		
ANNUAL CHANCE (%)	ANNUAL ODDS	CURRENT (2000S)	+9 INCHES SLR (2030S)	+36 INCHES SLR (2070S)
0.1	1 in 1,000	1.8	2.8	6.1
0.2	1 in 500	1.7	2.7	6.0
0.5	1 in 200	1.3	2.6	5.5
1	1 in 100	1.1	2.5	4.9
2	1 in 50	0.7	2.1	4.5
5	1 in 20	0.2	1.4	4.2
10	1 in 10	dry	1.0	3.7
20	1 in 5	dry	0.3	3.1
25	1 in 4	dry	dry	2.9
30	1 in 3	dry	dry	2.7
50	1 in 2	dry	dry	2.2
100	1 in 1	dry	dry	1.7

FLOOD PATHWAYS

There are four pathways that connect inland areas to the waterfront. The two pathways of greatest concern lead from the Marginal Street and Border Street waterfronts. The map on page 25 illustrates the dynamics of coastal flooding from these two pathways.

The Marginal Street waterfront in East Boston is the first and most likely place for coastal flooding to enter.

In the current 1% annual chance flood, water would first cross the waterfront at Lewis Street and the undeveloped site of Piers Park II. With 9 inches of SLR (2030s), the 1% annual flood would also enter between Clippership Wharf and 99 Sumner Street (Hodge Boiler Works). Water would flow from these locations to Marginal Street, and then to the entrance of the East Boston Greenway.

The Greenway entrance is about 1 foot lower than the current 1% annual chance flood level. North of the entrance, the Greenway slopes down further to roughly 2 feet below current high tide. It remains at this low elevation until it reaches Bremen Street Park.

The current 1% annual chance flood would fill this 1,400 feet long section of the Greenway, causing water to spill out and spread to low-lying areas between the Greenway, Meridian Street, and Bennington Street. Flooding from the Greenway would flow into the MBTA Blue Line tunnel portal near Bremen Street Park and the Sumner and Callahan tunnels. MassDOT is working on solutions to protect these highway tunnels from coastal flooding risks, and MBTA has carried out a preliminary vulnerability assessment of the Blue Line.

The table on page 26 highlights the 1% annual chance flood depths at the East Boston Greenway entrance with current, plus nine inches (2030s), and plus 36 inches (2070s) of sea level rise. It shows that flood depths at the Greenway entrance would be about 1.1 feet deep if a 1% annual chance flood hit Boston today. Flood depths would increase to 2.5 feet by the 2030s, and 4.9 feet by the 2070s.

The Border Street waterfront is the second most important flood pathway in East Boston. The critical area is between Maverick Street and Central Square.

In the current 1% annual chance flood, water would cross the waterfront at the Boston East Designated Port Area (DPA) Site. However, flooding would remain localized and not function as a flood pathway. With 9 inches of SLR (2030s), the 1% annual chance flood would flow across the Boston East DPA Site to Border Street and Decatur Street, and spread throughout low-lying areas of the community. Water could also flow across Shaw's and Liberty Plaza's waterfront parking lots, and into Central Square, but the water would be less than 6 inches deep.

The table on page 28 shows that flood depths at the Boston East DPA site would be about 0.8 feet deep in a 1% annual chance flood with 9 inches of SLR (2030s). Flood depths would increase to 3.6 feet by the 2070s.

Annual Chance Flood Depths At The Boston East DPA Site

Data source: Boston Harbor Flood Risk Model.

FEMA uses the 1% annual chance as a standard to assess flood risks and solutions. This table highlights how the 1% annual chance flood depth will increase with 9 inches and 36 inches of SLR.

		FLOOD DEPTH (FEET ABOVE EXISTING GROUND)		
ANNUAL CHANCE (%)	ANNUAL ODDS	CURRENT (2000S)	+9 INCHES SLR (2030S)	+36 INCHES SLR (2070S)
0.1	1 in 1,000	dry	1.5	4.8
0.2	1 in 500	dry	1.2	4.7
0.5	1 in 200	dry	0.9	4.2
1	1 in 100	dry	0.8	3.6
2	1 in 50	dry	0.5	3.2
5	1 in 20	dry	0.1	2.9
10	1 in 10	dry	dry	2.4
20	1 in 5	dry	dry	1.8
25	1 in 4	dry	dry	1.6
30	1 in 3	dry	dry	1.4
50	1 in 2	dry	dry	0.9
100	1 in 1	dry	dry	0.4

Other flood entry points and pathways could develop in the 1% annual chance flood with 21 inches (2050s) or 36 inches (2070s) of SLR:

- Flooding from Marginal Street could flow over roads east of the Greenway (21 inches, 2050s).
- Almost the entire Border Street waterfront could become a flood entry point (21 inches, 2050s).
- A flood pathway could develop through Porzio Park and Massport Harborwalk Park (21 inches, 2050s).
- A flood pathway could develop through Wood Island Bay (36 inches, 2070s).

DEVELOPMENT PLANS

The Marginal Street waterfront is undergoing significant redevelopment. New elevated buildings, roadways, and courtyards are under construction, planned, or complete. The elevation of these properties was a result of City of Boston and Massport climate resilience policies. There is an opportunity for future projects to tie into this newly-elevated waterfront. Such initiatives could improve flood protection, waterfront access, mobility, and open space.

Border Street is facing increasing pressure to redevelop as well. Large, underutilized, post-industrial waterfront sites could support a variety of land uses, including flood protection, open space, and mixed-use development. Regulatory and zoning reforms could unlock these opportunities.

The Lewis Street waterfront experienced flooding during a King Tide in 2016. With 36 inches of SLR (2070s), these annual high tides may cause extensive flooding. (top)

The Border Street East DPA site is at risk of coastal flooding with plus 9 inches (2030s), and plus 36 inches (2070s) sea levels. (bottom)

WE ASKED CHARLESTOWN RESIDENTS WHAT CONCERNS THEM MOST ABOUT COASTAL FLOODING AND SEA LEVEL RISE.

"I am concerned about failing infrastructure, especially **public transportation** *connecting Charlestown to the rest of the city."*

"I am concerned about development that does not prioritize the **public realm**, *affordable housing and public transportation."*

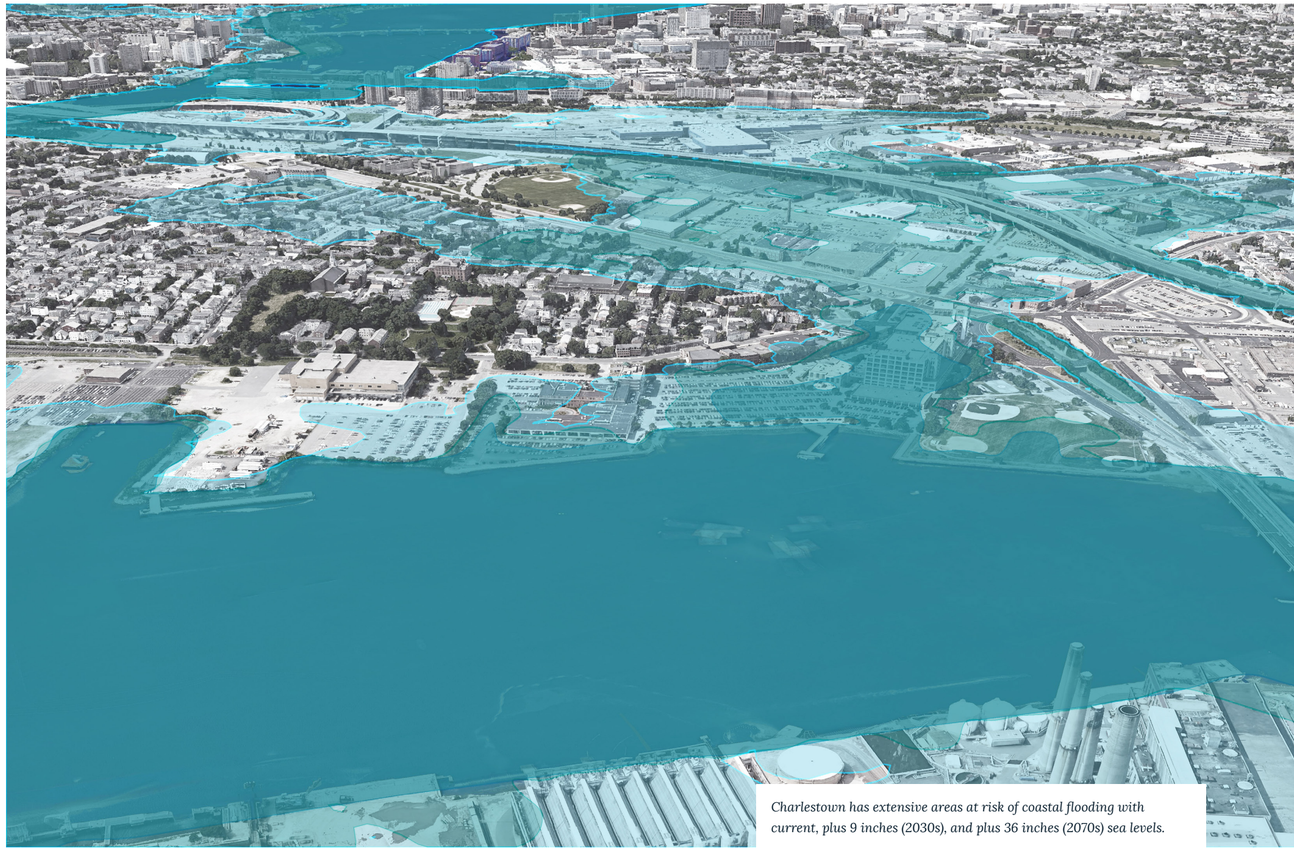
CHARLESTOWN

POTENTIAL IMPACTS

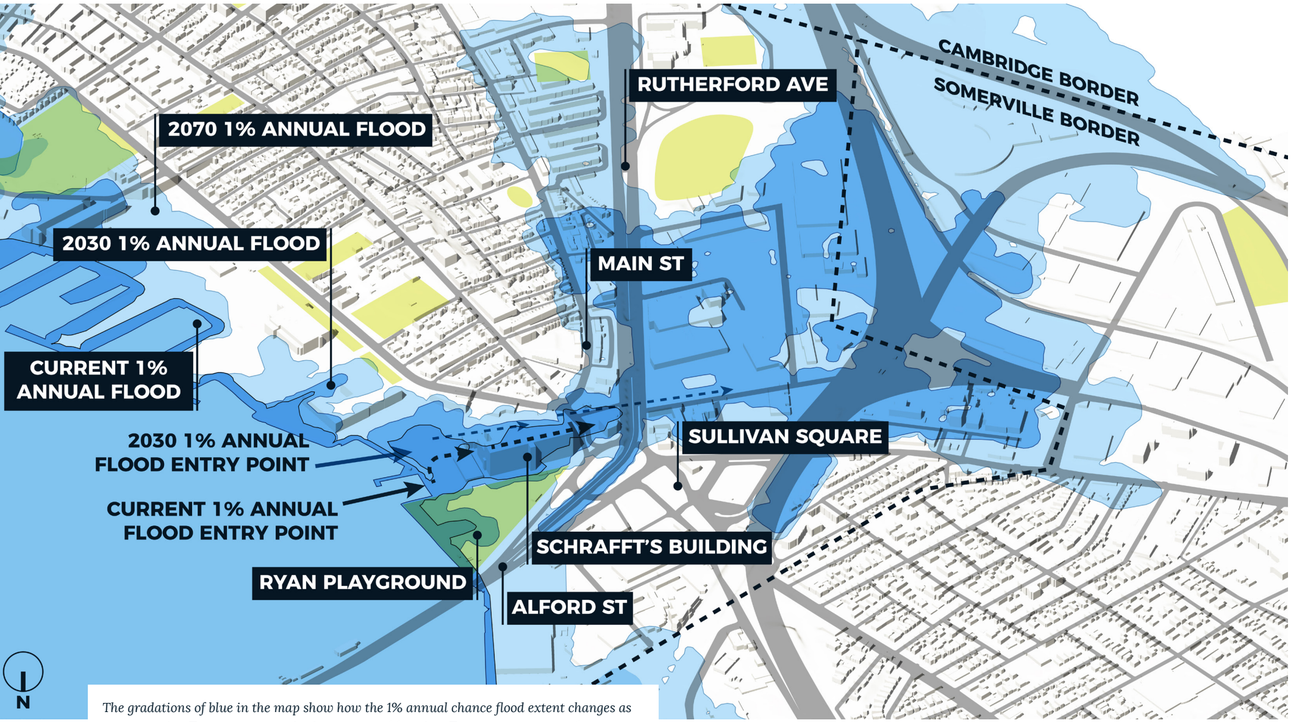
The Charlestown study area includes much of Sullivan Square, the Neck, Rutherford Avenue and areas of Somerville and Cambridge. Flooding of the study area would directly impact the following:

- Socially vulnerable residents.
- Dense residential development.
- Subway stations.
- Commuter rail, bus, and highway maintenance facilities.
- Highway ramps and underpass.
- Fire and emergency medical service stations.
- Combined stormwater and sewer systems.
- Industrial and commercial businesses.

In a 1% annual chance flood with 21 inches of SLR (2050s), flooding through this area could reach the Charles River, bypassing the New Charles River Dam. This could put Beacon Hill, Back Bay, Allston, South End, and areas of Cambridge at risk for flooding .



Charlestown has extensive areas at risk of coastal flooding with current, plus 9 inches (2030s), and plus 36 inches (2070s) sea levels.



The gradations of blue in the map show how the 1% annual chance flood extent changes as sea levels rise. The colors do not indicate depth of flooding. The arrows show the flood entry points and pathways with current sea levels, 9 inches of sea level rise (2030s), and 36 inches of sea level rise (2070s).

FLOOD PATHWAYS

The flood pathway that runs through Sullivan Square leads from low-lying areas along the Lower Mystic River waterfront. The mapon page 32 illustrates the dynamics of coastal flooding through this pathway.

The Sullivan Square waterfront is the most important flood entry point in Charlestown. It is the first and most likely place for coastal flooding to enter.

In the current 1% annual chance flood, water would first cross the waterfronts at Schrafft's City Center (529 Main Street and 465 Medford Street) and Ryan Playground. Water would fill the Schrafft's building parking lot and then flow onto Main Street through the Schrafft's Center driveway and Massport's dormant rail corridor. Flooding would remain localized around Main Street and Mishawum Street.

With 9 inches of SLR (2030s), the 1% annual chance flood would spread to Rutherford Avenue, into the highway underpass, and across various residential, industrial, and commercial areas around Sullivan Square.

The table below highlights the 1% annual chance flood depths at the Schrafft's Center parking lot with current, plus nine inches (2030s), and plus 36 inches (2070s) of sea level rise. It shows that flood depths at the parking lot would be about 0.7 feet deep if a 1% annual chance flood hit Boston today. Flood depths would increase to 2.0 feet by the 2030s, and 4.4 feet by the 2070s.

Other flood entry points could develop in the 1% annual chance flood with 21 inches (2050s) or 36 inches (2070s) of SLR:

- The New Charles River Dam could be flanked directly south of the dam (21 inches, 2050s) or overtopped (36 inches, 2070s), sending flood waters north to Sullivan Square through Cambridge, Charlestown, and Somerville.
- Flooding from Ryan Playground and the MBTA's bus maintenance facility could flow over Alford Street and into the underpass (36 inches, 2070s). MBTA is currently working on a bulkhead replacement and living shorelines project to prevent coastal flooding across their property's waterfront.

Annual Chance Flood Depths At The Schrafft's Parking Lot

Data source: Boston Harbor Flood Risk Model.

FEMA uses the 1% annual chance as a standard to assess flood risks and solutions. This table highlights how the 1% annual chance flood depth will increase with 9 inches and 36 inches of SLR.

		FLOOD DEPTH (FEET ABOVE EXISTING GROUND)		
ANNUAL CHANCE (%)	ANNUAL ODDS	CURRENT (2000S)	+9 INCHES SLR (2030S)	+36 INCHES SLR (2070S)
0.1	1 in 1,000	16.5	17.4	20.6
0.2	1 in 500	1.4	2.3	5.5
0.5	1 in 200	1.0	2.1	5.0
1	1 in 100	0.7	2.0	4.4
2	1 in 50	0.3	1.7	4.0
5	1 in 20	dry	1.0	3.7
10	1 in 10	dry	0.5	3.2
20	1 in 5	dry	0.1	2.5
25	1 in 4	dry	dry	2.3
30	1 in 3	dry	dry	2.1
50	1 in 2	dry	dry	1.7
100	1 in 1	dry	dry	1.2

DEVELOPMENT PLANS

The City is focused on improving infrastructure and planning for redevelopment around Sullivan Square and Rutherford Avenue, as described in *Imagine Boston 2030*. These initiatives are in early enough stages to integrate coastal resilience by design. There are also opportunities to expand planning to include the waterfront.

The City and MassDOT's Rutherford Avenue and Sullivan Square Redesign Project will redesign and reconstruct Rutherford Avenue, including the new underpass, and a new Sullivan Square grid of "Complete Streets" roadways in the area at risk of flooding. Construction is set to begin in 2021. The goals of the project are to:

- Reduce traffic congestion.
- Improve pedestrian, bicycle, and transit conditions and connectivity.
- Create new open space, and public realm.
- Provide opportunities for appropriate development.

The Boston Planning & Development Agency (BPDA) also carried out a land-use planning study in 2013 called the Sullivan Square Disposition Study. The study examined redevelopment scenarios for seven publicly-owned parcels in Sullivan Square. These parcels and their associated public realm and interconnectivity in Sullivan Square will be ready for development once the roadway redesign project is complete.

The Schrafft's Center waterfront at 465 Medford Street experienced minor flooding during a King Tide in 2016. With 36 inches of SLR (2070s), these annual high tides will cause extensive flooding.

04 COASTAL RESILIENCE SOLUTIONS

COASTAL RESILIENCE SOLUTIONS

The layered flood protection systems outlined in this report could provide long-term protection from rising sea levels and coastal flooding, and create social, environmental, and economic benefits for the people of East Boston and Charlestown and all who share in the health of the City and the Harbor.

Illustrations in this report provide an overview of the near and long-term actions that need to be implemented in the decades ahead as East Boston and Charlestown adapt to climate change. The proposed measures address multiple criteria and community priorities identified through stakeholder engagement.

Multiple priorities can be addressed by integrating coastal resilience solutions with new and existing waterfront open spaces. The measures proposed in this report include elevated waterfront parks, enhanced Harborwalks, improved connections to the waterfront, natural wetland buffers, increased tree canopy to combat higher temperatures, and site amenities such as hardscaped seating stairs and furnishings that serve both social and flood protection functions. They also reserve space for compatible, resilient, mixed-use redevelopment with smaller footprints and varying building heights and density that can help activate and finance the waterfront transformation.

Integrated solutions can provide multiple layers of protection from sea level rise and coastal floods, in concert with broader climate resilience measures such as stormwater management, urban heat island mitigation, adapted buildings and infrastructure, and community preparedness. They also have the potential to enhance the public realm, social equity, economic opportunity, waterfront access, and natural resources.

Summaries of the types of strategies selected and how they address multiple objectives are provided below. Implementation plans describing how these strategies would be implemented, along with detailed recommendations for near-term actions are provided in the sections that follow.

EVALUATION CRITERIA

In accordance with *Climate Ready Boston* Initiative 5.2 - determine a consistent evaluation framework for flood defense prioritization, a set of evaluation criteria was developed with input from stakeholders. These criteria guided the design and selection of coastal resilience strategies.

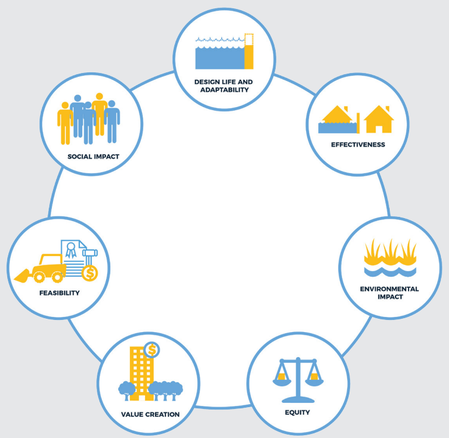
NEAR-TERM ACTIONS AND LONG-TERM ACTIONS

The near-term actions in this study address the main pathways for flooding with 9 inches of SLR (2030s). The long-term actions address the expansion of flood pathways and waterfront flood risks with 21 inches of SLR (2050s). Measures are designed high enough to provide effective flood protection from the 1% annual chance flood with 36 inches of SLR (2070s). However, with 36 inches of SLR (2070s), additional flood pathways (e.g., Wood Island Bay in East Boston and the New Charles River Dam in Charlestown) will develop that need to be addressed in future planning and design work.

Residents also provided feedback on which categories were most important to them in online surveys and at the project open house in East Boston. Residents chose effectiveness as the most important category to consider in the evaluation, followed by design life, environmental impact, and social impact.

Consequently, descriptions of near-term actions in this report include an explicit statement as to the effective time horizon, sea level rise amount, and percent annual chance protection, number of residents protected, and other relevant metrics.

Evaluation Criteria established to help guide and rank proposed climate resilience strategies



CATEGORY	CRITERIA
EFFECTIVENESS	*Maximum level of protection (% annual chance / SLR scenario)* *Reduction in flood extent* *Avoided damage and loss* *Residents protected* *Critical assets protected*
FEASIBILITY	*Stakeholder acceptance* *Constructability* *Permitting* *Affordability: Cost of Construction + Cost of Maintenance* *Replicability*
DESIGN LIFE + ADAPTABILITY	*Design Life* *Performance Horizon* *Adaptability/Flexibility* *Phase-ability and Time to Implementation* *Maintenance Requirements*
SOCIAL IMPACT	*Recreational* *Cultural* *Aesthetic*
EQUITY	*New and Equitable Access to Waterfront* *Additional Benefits for Vulnerable Populations* *Community Partnerships* *Protection of Affordable Housing over the Long Term*
VALUE CREATION	*New Value Created on Sites or Adjacent Sites* *Capacity to Catalyze Future Funding and Investment*
ENVIRONMENTAL IMPACT	*Water and Air Quality* *Habitat Value* *Human Health Benefits* *Mitigation of Other Climate Hazards (Heat, Stormwater)*

East Boston residents provide feedback during the first East Boston Community Open House.

COMMUNITY FEEDBACK

Over 400 residents from East Boston and Charlestown participated in the design process through meetings, community events, open houses, and an online survey. East Boston and Charlestown residents shared their desire for effective and long-lasting solutions to keep them safe from coastal flooding. They worry about how floods will threaten their safety, property, and livelihoods. Additionally, many shared a strong desire for solutions to address other concerns that affect them every day. Those concerns include mobility, affordability, open space, and waterfront access.

They want a safe and reliable transportation system. Without it, their access to jobs and healthcare is at risk. Desired solutions included protecting the highway and transit infrastructure that connects them to greater Boston, expanding the network of safe bicycling and pedestrian connections, and providing water transit options.

They want their neighborhoods to be affordable for people of all incomes, ages, and backgrounds. That means finding ways to reduce the growing cost of flood insurance, protecting and creating new affordable housing, and expanding economic opportunities for local workers and businesses.

Finally, residents want more open space and better access to their waterfront. Open space access in areas like Eagle Hill and Sullivan Square is below citywide averages, and East Boston has the least accessible waterfront of any neighborhood in Boston. Solutions should provide new open space with a diversity of recreational and passive uses, and make the waterfront accessible to all.

> *"Very important topic, glad to see you publicly discussing the options."*
>
> *–East Boston resident*

PROPOSED STRATEGIES

The proposed strategies are coastal flood protection systems integrated with open space. They combine different in-water, shoreline, and upland features to provide flood protection that, over time, becomes comprehensive and layered, providing redundancy in the system which protects against potential damages from failure in any one element.

They also address community priorities. Their designs emphasize accessibility, recreation, connections, views, social spaces, and ecological features while reserving space for appropriate mixed-use redevelopment. Overall, they could improve the public realm in these areas, provide more access for the public use of waterfronts, and maximize performance across a variety of evaluation criteria. These strategies are categorized below into open space strategies, and infrastructure and development strategies.

OPEN SPACE STRATEGIES

Open space strategies score very high using the evaluation criteria developed, specifically with regard to effectiveness, adaptability, social and environmental impact, value creation and equity. They increase the amount of vegetated, permeable, and tree-covered surface in the neighborhoods and improve connectivity and mobility, helping to close the equity gaps in open space and waterfront access and mitigate the impacts of other climate change hazards, such as extreme rainfall and heat. Additionally, they can have a positive impact on shoreline habitat and create access to recreational resources.

Elevated waterfront parks and plazas block critical flood entry points by raising the minimum elevation within the park. They also provide public open spaces for recreation, education, and cultural programming. Their high points are set back from and gently slope towards the waterfront, providing enhanced views of the Harbor.

Parks include soft features such as stormwater gardens, open lawn, recreational fields and hard features such as amphitheater-style seating, all of which can double as flood protection and social spaces. They also reserve space for new stormwater pumping infrastructure that may be needed to control street flooding from extreme rainfall.

Open space can be activated throughout the year to provide increased social activity and public health. Spaces can be programmed for performances, farmer's markets, community gardens, and festivals in warmer weather, and pop-up ice-skating rinks, winter markets, and sledding in the winter. These activities bring the community together and increase cohesion.

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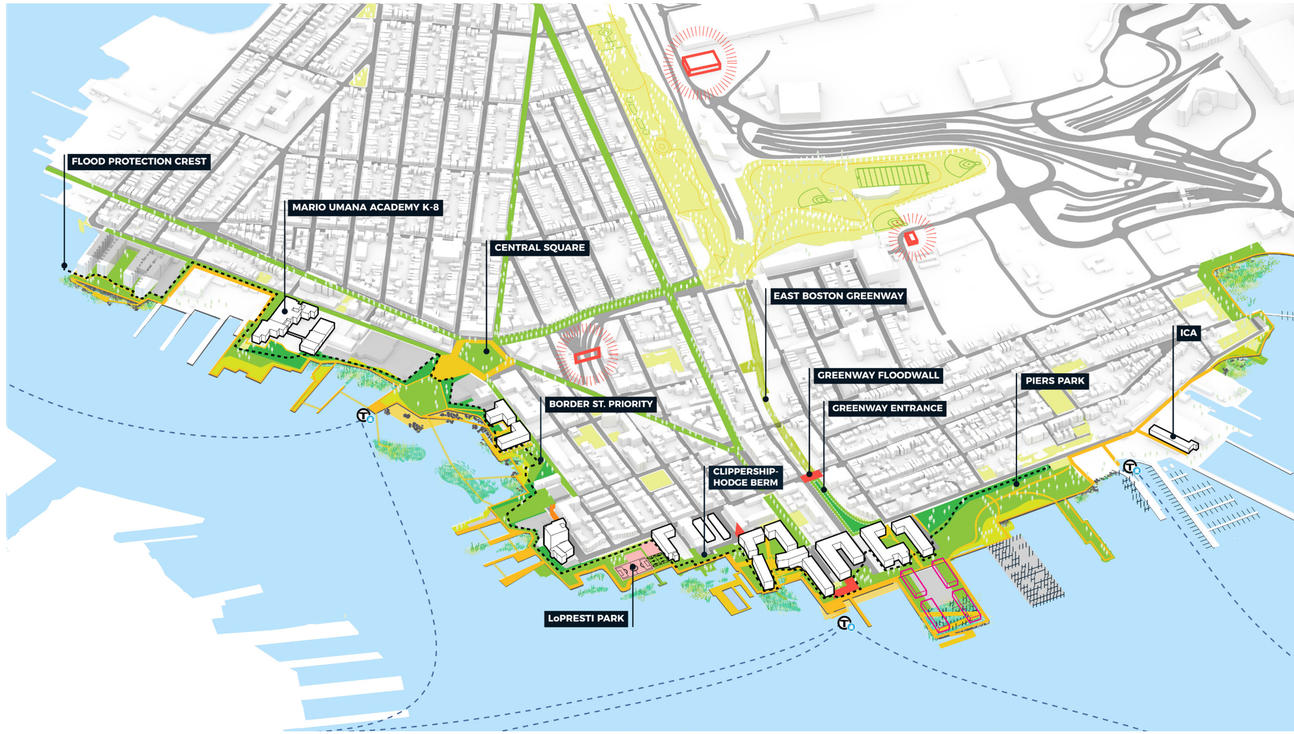


East Boston's long-term climate resilient waterfront strategy.

Charlestown's long-term climate resilient waterfront strategy.

Elevated waterfront pathways connect to these parks and the broader Harborwalk and transportation network. Elevated pathways are on narrow strips of land, called berms. Berms slope up and down over a short distance, towards the shoreline. They are implemented where available space is not sufficient for waterfront parks or where future development or other infrastructure may be anticipated or required and can be placed behind them.

Docks and other in-water features serve as recreational, educational, and aesthetic resources. They help residents exercise their rights to fish, fowl, and navigate along the waterfront.

Nature-based features such as created marshes, living shorelines, wetland terraces, sandy beaches, rocky shores, and floating wetlands can be implemented where shoreline conditions are appropriate. These enhance the Harbor's natural resources and function as natural buffers from storm damage and increased rainfall. They serve in some cases as an extension of the waterfront parks and pathways, increasing available space and protecting them from the wear and tear of tidal fluctuations and waves.

Mobility and connectivity improvements make it easier, safer, and more enjoyable to move around the neighborhood. New networks of parks, pathways, and docks provide options for pedestrian, bicycle, and water transportation.

Complete streets connect to these networks through the heart of the neighborhoods, so residents can access the waterfront, public transit, schools, parks, jobs, local businesses, and social services. Residents are drawn into the waterfront by sight lines from neighborhood streets and open space views.

Projected Sea Level Rise and 1% Annual Chance Flood Elevations

Data sources: Climate Ready Boston projections and BH-FRM. Elevations are in Boston City Base (NAVD 88 elevations are 6.5 feet lower than Boston City Base)

	CURRENT (2000)	2030S	2050S	2070S
RELATIVE SEA LEVEL RISE		9 inches	21 inches	36 inches
1% ANNUAL CHANCE FLOOD ELEVATION (BOSTON CITY BASE)	15.7 feet	17 feet	18 feet	19.5 feet
TARGET FLOOD PROTECTION ELEVATION (BOSTON CITY BASE)	16.7 feet	18 feet	19f eet	20.5 feet

INFRASTRUCTURE AND DEVELOPMENT STRATEGIES

Elevated roadways and deployable flood walls are relatively simple and affordable solutions to block critical near-term flood pathways. They cannot provide long-term protection because their height is limited by surrounding buildings and infrastructure, however, they are important layers of coastal flood protection systems, providing early actions that score well in terms of feasibility, near-term effectiveness and in some cases adaptability. Eventually, waterfront protection systems make these measures redundant. If waterfront systems fail, these measures provide some backup protection.

Mixed-use development, properly planned and designed, invigorates inactive post-industrial sites on the waterfront. Taller buildings with smaller footprints maximize the space available for parks and flood protection, while preserving or increasing development value. Zoning requirements can be updated for residential buildings to include additional housing for low and middle income households. Ground floors can provide for public uses – supermarkets, retail, restaurants, entertainment, education, and arts.

Through zoning and financing strategies, value captured from this development can help pay for the coastal flood protection system. With ground floors raised to the required minimum elevation, development can provide flood protection for building occupants and for inland properties when completed alongside raised roadways and waterfront open space.

Local businesses are supported through the addition of new ground-floor uses in mixed-use development, and existing ones enjoy new customers and opportunities to expand. Open space, commercial, and cultural attractions create a draw for visitors, who can access the neighborhood by subway, bus, bicycle, and boat. Their visit takes them through the neighborhoods where they eat and shop at local establishments. Small entrepreneurs find opportunity within parks and open space for vending and other recreation-based services such as fitness classes.

Maritime industries concentrate where they are best situated to thrive. These are sites with well-developed shorelines and deepwater channels. Public support can help industries upgrade their infrastructure and equipment, so they can help Boston remain a competitive port city. These investments score well relative to value creation and social impact.

"Can we make these neighborhoods accessible to residents not just with public lands but with affordable corner stores, cafes and restaurants?"

– East Boston resident

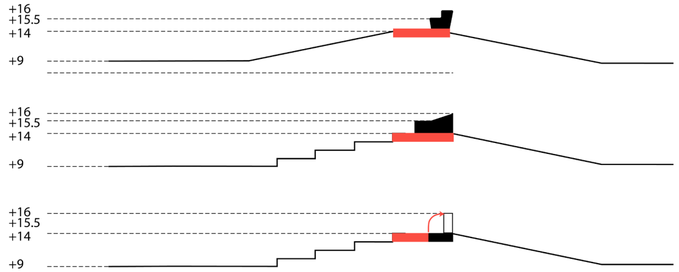
EFFECTIVENESS AND ADAPTABILITY

Primary flood protection measures, such as elevated parks and berms, have a lifespan of 50 years or longer, with periodic maintenance and renewal. They are designed to protect up to a 1% annual chance coastal flood with 36 inches of SLR (2070s), plus 1 foot of freeboard. Based on *Climate Ready Boston* projections and the Boston Harbor Flood Risk Model (BH-FRM), this design flood elevation is approximately 20.5 feet in Boston City Base (14 feet NAVD88), similar to the current 1% annual chance flood plus 5 feet, and the 0.1% annual chance flood elevation with 36 inches of SLR (2070s).

Open space systems are also adaptable to even greater sea level rise. Parks and pathways reserve space that can be built higher, if needed in the future. At least 2 feet of extra flood protection is possible within their proposed footprints, which could extend effectiveness for an estimate of 20 additional years. Means of further elevation include adding fill, integrating structural furniture that adds height and social capacity, or installing deployable flood walls.

Based on Climate Ready Boston projections, the design flood elevation is approximately 20.5 feet in Boston City Base (14 feet NAVD88)

The site-specific measures that make up the strategies for East Boston and Charlestown are replicable and flexible. They can be implemented incrementally over time and phased by priority relative to the rate of sea level rise and the growing flood risk. These same types of measures may be applicable in other neighborhoods.



Coastal flood protection systems can be further elevated using integrated seating (top) planters and/or seat walls (middle) and deployable flood walls (bottom). The numbers shown are elevations in feet NAVD88, which can be converted to Boston City Base by adding 6.5 feet.

05 IMPLEMENTATION ROADMAPS

IMPLEMENTATION ROADMAPS

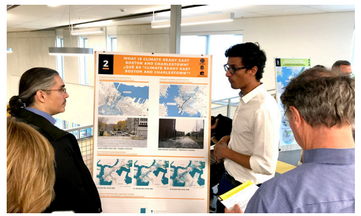
Roadmaps were developed to guide the implementation of near-term actions in the East Boston and Charlestown study areas between now and 2030, and long-term actions through 2050 and beyond. They include high level phasing plans, cost estimates, and benefit-cost analyses. Near-term actions are described in more detail, with recommendations on design, policies, partnerships, and funding.

The recommended phasing plans reflect current understandings of how flood risks will evolve. They take into account foreseeable cycles of development and redevelopment and the time necessary for completing different actions. They also provide flexibility to adapt plans as more is learned about the risks and solutions.

Order-of-magnitude estimated costs for capital projects were developed to inform long-term planning. They are based on estimated costs per acre for typical waterfront berms, parks, and shoreline protection features, and scaled based on how high they need to be built above the surrounding ground. The estimates are generally presented as ranges and include large contingencies due to the limited information available on existing conditions and future designs.

Both costs and phasing plans are estimates and recommendations only, and should not be used for detailed planning.

Benefits of flood protection and overall cost-effectiveness were estimated for the recommended near and long-term actions in each study area. The benefits of fully implementing the identified coastal resilience solutions extend well beyond flood protection to include social, ecological, and economic factors, although many of these benefits cannot be easily quantified. The directly quantifiable benefit of flood protection, or "avoided loss", is the amount of flooding losses without the proposed measures minus the losses with these measures, weighted by the probability of such losses occurring.



East Boston and Charlestown residents provide feedback at the public open house held at Excel Academy (top) and Schrafft's Center (bottom).

Loss estimates are based on *Climate Ready Boston* data from within the study areas. They include estimated losses from damages to buildings and their contents, displacement costs, impacts to productivity, and mental stress, as defined in the *Climate Ready Boston* report. Further details on the loss estimation data are provided in the *Climate Ready Boston* Approach and Methodology Appendix. These estimates are rough because the benefits that are unaccounted for in this analysis are substantial. They include:

- Avoided business interruption costs;
- Avoided restoration costs related to infrastructure damage and disruption;
- Avoided losses in Cambridge, Somerville, and other areas of Boston;
- Impacts to the regional economy;
- Future development, property values, and population density; and
- Other social, economic, and environmental benefits.

Further research and analysis can help shed light on these and other benefits, so that they can be considered as projects move forward in the implementation process.

Net project benefits and benefit-cost ratios were estimated to measure the cost-effectiveness of an action or group of actions. First, the avoided losses from taking action were annualized for the 10%, 2%, 1%, and 0.1% annual chance floods with 9 inches (2030s) and 21 inches (2050s) of SLR. Then, the net present value of these benefits was calculated over a 20-year time period, using a discount rate of 7%, and compared with current estimated costs of implementation. Actions were considered cost-effective if the benefits were greater than or equal to the costs (i.e., benefit-cost ratio of 1.0 or greater). The amount of benefit left over after subtracting the costs was the net benefit.

As summarized in the following table and described below, the proposed coastal resilience solutions for East Boston and Charlestown are cost-effective.

Estimated Costs and Benefits of Near and Long-Term Actions

EAST BOSTON

ESTIMATED COST	$121 - 200 million
NET PROJECT BENEFIT	$443 - 522 million
BENEFIT-COST RATIO	3.2 - 5.3

CHARLESTOWN

ESTIMATED COST	$33-62 million
NET PROJECT BENEFIT	$201 - 229 million
BENEFIT-COST RATIO	4.3 - 7.9

Estimated Costs and Benefits of Near-Term Actions in East Boston

ESTIMATED COST	$48-80 million
NET PROJECT BENEFIT	$29-69 million
BENEFIT-COST RATIO	1.4 – 2.7

EAST BOSTON

The near-term actions in East Boston's implementation roadmap address the Marginal Street and Border Street pathways for flooding with 9 inches of SLR (2030s). The long-term actions address the expansion of flood pathways and waterfront flood risks with 21 inches of SLR (2050s). Measures are designed to be high enough to provide effective flood protection from the 1% annual chance flood with 36 inches of SLR (2070s). However, with 36 inches of SLR (2070s), additional flood pathways (i.e., Wood Island Bay) will develop that need to be addressed in future planning and design work.

NEAR-TERM ACTIONS

In East Boston, implementation should begin with the Marginal Street flood pathway, which is at risk of flooding with current sea levels. Physical measures to address this pathway include a deployable flood wall in the East Boston Greenway, new elevated open spaces at the Greenway entrance and Piers Park II, and adaptations to ongoing development projects.

To address the Border Street flood pathway, which is at risk of flooding with 9 inches of SLR (2030s), upfront planning and regulatory measures may be needed to facilitate the implementation of solutions, like a waterfront park at Central Square. Potential changes to designated port areas, the municipal harbor plan, and zoning in the near term can help ensure that future waterfront redevelopment on Border Street contributes to the implementation of identified coastal resilience solutions.

Implementing all near-term actions would protect over 10,800 residents, at least 250 businesses, and a variety of critical infrastructure, such as transportation tunnels, first responder facilities, and the East Boston Neighborhood Health Center, up to the 1% annual chance flood with 9 inches of SLR (2030s), plus 1 foot of freeboard. This protection level is roughly equivalent to the 1% annual chance flood with 21 inches of SLR (2050s). At this level of protection, from a single event these measures would prevent an estimated $620 million in losses.

Residual risks from localized flooding at properties on the waterfront, such as Mario Umana Academy, various maritime industrial facilities, and residences near Porzio Park, would remain until the long-term actions are implemented.

Greenway Flood Wall: A deployable flood wall across the Greenway under Sumner Street would provide immediate protection from coastal flooding to over 4,200 residents, at least 70 businesses, transportation tunnels, and critical service providers at an estimated cost of $100,000. This section of the East Boston Greenway is owned by the City of Boston and maintained by the Parks and Recreation Department.

The flood wall would be approximately 7 feet tall and effective up to the current 1% annual chance flood level, plus 1 foot of freeboard. If flooding exceeded this elevation, it would go around the flood wall from Border Street. Additional layers of protection will be needed at the Greenway Entrance, Piers Park II, and Border Street to protect East Boston from these growing risks.

Because these flood walls must be manually deployed, an operational plan needs to be established for identifying potential flood events and installing the flood walls. Massport has established protocols for similar actions at Logan International Airport in East Boston.

Deployable flood walls, such as the type shown in these renderings of the Greenway under Sumner Street, are installed only when a flood is anticipated. They are otherwise kept in storage.

Greenway Entrance and Piers Park II: Elevating the Greenway entrance (owned by the City) and Piers Park II (owned by Massport), up to 5.5 feet above the existing grade would block the Marginal Street flood pathway from a 1% annual chance flood with 36 inches of SLR (2070s), with 1 foot of freeboard. These projects would have a lifespan of 50 years or longer.

The Greenway entrance and Piers Park II would provide effective protection from the current 1% annual chance flood, plus 1 foot of freeboard, to over 4,600 residents, at least 70 businesses, transportation tunnels, and first responder facilities. These near-term actions will become more effective over time, as solutions to other flood pathways are implemented on Border Street, and eventually at Porzio Park and Wood Island Bay. Massport is initiating a community planning process to redesign Piers Park II.

At the East Boston Open House, community members responded positively to ideas for the park's design, such as waterfront views, improved plantings, stormwater gardens, social spaces, reuse of the historic caboose, and wayfinding information.

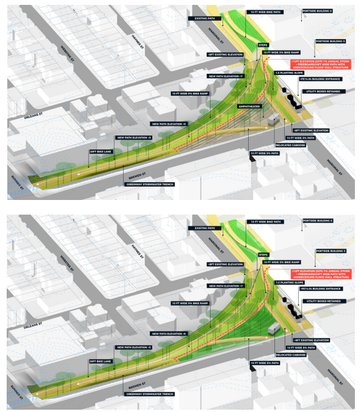
We developed four options for the Greenway entrance that differ slightly in their form and function. Bird's-eye renderings of two options, at right, illustrate what each of these options might look like. Two options have the character of a more traditional parkway with sloped seating lawns (shown at bottom), while the others feature a large plaza with hardscaped seating and space for events (shown at top). Community members who attended the project's Open House favored the parkway concept.

The estimated cost for design and construction is $3.1-5.3 million. This range is to account for unknown characteristics of the site (e.g., soil quality) and final design (e.g., utilities and landscaping) that could decrease or increase the project costs.

Possible sources of grant funding include:

- CZM's Coastal Resilience Grants program
- Massachusetts Division of Conservation Services PARC Grants
- FEMA's Pre-Disaster Mitigation Program
- US Army Corps of Engineers' Section 103 program

The project should be designed and operated to standards set by the US Army Corps of Engineers and Federal Emergency Management Agency. That way the project will be eligible for federal funding if repairs are needed, and the community can qualify for flood insurance reductions.



Solutions for the Greenway entrance differ slightly in their form and function. Two options shown above allow for a large lawn or 'green' or a large hardscape plaza.

One version of a new elevated entrance to the East Boston Greenway provides flood protection, space and shade while retaining pedestrian and cycling access between the neighborhood and the Greenway.

Clippership-Hodge Berm: Elevating the Harborwalk between Clippership Wharf, Clipper Ship Apartments, and 99 Sumner Street (Hodge Boiler Works), in combination with a deployable flood wall across Lewis Street, would protect residents in these buildings and nearby affordable housing, and the new MBTA Maverick Station entrance from flooding damage and disruption. The estimated cost for design and construction is $500,000 to $900,000 for the berm and less than $150,000 for the deployable flood wall.

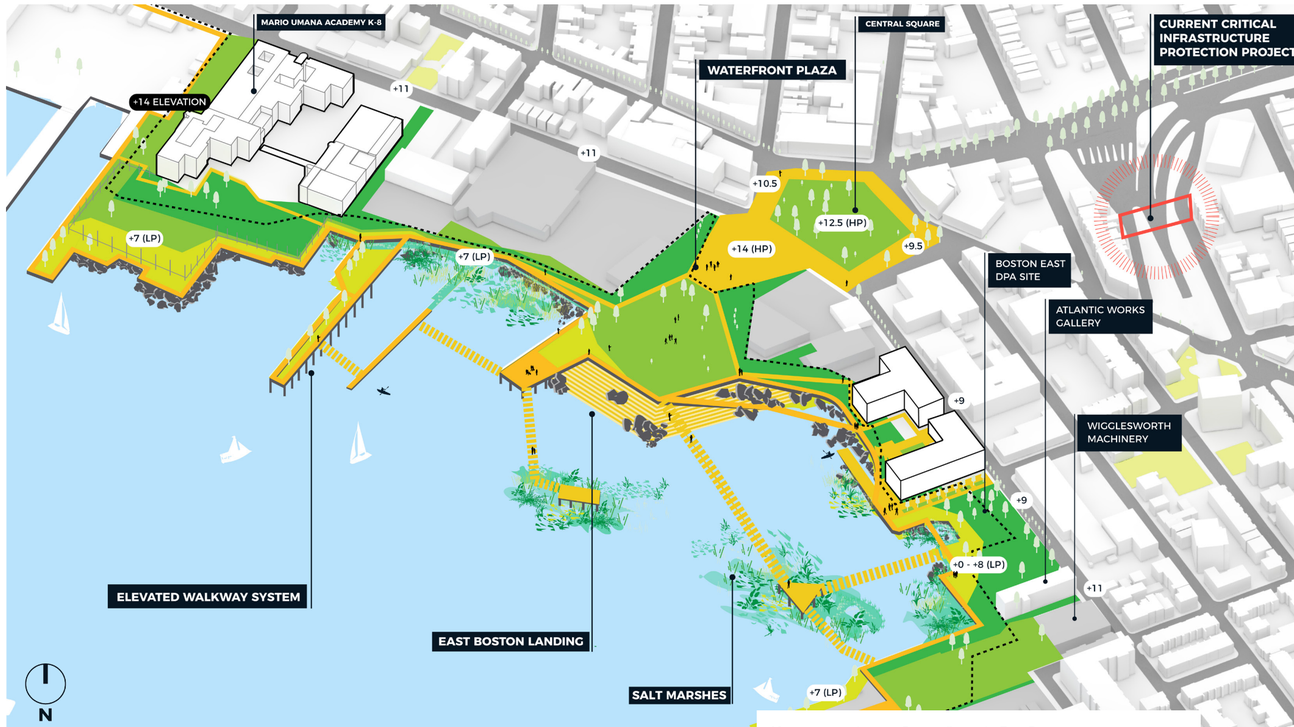
This is a time-sensitive opportunity to integrate climate resilience in ongoing construction projects that are likely to be complete by 2025. This recommendation is consistent with *Climate Ready Boston* Initiative 9.3, to "promote climate readiness for projects in the development pipeline."

Border Street Priority Area: The Border Street waterfront is the second most important flood pathway in East Boston. Creating a system of elevated parks, Harborwalks, docks, and nature-based features on the Border Street waterfront would address these risks along with multiple community objectives, including open space, mobility, waterfront access, and others. Raised roadways or a system of permanent flood walls would be effective alternatives, but would only serve flood protection purposes.

Over the long-term this system would extend from Mario Umana Academy to the Eddy, in addition to a separate system at Shore Plaza. If fully implemented, these measures would create 11 acres of new, green, open space and almost half a mile of newly accessible waterfront. It would also reserve space for redevelopment set-back from the waterfront. Allowing for higher and denser redevelopment in these areas would offset the loss of developable space taken up by flood protection and open space systems, and generate value that can be captured to help pay for implementation.

Solutions should be implemented first at high priority reaches between Mario Umana Academy and Wigglesworth where the flood pathway would form in the 1% annual chance flood with 9 inches of SLR (2030s). These include an elevated open space at the Boston East DPA site and a signature waterfront park at Central Square with elevated Harborwalks extending in both directions. The systems should be designed to eventually protect up to the 1% annual chance flood with 36 inches of SLR (2070s), so that they can be extended in both directions over time without having to further elevate.

Implementing all near-term actions would protect over 10,800 residents, at least 250 businesses, and a variety of critical infrastructure and community services, such as transportation tunnels and the East Boston Neighborhood Health Center among others. At this level of protection, from a single event the measures would prevent an estimated $620 million in



Near-term actions on Border Street in East Boston could create a coastal flood protection system integrated in a new network of open spaces, which could be extended over time as sea levels rise.

flood-related losses.

The estimated cost of designing and constructing priority flood protection projects on Border Street by 2030 is $24-39 million. In only 20 years of their 50-year effective lifespan, these solutions would be cost-effective, generating net expected project benefits of $443-522 million and achieving a benefit-cost ratio of 3.22-5.3.

The highest priority site, where flooding is most likely to enter the Border Street flood pathway, is the Boston East DPA site between Boston East and Atlantic Works. This site will be redeveloped in the near term as an open space with a new Harborwalk and shoreline protection structures and possibly a maritime industrial building. However, as currently planned, it will not be sufficiently elevated to prevent flooding from passing through the property. Additional fill will be required to raise the open space to the needed elevation (14ft NAVD88).

The next priority is to address the risk of flooding through the Liberty Plaza and Shaw's properties. The vision for these sites is to create a new waterfront park, with space reserved for redevelopment. A park at this location would connect with and amplify the benefits of the recent improvements to Central Square, implemented by the Boston Transportation Department and Public Works Department. This connection would provide sight lines of the water from Bennington Street and Meridian Street and increase foot traffic through the Main Streets commercial district to the benefit of small local businesses.

The park could include an extended plaza with waterplay features for the enjoyment of families in the area and to help mitigate the impacts of urban heat. The edge of this plaza would meet the target flood protection elevation, and allow for longer vistas of the waterfront. A large lawn could be programmed with cultural and entertainment events or used for passive recreation. At the waterfront edge of the lawn, a stepped amphitheater could provide seating and direct access to the water for recreational and educational purposes. In addition, a water shuttle dock could provide important connections to and from East Boston and the city's job centers.

There are important existing uses on these properties that would need to be provided for as part of redevelopment, including retail space, East Boston's only supermarket, and a maritime industrial use. The planning process for this area should consider ways to accommodate these uses within the footprints reserved for redevelopment or other more suitable locations in East Boston.

In addition, the need for stormwater management systems, including pumping stations, should be further evaluated, and if needed, included in park designs. Several outfalls located along this waterfront may need to be adapted to prevent water from building up or backflowing during heavy rainfall events. These needs have not been evaluated and accounted for in the estimated costs of construction.

There are two scenarios for how Border Street

Easements, designated port area changes, and re-zoning are needed to facilitate implementation on priority Border Street properties.

priority actions could proceed. A single public owner, such as the City, could implement them as a single project, for example with funding and technical support from the US Army Corps of Engineers. Alternatively, multiple owners or partners could implement them as a series of projects. Different actors, including the City, philanthropies, land conservation trusts, and the private sector have capabilities that could be brought to bear in such a scenario. The estimated cost of designing and constructing priority flood protection projects on Border Street by 2030 is $24-39 million.

Planning and Regulatory Tools: Implementing these actions will require a significant planning process with input from the community, property owners, State regulators, potential funding partners, and others. A comprehensive waterfront planning initiative in this area, including municipal harbor and designated port area planning procedures could codify new zoning and other land use controls.

By furthering *Climate Ready Boston Initiatives* 5.1 - *Establish Flood Protection Overlay Districts and require potential integration with flood protection systems* and 9.5 - *Incorporate future climate conditions into area plans*, these efforts will provide an important testing ground for approaches that could be applied elsewhere in Boston, including working with the private sector to implement coastal resilience solutions.

For example, the areas between Mario Umana Academy and the Eddy are largely within Designated Port Areas. Some measures proposed on Border Street are not allowed in designated port areas, because they may prevent future water-dependent industrial uses. These include important elements such as waterfront parks and mixed-use development that could activate and help finance the coastal flood protection system.

The Municipal Harbor Plan and State regulations provide the framework for reexamining the boundaries of the existing designated areas in East Boston, including in the context of the broader Harbor. These areas may no longer meet the specific criteria the State uses for designation. Significant changes have occurred on land and water over the decade since the last review. Lifting the designation could enable the implementation of the proposed flood protection strategies, as well as appropriate redevelopment.

It may be beneficial for the City to secure land rights or easements on several properties. Easements to inspect and maintain flood protection infrastructure are required for projects to be eligible for public funding and financing, including federal support. They are also required for FEMA to recognize the flood protection system in flood insurance maps. Through these efforts, the City will need to balance the efficiencies of implementing the Border Street flood protection infrastructure through public interventions or public, private, and non-profit partnerships.

BPDA may also use established municipal harbor planning procedures to develop an updated plan for Border Street. This plan would allow the City to develop locally-appropriate modifications to how the State applies its waterfront development regulations. This plan would provide important tools, including changes to building heights and density provisions and identification of critical open spaces, that may be needed to support a pattern of development that is compatible with the coastal resilience strategy.

POTENTIAL EAST BOSTON NEIGHBORHOOD DISTRICT ZONING CODE REVISIONS	VALUE FOR IMPLEMENTING COASTAL RESILIENCE SOLUTIONS
Establish a Flood Protection Overlay District and require potential integration with flood protection systems (Climate Ready Boston Initiative 5.1)	*Requires that development proposals do not prevent the future creation of flood protection infrastructure*
Establish an Interim Planning Overlay District between Mario Umana Academy and the Eddy	*Provides the BPDA with time to complete planning studies while maintaining oversight to ensure near-term development is not incompatible with coastal resilience solutions*
Transfer priority parcels on Border Street from Community Commercial and Maritime Economy Reserve subdistricts to Waterfront Commercial subdistricts	*Acceptable and Conditional uses in Waterfront Commercial subdistricts generate more value to help fund flood protection infrastructure*
Increase open space requirements for Waterfront Commercial subdistricts beyond the current 50%	*Ensures generous public open space is reserved for future flood protection infrastructure, and encourages smaller building footprints for improved urban quality*
Consider substitute provisions to Chapter 91 minimum use limitations and numeric standards through a public municipal harbor planning process	*Tradeoffs for substitute provisions to Chapter 91 minimum use limitations and numeric standards offsetted by increased open space and flood protection infrastructure requirements*
Include coastal flood protection infrastructure in the list of Planned Development Area Public Benefits	*Provides BPDA with a policy for approval of development plans on the basis of whether they provide coastal flood protection as a public benefit*
Include coastal flood protection in the list of Proper Public Purposes under Chapter 91 Tideland Requirements	*Provides BPDA with a policy for recommending a State Chapter 91 License approval on the basis of whether a project adequately addresses the public interest in coastal flood protection*
Add to Waterfront Design Guidelines that projects should prevent flooding from crossing over their property and should provide equal or higher flood protection than their waterfront abutters	*Provides BPDA with a policy for approval of large projects and inclusion of conditions on the basis of whether they meet coastal flood protection design guidelines*

POTENTIAL ARTICLE 80 DEVELOPMENT REVIEW AND APPROVAL REVISIONS	VALUE FOR IMPLEMENTING COASTAL RESILIENCE SOLUTIONS
Require information on project location relative to coastal flood pathways within Flood Protection Overlay Districts in the Scope of Large Project Reviews and Contents of Reports	*Gives the City more information about proposed projects and potential opportunities and conflicts with district-scale coastal resilience strategies*
Add to Standards for Large Project Review Approval that projects in Flood Protection Overlay Districts should prevent flooding from crossing over their property and should provide equal or higher flood protection than their waterfront abutters	*Provides BPDA with a policy for approval of large projects and inclusion of conditions on the basis of whether they meet coastal flood protection design guidelines*

Estimated Costs and Benefits of Long-Term Actions in East Boston

ESTIMATED COST	$121-200 million
NET PROJECT BENEFIT	$443-522 million
BENEFIT-COST RATIO	3.2 – 5.3

LONG-TERM ACTIONS

The next tier of measures would expand the reach of coastal resilience solutions along the study area waterfront to independently address risks from the 1% annual chance flood with 21 inches of SLR (2050s), plus 1 foot of freeboard. However, with additional flood protection measures in other parts of the neighborhood, their heights would protect up to the 1% annual chance flood with 36 inches of SLR (2070s), plus 1 foot of freeboard.

Elevated parks and pathways at Mario Umana and Shore Plaza would protect vulnerable affordable housing residents and critical facilities. Porzio Park and Massport Harborwalk Park would be elevated to address the flood pathway that could develop through this area with 21 inches of SLR (2050s). As existing parks and buildings reach the age where renewal investments are needed, they would incorporate waterfront flood protection measures that tie into the broader system.

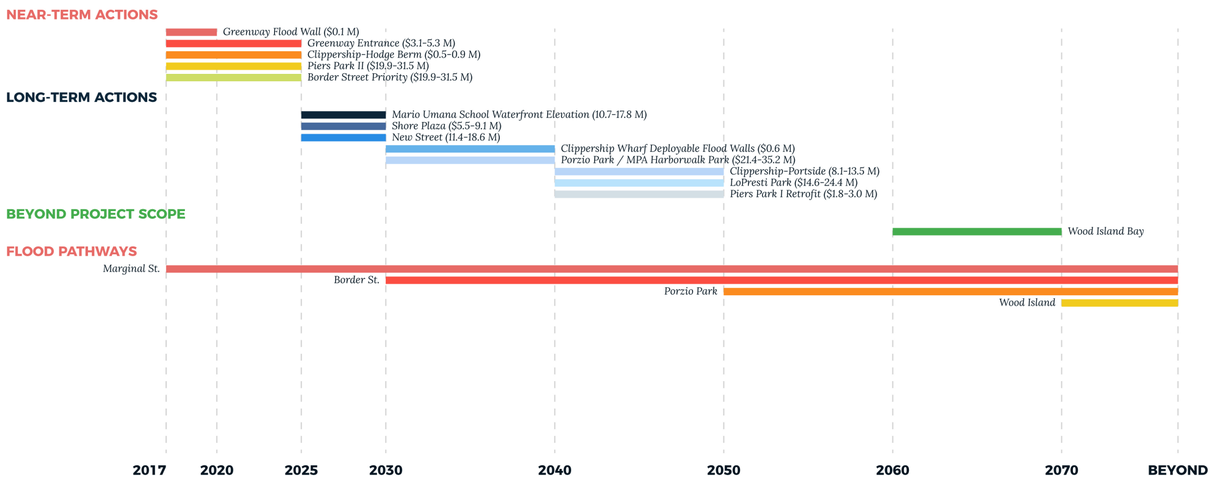
Full implementation of near- and long-term measures would protect over 13,200 residents, at least 310 businesses, drainage and combined sewer systems, and many critical facilities up to the 1% annual chance flood with 21 inches of SLR (2050s), plus 1 foot of freeboard. At this level of protection, from a single event these measures would prevent an estimated $1.3 billion in losses.

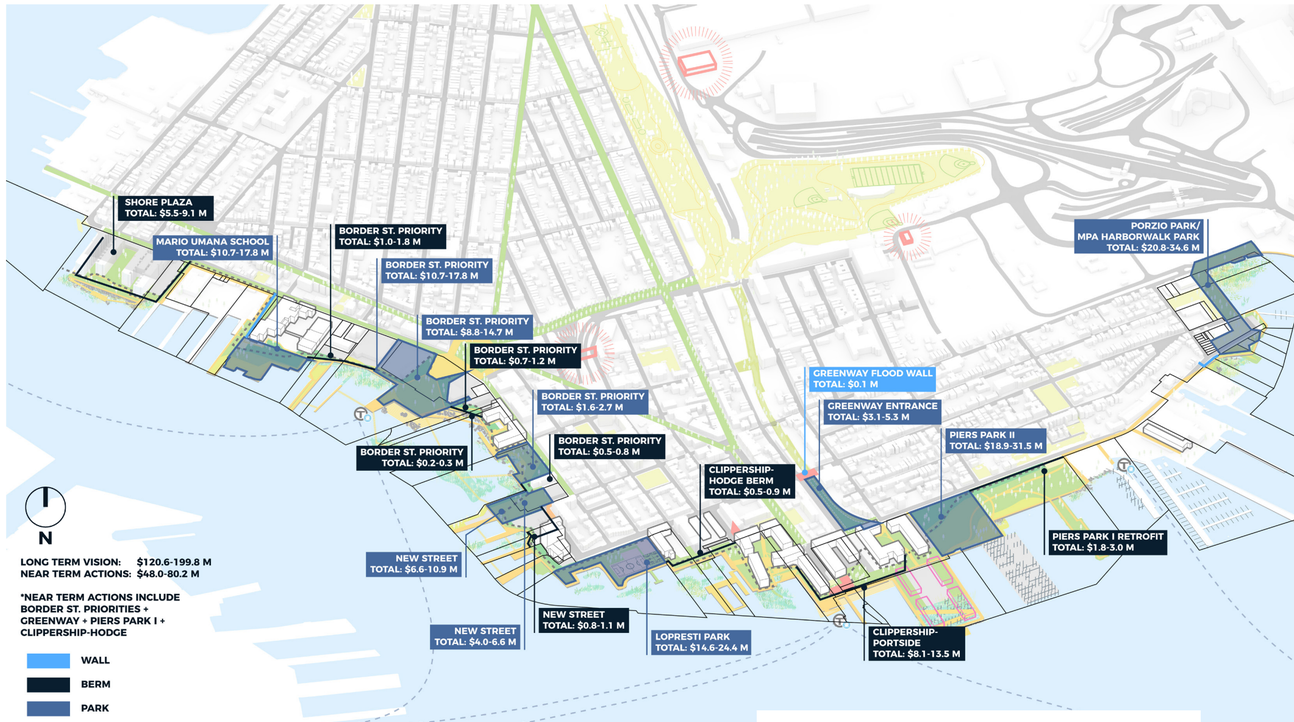
Additional measures would be needed to address the potential flood pathway through Wood Island Bay (36 inches of SLR, 2070s) to extend the effectiveness of coastal resilience solutions. In addition, measures designed and built in the 2030s and 2050s would need to be evaluated to determine whether and how they should be adapted to provide higher protection when sea level rise exceeds 36 inches. For example, adding 2 feet of flood protection could extend their effective life by about 20 years or more.

East Boston's long-term climate resilient waterfront includes new waterfront parks and plazas connected to other existing assets such as Central Park and Border Street's retail center.

RECOMMENDED TIMELINE: EAST BOSTON

Recommended phasing plan for coastal resilience solutions in the East Boston study area.
Both costs and phasing plans are estimates and recommendations only, and should not be used for detailed planning.





Estimated costs for coastal resilience solutions in the East Boston study area. Both costs and phasing plans are estimates and recommendations only, and should not be used for detailed planning.

East Boston's long-term climate resilient waterfront strategy.

East Boston Open House participants indicate their desires for the future of the waterfront at the first public Open House. Input was used to help create the long-term strategy shown on the previous page.

CHARLESTOWN

The near-term actions in Charlestown's implementation roadmap address the Sullivan Square flood pathway for flooding with 9 inches of SLR (2030s). The long-term actions address the Ryan Playground flood pathway which form with 36 inches of SLR (2070s). Measures are designed to be high enough to provide effective flood protection from the 1% annual chance flood with 36 inches of SLR (2070s). However, with 21 inches (2050s) or 36 inches (2070s) of SLR, additional flood pathways (i.e., New Charles River Dam) will develop that need to be addressed in future planning and design work.

NEAR-TERM ACTIONS

In Charlestown, the implementation roadmap is less complex, because there is one critical flood pathway which can be addressed by a small number of near-term actions and owners. Proposed near-term actions would integrate coastal resilience solutions in existing City of Boston capital projects and create a new waterfront open space and flood protection system through private redevelopment.

A small section of Main Street, in front of the Schrafft's Center, should be elevated as part of the Rutherford Avenue and Sullivan Square redesign project, currently in design and scheduled to begin construction in 2021. The redesign project is being led by the Boston Transportation Department, in partnership with the Massachusetts Department of Transportation.

In addition, low-lying areas of the Ryan Playground waterfront should be elevated as part of the park's next scheduled renovation. Additional long-term actions would be needed to further elevate the waterfront to prevent the park from becoming a flood pathway in higher SLR conditions. Ryan Playground is owned by the City of Boston and managed by the Parks and Recreation Department.

The more complex near-term action is to create a new system of elevated parks and pathways along the Schrafft's Center waterfront, combined with private redevelopment. The minimum elevation along the crest of these new waterfront open spaces would be high enough to protect up to the 1% annual chance flood with 36 inches of SLR (2070s), plus 1 foot of freeboard.

In addition to being a critical component of the long-term flood protection system, measures at Schrafft's Center would provide significant new open space and waterfront access for the Sullivan Square community, and create economic development opportunities. Planning and regulatory controls should be used to take advantage of these opportunities in conjunction with the *Imagine Boston* 2030 plans for Sullivan Square.

These actions would protect about 330 residents, at least 60 businesses, first responder facilities, and various transportation infrastructure from the 1% annual chance coastal flood with 9 inches of SLR (2030s), plus 1 foot of freeboard. At this level of protection, from a single event these measures would prevent an estimated $390 million in losses. The projects are estimated to cost in the $30-53 million range.

Because the Schrafft's Center projects account for most of these costs and continue to function and generate benefits up to 21 inches of SLR (2050s), cost-effectiveness needs to be considered over a longer time horizon. As discussed below, these actions are highly cost-effective over the long term.

Main Street Elevation: The critical flood pathway in the Charlestown study area leads through a narrow, low-lying section of Main Street before spreading across the community. This section is located in front of the Schrafft's Center driveway, between Bunker Hill Street and Alford Street.

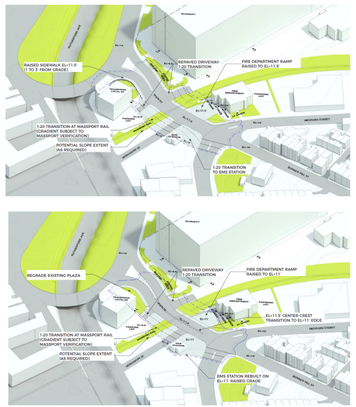
Elevating this section of Main Street an average of 2 feet above the existing grade would block the main flood pathway through Charlestown from 1% annual chance flooding and 9 inches of SLR (2030s), plus 1 foot of freeboard. This would protect over 250 residents, at least 60 businesses, drainage and combined sewer systems, first responder facilities, and the Rutherford Avenue underpass. Achieving a higher flood protection level would not be feasible unless the existing fire station at the intersection of Medford Street and Main Street were redesigned or relocated.

The City could integrate the roadway elevation in the ongoing Rutherford Avenue and Sullivan Square redesign project, currently in design and scheduled to begin construction in 2021.

Two design alternatives for elevating Main Street are feasible. One alternative is to meet the target flood protection elevation at the centerline of the road, and the other is to meet it across the entire width of the road. Renderings of these alternatives are shown below.

In either alternative, the elevated roadway would tie into high ground on Medford Street, Bunker Hill Street, and Alford Street. The Rutherford Avenue project will reconstruct the intersection of Main Street and Alford Street, among many other improvements.

Raising the road may impact utilities and drainage infrastructure. The eastern side of Main Street may need separated drainage, for example. This would prevent flood water from crossing under the roadway through drain pipes.



Two options for raising Main Street to act as flood protection are shown. The entire width of Main Street could meet the target flood protection elevation (top) or the centerline of Main Street could meet the target flood protection elevation and then slope down toward the edge of the road (bottom).

More detailed design work will be needed to coordinate the roadway elevation with the following existing features:

- Schrafft's Center, Teamsters, fire station, and EMS station driveways.
- Teamsters building park area.
- EMS station site.
- Massport's dormant rail line.

The estimated cost for design and construction is $2-3 million, including reconstructing the roadway with a higher elevation and reworking utilities, driveways, and sidewalks. Possible funding sources include:

- CZM's Coastal Resilience Grants program
- FEMA's FEMA Pre-Disaster Mitigation Program
- US Army Corps of Engineers' Section 103 program

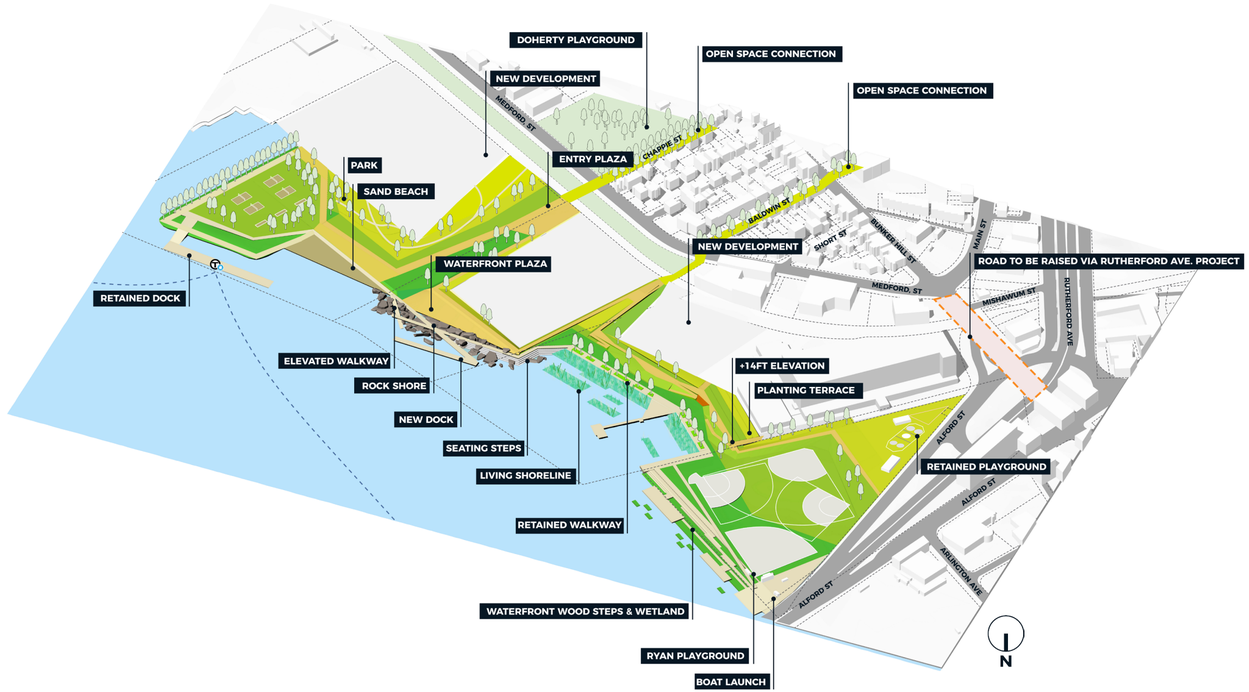
Schrafft's Center Waterfront: Redevelopment of the Schrafft's Center waterfront with elevated parks, nature-based features, and mixed-use buildings would bring value to residents, providing new opportunities for recreation, social activities, mobility, and commerce, while also restoring natural resources in the Harbor.

It would also reinforce and extend flood protection provided by elevating Main Street, protecting about 330 residents, at least 60 businesses, drainage and combined sewer systems, first responder facilities, and critical transportation infrastructure, such as Rutherford Avenue and its underpass, from the 1% annual chance coastal flood with 9 inches of SLR (2030s), plus 1 foot of freeboard. At this level of protection, from a single event these measures would prevent an estimated $390 million in losses, including over $100 million from Schrafft's Center itself.

The estimated cost for design and construction across the three properties is $28-53 million. The measures should be constructed by 2030 to align with and support the *Imagine Boston 2030* plans for an expanded neighborhood in Sullivan Square.

In the 2050s (21 inches of SLR), these actions would generate net project benefits of $201-229 million from flood protection alone. In combination with long-term actions at Ryan Playground, the Schrafft's Center waterfront solutions would block flood pathways from the Lower Mystic River in the 1% annual chance flood with 36 inches of SLR (2070s), plus 1 foot of freeboard.

Elevated parks and pathways would be created in areas that are currently used as surface parking lots. Across the waterfront, these open spaces would establish a consistent flood protection elevation equal to a 1% annual chance flood level with 36 inches of SLR, plus 1 foot of freeboard (2070s). Sufficient open space would be reserved to increase this flood protection level by at least 2 feet (estimated to extend the effectiveness by around 20 years or more), if needed in the future. A substantial amount of fill would be required to elevate these areas. Existing elevations vary, but are as much as 7.5 feet lower than the proposed future elevation in some places.



The Sullivan Square waterfront is anchored by new open space and flood protection systems across three Schrafft's Center properties in the long-term climate resilient strategy..

Open spaces would be laid out and designed to establish strong visual and access connections to the waterfront. High points in the system would be pulled back from the shoreline at key access points from the neighborhood, establishing longer vistas as opposed to sharp grade changes near the water's edge. Access points would be improved with road markings, signage, and sidewalks to provide safe, accessible, and inviting connections across Medford Street.

The open space designs should include varied social, recreational, and ecological spaces, expanding on those already provided by Ryan Playground and Doherty Playground. The shallow water at the Schrafft's Center waterfront could feasibly support a living shoreline and marsh. Other natural features that could be feasible include a sandy beach (a nod to the historic Dewey Beach), and rocky shore. Community stakeholders at the Charlestown Open House were supportive of living shorelines and stormwater gardens. These features would add climate resilience, aesthetic, educational, and recreational value to recent Harborwalk improvements.

There are also opportunities to provide water transit service onsite. Community stakeholders expressed an interest in services that are regular and affordable. Schrafft's Center currently has one of the City's few public boat ramps. However, at its current location, its use may conflict with the proposal for ecological restoration. The boat ramp and water transit service could both be located at the deep water channel, near the south end of the properties. An alternative would be to provide a boat ramp at Ryan Playground.

The proposed flood protection system is laid out to reserve substantial portions of the properties, set back from the waterfront, for mixed-use redevelopment. Potential zoning changes related to allowable uses, building heights, and density could increase the commercial viability of redevelopment to offset the costs of implementing the open space and flood protection improvements.

The City could obtain easements for inspection and maintenance over flood protection infrastructure, either in advance or through the Wetlands Protection Act approvals process for individual projects. Easements are required for the project to be eligible for public funding, including federal support, and to qualify the community for flood insurance reductions. The design of flood protection infrastructure should also meet federal agencies' engineering and operational standards.

Planning and Regulatory Tools: Planning and other regulatory efforts will facilitate implementation of the measures on the Schrafft's Center waterfront. For example, zoning can include coastal resilience design guidelines and open space requirements.

The proposed flood protection system would reserve substantial portions of the properties, set back from the waterfront, for mixed-use redevelopment. Potential zoning changes related to allowable uses, building heights, and density could increase the commercial viability of redevelopment to offset the costs of implementing the open space and flood protection improvements. Pairing these changes with value capture and district improvement financing strategies may create opportunities to share implementation costs with the private sector.

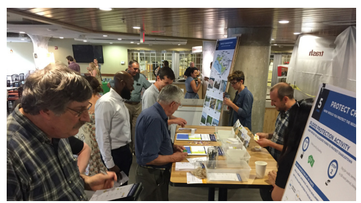
POTENTIAL CHARLESTOWN WATERFRONT HARBORPARK DISTRICT ZONING CODE REVISIONS	VALUE FOR IMPLEMENTING COASTAL RESILIENCE SOLUTIONS
Establish a Flood Protection Overlay District and require potential integration with flood protection systems (Climate Ready Boston Action 5.1)	*Requires that development proposals do not prevent the future creation of flood protection infrastructure*
Establish a new special subdistrict modeled after the Charlestown Gateway Subdistrict and transfer Schrafft's Center parcels from Waterfront Manufacturing and Maritime Economy Reserve subdistricts to the new special subdistrict	*Diverse and high value Acceptable and Conditional uses generate more value to help fund flood protection infrastructure*
Increase open space requirements for special subdistrict beyond the 50% required in the Gateway Subdistrict	*Ensures generous public open space is reserved for future flood protection infrastructure, and encourages smaller building footprints for improved urban quality*
Consider substitute provisions to Chapter 91 minimum use limitations and numeric standards through a public municipal harbor planning process	*Tradeoffs for substitute provisions to Chapter 91 minimum use limitations and numeric standards offsetted by increased open space and flood protection infrastructure requirements*
Include coastal flood protection in the list of Proper Public Purposes under Chapter 91 Tideland Requirements	*Provides BPDA with a policy for recommending a State Chapter 91 License approval on the basis of whether a project adequately addresses the public interest in coastal flood protection*
Add to Urban Design Guidelines that projects should prevent flooding from crossing over their property and should provide equal or higher flood protection than their waterfront abutters	*Provides BPDA with a policy for approval of large projects and inclusion of conditions on the basis of whether they meet coastal flood protection design guidelines*

POTENTIAL ARTICLE 80 DEVELOPMENT REVIEW AND APPROVAL REVISIONS	VALUE FOR IMPLEMENTING COASTAL RESILIENCE SOLUTIONS
Require information on project location relative to coastal flood pathways within Flood Protection Overlay Districts in the Scope of Large Project Reviews and Contents of Reports	*Gives the City more information about proposed projects and potential opportunities and conflicts with district-scale coastal resilience strategies*
Add to Standards for Large Project Review Approval that projects in Flood Protection Overlay Districts should prevent flooding from crossing over their property and should provide equal or higher flood protection than their waterfront abutters	*Provides BPDA with a policy for approval of large projects and inclusion of conditions on the basis of whether they meet coastal flood protection design guidelines*

Ryan Playground: Ryan Playground's low-lying waterfront playing fields, seating, dugouts, and lighting systems would be vulnerable to damage in the 1% annual chance flood with 9 inches of SLR (2030s). If proposed near-term actions at Schrafft's Center are not taken, flooding from Ryan Playground would flow to the Schrafft's Center parking lot, and if Main Street is not elevated, this water would cross Main Street into the community. Assuming that one or both of these projects is implemented by 2030, flooding from Ryan Playground would remain localized to the waterfront.

To protect the park from such flood damages and reduce its potential contribution to broader flooding, low-lying areas near the waterfront should be raised to the 1% annual chance flood level with 9 inches of SLR (2030s). This recommendation is consistent with *Climate Ready Boston Initiative* 8.5 - Prepare outdoor facilities for climate change. Areas would be filled to meet the surrounding grade. Existing elevations along the park's edge vary, but would need to be raised no more than 1.5 feet. The lowest areas in the baseball outfields would need to be raised as much as 3 feet.

The estimated cost for design and construction of this near-term solution is $300,000-500,000. Including these improvements as part of the park's next scheduled renovation would increase efficiencies and minimize disruptions to park use. It would also make it easier and less costly to further elevate in the future. Additional long-term measures along the waterfront would be needed to prevent the park from becoming a flood pathway in a 1% annual chance flood with 36 inches of SLR (2070s).



Attendees at the Charlestown Open House provide feedback on the proposed solutions.

Ryan Playground short-term and long-term solutions together with redevelopment of the Schrafft's Center waterfront create a newly revitalized park with elevated pathways, plazas and beaches.

Estimated Costs and Benefits of Near and Long-Term Actions in Charlestown

ESTIMATED COST	$33-62 million
NET PROJECT BENEFIT	$201 - 229 million
BENEFIT-COST RATIO	4.3 - 7.9

LONG-TERM ACTIONS

Ryan Playground: In a 1% annual chance flood with 36 inches of SLR (2070s), flooding from Ryan Playground could flow over Alford Street and into the underpass onto Rutherford Avenue. This would bypass flood protection systems at Schrafft's Center and Main Street.

Further elevating the waterfront edge of Ryan Playground as part of future renovations would provide an even longer-term solution, in concert with near-term actions on the Schrafft's Center waterfront. The design of such improvements could also enhance Ryan Playground's recreational, aesthetic, and ecological value.

The long-term actions proposed for Ryan Playground would raise the park's edge to the 1% annual chance flood level with 36 inches of SLR (2070s), plus 1 foot of freeboard. This elevation would be met at the top of a raised pathway with vistas of the Lower Mystic and integrated seating for viewing the playing fields. In areas where space is constrained by lighting and dugouts, the pathway would transition to a seating bench that doubles as a flood wall.

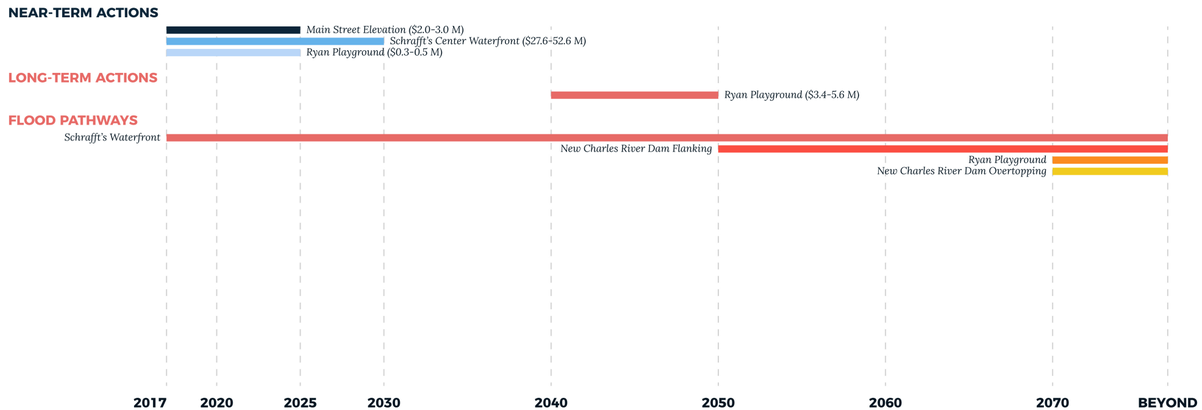
The existing seawall at the water's edge could be redesigned to provide a more naturalized shoreline, such as a terraced retaining wall, planted with wetland species. The shallow mud flats could be restored to marsh, expanding the habitat created in the shallow areas of the Schrafft's Center waterfront.

The estimated cost for design and construction of these long-term measures is $3.7-6.1 million. These substantial improvements should be made incrementally by 2050 as part of future park renovations, or sooner if funding is available. Due to the high cost of these improvements, the City may need to combine grants from several programs to fund it. Potential sources of grant funding include:

- CZM's Coastal Resilience Grants program
- Massachusetts Division of Conservation Services PARC Grants
- Massachusetts Division of Conservation Services Land and Water Conservation Fund Grants
- Massachusetts Office of Energy and Environmental Affairs Seawall Repair or Removal Program

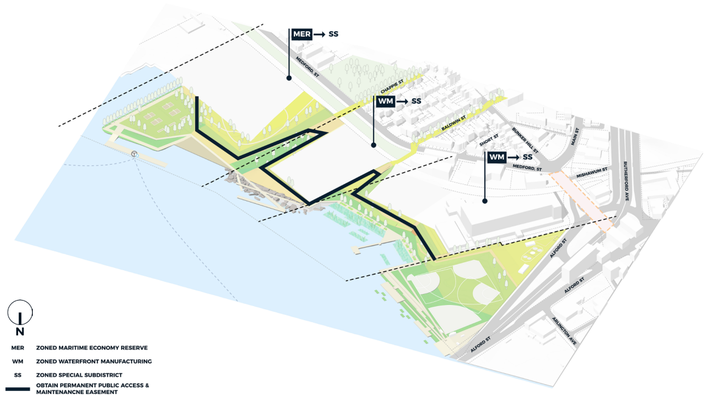
RECOMMENDED TIMELINE: CHARLESTOWN

Recommended phasing plan for coastal climate resilience solutions in the Charlestown study area.
Both costs and phasing plans are estimates and recommendations only, and should not be used for detailed planning.



Full implementation of near and long-term measures would protect about 1,000 residents, at least 100 businesses, drainage and combined sewer systems, critical transportation infrastructure, and first responder facilities up to the 1% annual chance flood with 21 inches of SLR (2050s), plus 1 foot of freeboard. At this level of protection, from a single event these measures would prevent an estimated $591 million in losses.

Additional measures would be needed to address the potential flanking (21 inches, 2050s) and overtopping (36 inches, 2070s) of the New Charles River Dam to extend the effectiveness of coastal resilience solutions. In addition, measures designed and built in the 2030s and 2050s would need to be evaluated to determine whether and how they should be adapted to provide higher protection when sea level rise exceeds 36 inches. For example, adding 2 feet of flood protection could extend their effective life by about 20 years or more.



Local zoning changes for the three Schrafft's Center properties could facilitate implementation by allowing higher value land uses.

Charlestown's long-term climate resilient waterfront