

COASTAL RESILIENCE SOLUTIONS FOR SOUTH BOSTON

FINAL REPORT

October 2018



Mayor Martin J. Walsh





October 2018

Dear Neighbors,

Boston is proving that climate resilience doesn't just protect us from storms and rising tides – it also enhances our neighborhoods and improves quality of life all year round. Projects all across the Harbor, from Langone-Puopolo Park in the North End to Martin's Park in the Fort Point Channel, create beautiful green spaces that improve everyone's access to the waterfront. In all of this work, we're engaging residents every step of the way. It's about making sure any action we take has many benefits for our residents, and that residents are always included in the planning process.

Last year, we released our *Coastal Resilience Solutions for East Boston and Charlestown* report. That was our first neighborhood resilience plan. It showed us where we were most at risk and what we need to do to protect our residents, homes, and infrastructure. We immediately went to work to implement those recommendations. This summer, we installed a deployable floodwall across the East Boston Greenway that protects the neighborhood behind it from flooding. We're raising Main Street in Charlestown as part of the Sullivan Square redesign to protect that vulnerable community, as well. We developed resilient infrastructure standards for our public rights-of-way, and we're working on zoning to make sure new development is climate-ready. We also trained more than 70 Bostonians on climate change and how to talk about the impacts to their backyards. In turn, they went out into their communities and led conversations with more than 700 of their neighbors about how we can prepare our city for climate change.

In 2018, we all felt the effects of climate change in our neighborhoods. We saw stronger rains and higher flooding along our waterfront during three big winter storms, and strong heat waves throughout the summer. That's why we're working hard to make sure our city is ready for the impacts we face today, and the changes we know we'll see in the years to come.

I'm proud to build on this momentum by presenting you with our next neighborhood resilience plan, which is focused on another area that is at risk for flooding and storm surges: South Boston. This report, which we created with the support of the Barr Foundation, helps us understand these risks and how we can best address them. We've got a lot of work to do, and in order to make our city stronger, safer, and more equitable, it's important that we work closely with the private sector and community partners.

We look forward to working with you in your neighborhoods.

Sincerely,

A handwritten signature in black ink, appearing to read "Martin J. Walsh".

Martin J. Walsh, Mayor of Boston



CRSB Open House March 6th. 2018

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ACKNOWLEDGMENTS

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.

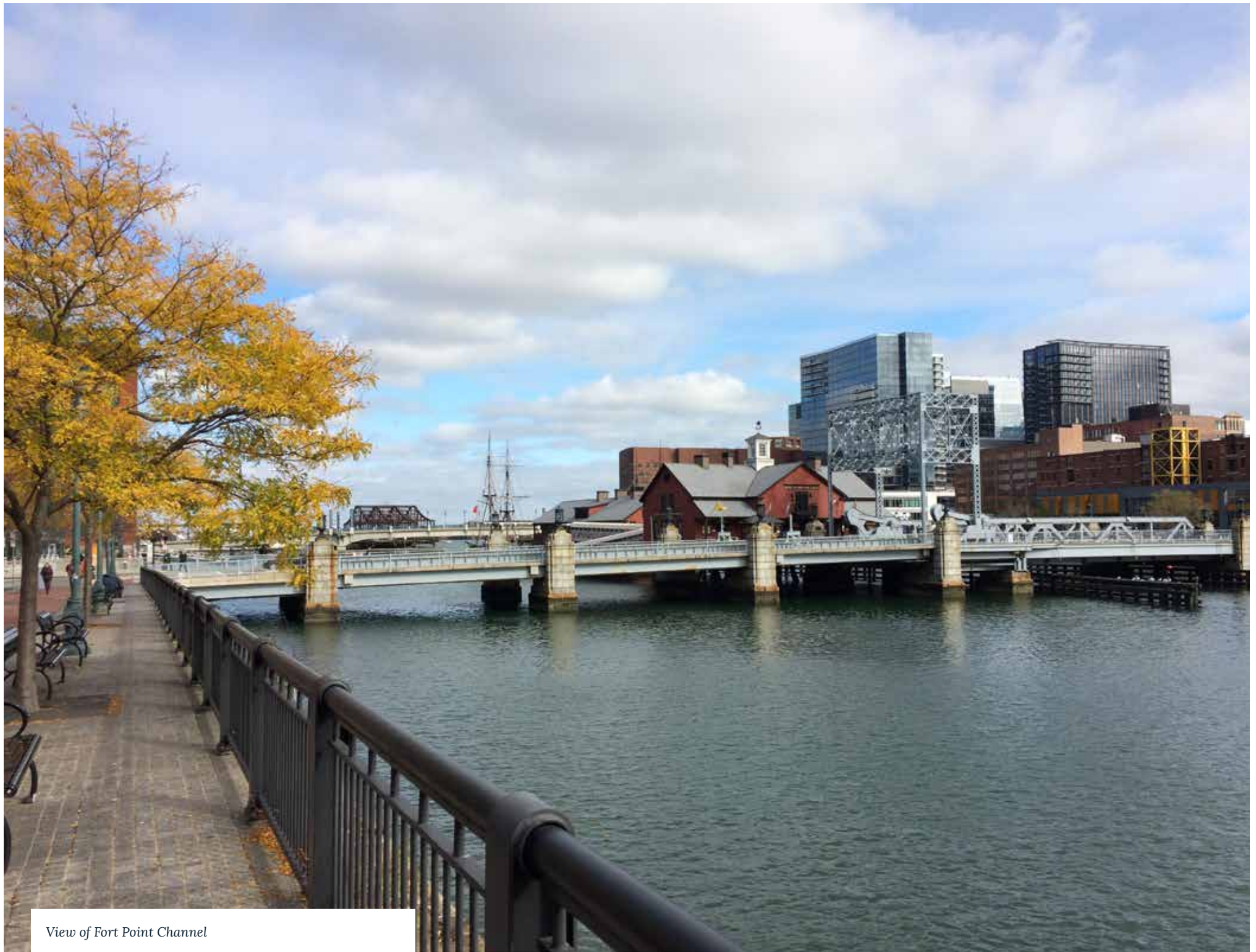
The following partners provided valuable insight into the project:

- » Boston Planning & Development Agency
- » Boston Water and Sewer Commission
- » Boston Parks and Recreation Department
- » Boston Public Works Department
- » Boston Inspectional Services Department
- » Boston Landmarks Commission
- » Boston Conservation Commission
- » Boston Housing Authority
- » Mayor's Office of Resilience and Racial Equity
- » Mayor's Office of Neighborhood Services
- » Imagine Boston 2030
- » Massachusetts Executive Office of Energy and Environmental Affairs
- » Massachusetts Department of Transportation
- » Massachusetts Department of Environmental Protection
- » Massachusetts Department of Conservation and Recreation
- » Massachusetts Emergency Management Agency
- » Massachusetts Bay Transit Authority
- » Massachusetts Water Resources Authority
- » Massachusetts Port Authority
- » Massachusetts Office of Coastal Zone Management
- » MassDevelopment
- » University of Massachusetts Boston School of the Environment
- » United States Army Corps of Engineers
- » Boston Green Ribbon Commission

The following organizations helped us engage with their stakeholder communities:

- » A Better City
- » Andrew Square Neighborhood Association
- » Boston Harbor Now
- » Boston Marine Park Business Association, Inc
- » Fort Point Arts Association
- » Fort Point Neighborhood Association
- » Friends of Fort Point Channel
- » Trustees of Reservations

The City of Boston would like to thank the Barr Foundation for their generous support.



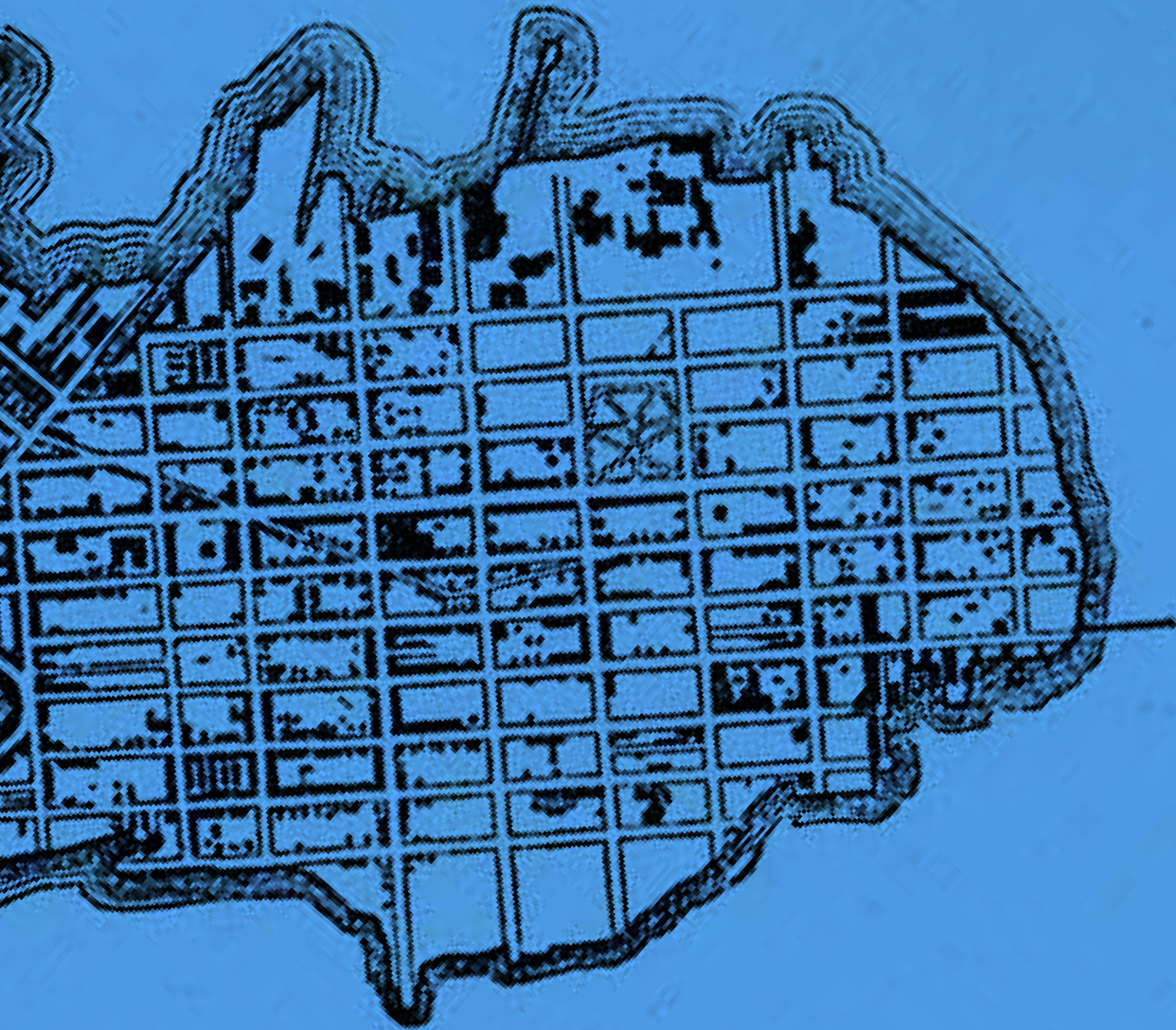
View of Fort Point Channel

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02 CONTEXT AND APPROACH



CONTEXT AND APPROACH

Coastal Resilience Solutions for South Boston is the second neighborhood coastal resilience plan to come out of the Climate Ready Boston initiative, following the October 2017 “Coastal Resilience Solutions for East Boston and Charlestown” report.

Coastal Resilience Solutions for South Boston presents near-term strategies as well as a long-term vision for reducing risk due to sea level rise and coastal flooding in South Boston. The project was led by the City of Boston Environment Department and the Boston Planning and Development Agency (BPDA), and was funded by a grant from the Barr Foundation, with support from the City.

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
- » A detailed vulnerability assessment of the city and specific focus areas
- » Principles, strategies, and initiatives to achieve the City’s climate preparedness goals

Climate Ready Boston recommended that the City “prioritize and study the feasibility of district-scale flood protection” in South Boston and other focus areas (Initiative 5.3), and “develop local climate resilience plans in vulnerable areas to support district-scale climate adaptation” (Initiative 4.1).

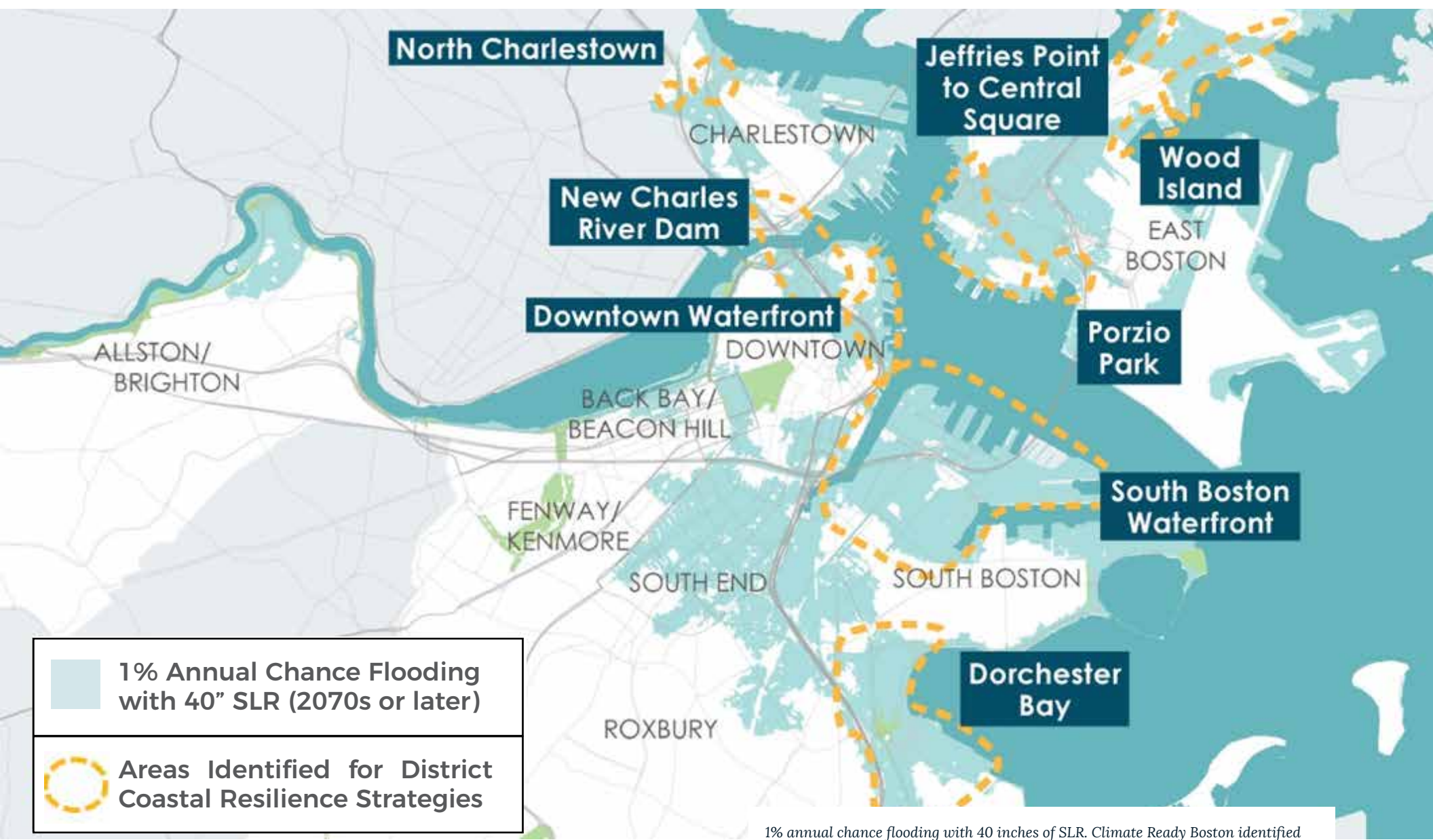
Climate Ready Boston’s vulnerability assessment identified the South Boston neighborhood as particularly vulnerable to coastal flooding and sea level rise within the next few decades. Toward the end of the century, much of the South Boston Waterfront will be exposed to flooding from high tide, with many areas exposed to the 10 percent annual chance flood. Additionally, if no action is taken, the flood pathways from the South Boston neighborhood are expected to extend into other parts of the City, including the South End, as sea levels rise.

WHY SOUTH BOSTON?

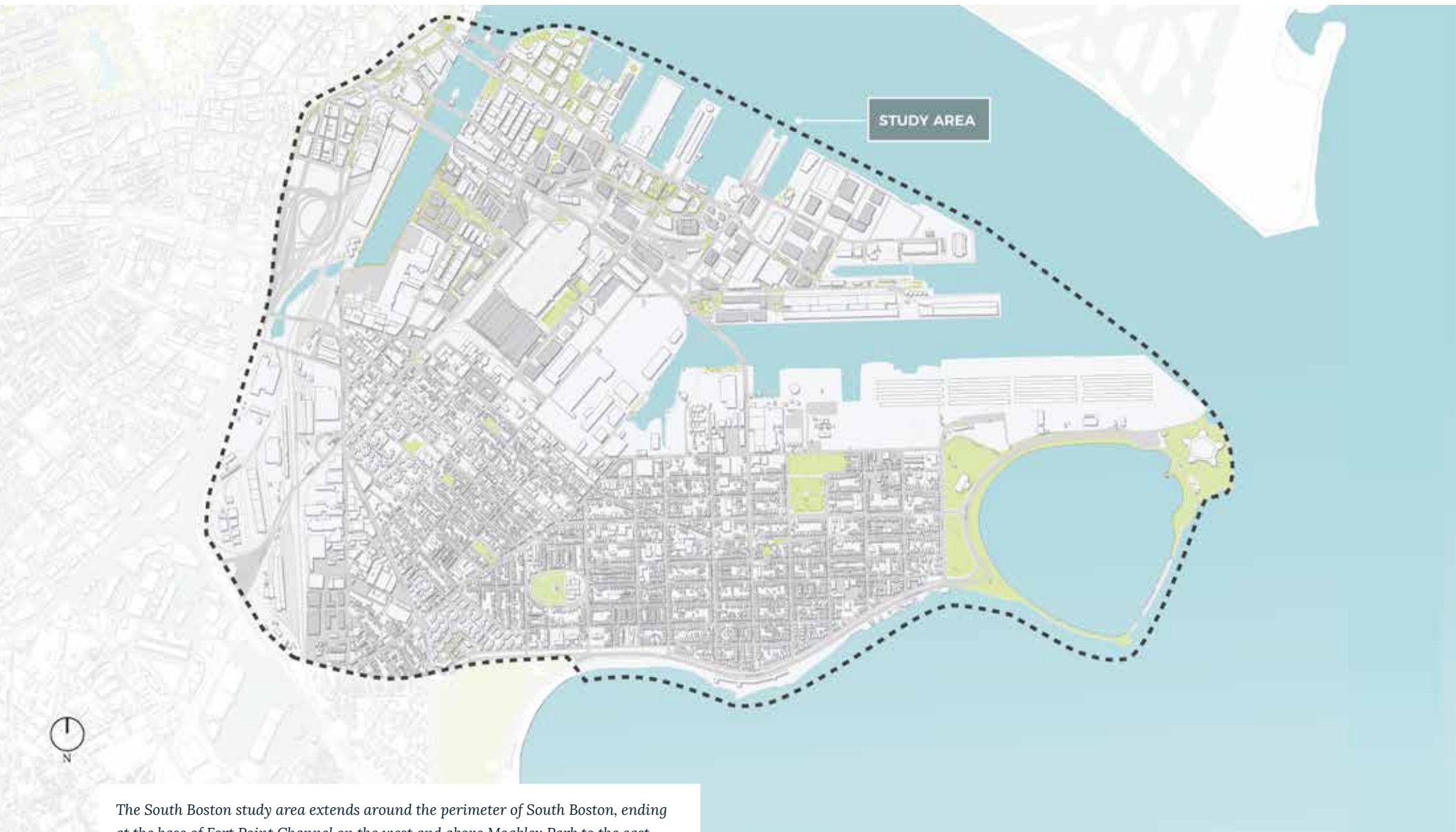
“Of all Boston focus areas, South Boston consistently faces the greatest or near-greatest exposure and potential losses to coastal flooding across all sea level rise conditions and flood events.”

- Climate Ready Boston

South Boston is one of the most rapidly developing areas of the City. In 2014, South Boston employed 82,000 people across a broad spectrum of sectors and was responsible for putting close to \$20 billion in sales and revenue into the economy. In addition, the City projects the population to double between 2010 and 2030 to 60,000 residents.



1% annual chance flooding with 40 inches of SLR. Climate Ready Boston identified the need for district-scale flood protection strategies in Charlestown, East Boston, South Boston, Downtown, and Dorchester. Source: Climate Ready Boston



The South Boston study area extends around the perimeter of South Boston, ending at the base of Fort Point Channel on the west and above Moakley Park to the east.

PROJECT DEVELOPMENT OVERVIEW

MISSION STATEMENT

“The resiliency strategy outlines a series of layered flood control measures that provide protection from rising sea levels and storm surges, and create social, environmental, and economic benefits and value to the people of South Boston and all who share in the health of the city and the harbor.”

The *Climate Ready South Boston* initiative kicked off in the fall of 2017. This report provides conceptual technical design and regulatory options which will require further evaluation, and detailed design to bring to the final stages of implementation.

December 2016 - Climate Ready Boston

Climate Ready Boston assessed the nature and urgency of climate related challenges within the City of Boston. This report laid out recommendations and a roadmap for the City to follow in order to adapt to the hazards and challenges associated with climate change. Among these recommendations was the development of district level climate and coastal adaptation strategies.

October 2017 - Coastal Resilience Solutions for East Boston and Charlestown

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. The report presents near- and long-term strategies for protecting East Boston and Charlestown from sea level rise and coastal flooding.

Fall of 2017 to Summer 2018 - Coastal Resilience Solutions for South Boston project

The *Coastal Resilience Solutions for South Boston* project provides a deeper look into the flood risk, technical, and regulatory challenges. Basic activities included:

1. Review of existing information, plans, capital plans
2. Extensive stakeholder engagement
3. Technical evaluations of feasible strategies
4. Development of conceptual design options
5. Review of permitting and development of regulatory resilience options

The report includes recommended priorities, near- and mid-term design, policy, and planning actions, and long-term conceptual design level options.

In progress / ongoing as a result of Coastal Resilience Solutions for South Boston project

- » Continued engagement for implementation planning
- » Funding and financing coordination, as well as property owner and partnership discussions
- » Coordination with regulators and permitting agencies

COMMUNITY CONTEXT

South Boston contains nearly every type of waterfront in a single district: manufacturing, an art district, waterfront condos, marinas, waterfront parks, piers and maritime uses, historic buildings, industrial uses, the port, beaches, and more. The area exhibits a variety of ownership and occupancy structures, land uses, stages of development, needs and considerations, resources, and expectations for the future. South Boston maintains industrial and marine uses at the Port of Boston, the Raymond L. Flynn Marine Park, and the Fish Pier. Large Boston Housing Authority developments can be found in the South Boston neighborhood. Beaches and recreational amenities along William J. Day Boulevard out to Pleasure Bay and Castle Island are important to the residential community.

In recent years, the South Boston waterfront has experienced rapid transformation as the result of a significant development and investment. From 2010–2013, the South Boston waterfront was the fastest-growing urban area in the Commonwealth, adding

approximately ten million square feet of development. The waterfront has become a hub for recreation and culture, with the expansion or opening of numerous attractions, including the Boston Convention and Exhibition Center (opened 2004), Institute of Contemporary Art (opened 2006), and Boston Children's Museum (renovated 2007).

The South Boston district is expected to reach full build-out by the year 2030 with the population nearly doubling from 2015 to nearly 60,000.¹

In 2014, there were significantly more jobs (roughly 80,000)² in South Boston than residents (over 30,000). Professional services, legal, financial, and insurance industries made up a third of the neighborhood's jobs, and 10 percent were in accommodation and food services. Another 10 percent of South Boston jobs are hosted by local, state, and federal government agencies.

¹ We performed a build-out analysis of the district based on the Boston Planning and Development Agency existing zoning codes determining developable land limits. A build-out analysis estimates the amount and type of developable space in an area based on existing land use policy. Once an area reaches build-out, redevelopment or policy change would be the mechanisms for growth and change in land use in an area. Analysis assumptions included: (a) the first two floors of building space in mixed use will be commercial, (b) that over time, structures will be replaced or renovated to full build-out, and (c) all parcels have parallel sides

² Jobs represent the annual average of monthly jobs within South Boston, and represents both full-time and part-time employment.



View of Downtown Boston looking across the Fort Point Channel.
Source: Halvorson Design Partnership



The Boston Tea Party Ships & Museum in the Fort Point Channel.
Source: Halvorson Design Partnership



Castle Island and Pleasure Bay Source: Wikimedia Commons

TOP EMPLOYMENT INDUSTRIES IN SOUTH BOSTON³

Economic Industry Category	Economic output from South Boston 2014	Employment in South Boston 2014
Professional Services	\$4.1 billion	17,000
Legal, Finance, Insurance	\$4.1 billion	11,000
Food & Accommodations	\$0.6 billion	9,000
Government	\$1.4 billion	8,000
Medical and Hospital	\$1.1 billion	7,000
All Other Industries	\$7.4 billion	31,000

Less than 10 percent of the South Boston resident population lives and works within the district, and 95 percent of all jobs within the district are held by persons commuting from outside the district.⁴



The Seaport District is attracting an growing and diverse array of businesses and offers other cultural and commercial uses.

Photo Source: levydr722

³ The *Climate Ready South Boston* team summarized economic industry categories from the IMPLAN 2014 Suffolk County Plus Package dataset used in the *Climate Ready Boston* Exposure and Consequence Analysis.

⁴ Source: U.S. Census Bureau, OnTheMap Application and LEHD Origin-Destination Employment Statistics (Beginning of Quarter Employment, 2nd Quarter of 2002-2014)

COASTAL FLOOD RISK OVERVIEW

Tidelands that were historically filled in Boston were designed to be safe from tides. Sea level rise puts filled tidelands and other low-lying areas at growing risk of coastal flooding. These risks are especially clear in South Boston.

The historic shoreline in South Boston was limited to what is now the South Boston residential neighborhood. This area has historically been, and remains today, the only high ground in the district. Even with 40 inches of sea level rise, we can expect limited coastal flooding in the historic South Boston residential neighborhood.

In South Boston, 9 inches of sea level rise could result in a ten-fold increase in flood risk over less than two decades.



Shoreline in 1852 and shoreline today. Much of the South Boston neighborhood has been formed through the introduction of fill over time. These filled areas are often lower in elevation and more susceptible to coastal flooding.

- » In 2013, most of Fort Point Channel and isolated areas in other parts of South Boston were exposed to flood elevations with at least a 1-percent (1 in 100) annual chance of occurrence
- » With 9 inches of sea level rise expected by the 2030s, most of the filled areas of South Boston will have at least a 5-percent (1 in 20) annual chance of flooding
- » With sea levels 40 inches higher, the current 0.5 percent (1 in 200) annual chance flood will occur at least on an annual basis
- » With 40 inches of sea level rise, most of the filled areas of South Boston and much of the waterfront along the South Boston neighborhood can expect at least annual or semi-annual flooding, if nothing is done
- » With 40 inches of sea level rise without action, the South End could experience at least one foot of flooding during a 1-percent annual chance flood event with water flowing from the Fort Point Channel

SEA LEVEL RISE SCENARIOS

Climate Ready Boston used three sea level rise scenarios (9, 21, and 36 inches). The actual sea level rise Boston experiences will be driven by many factors, primarily global carbon emissions. Climate Ready Boston projections indicate that Boston's sea levels will probably rise (from 2013 levels) by 9 inches as soon as 2030 if emissions continue at their current pace, 21 inches as soon as 2050, and 36 inches as soon as 2070.

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 Resilience and Preparedness Checklist". This level is equivalent to the Climate Ready Boston 36-inch level. See Climate Ready Boston for more details on sea level rise probabilities. This report refers to the long-term scenario as "40 inches" of sea level rise.

Flooding that occurred in South Boston and other neighborhoods during extra-tropical storms Grayson (January 2018) and Riley (March 2018) were consistent with the model.

Percent Annual Chance

A "1-percent annual chance flood" has a 1 in 100 chance of being equaled or exceeded in any given year. Though the chance of occurrence each year may seem relatively low, a 1-percent annual chance flood elevation could be reached multiple times in a given year, decade, or century. These flood elevations have close to a one in three chance of being reached at least once during a 30-year mortgage, for example.

Climate Ready Boston uses a 1-percent annual chance water level / 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. Some areas within the 1-percent annual chance floodplain have a much higher probability of flooding.

A 1-percent annual chance flood elevation is 10 times less likely than a 10 percent annual chance flood elevation. As sea levels rise, a 1-percent annual chance flood elevation today could be a 10- or even 99-percent annual chance flood elevation in the future. The Federal Emergency Management Agency (FEMA) flood maps have historically been based on the 1-percent annual chance flood elevation, and the National Flood Insurance Program currently requires that all new development and redevelopment be protected to at least the 1-percent annual chance of flooding.

Most of the filled areas of South Boston are at risk to the 5-percent (1 in 20) annual chance flood level with 9 inches of sea level rise, including portions of the inland Boston Convention and Exhibition Center. The 5-percent annual chance flood with 9 inches of sea level rise would flood far inland from Fort Point Channel and would connect flood pathways on the South Boston Waterfront to those originating on Seaport Boulevard, the Raymond L. Flynn Marine Park, and Reserved Channel.

Annual Chance Flood Depths

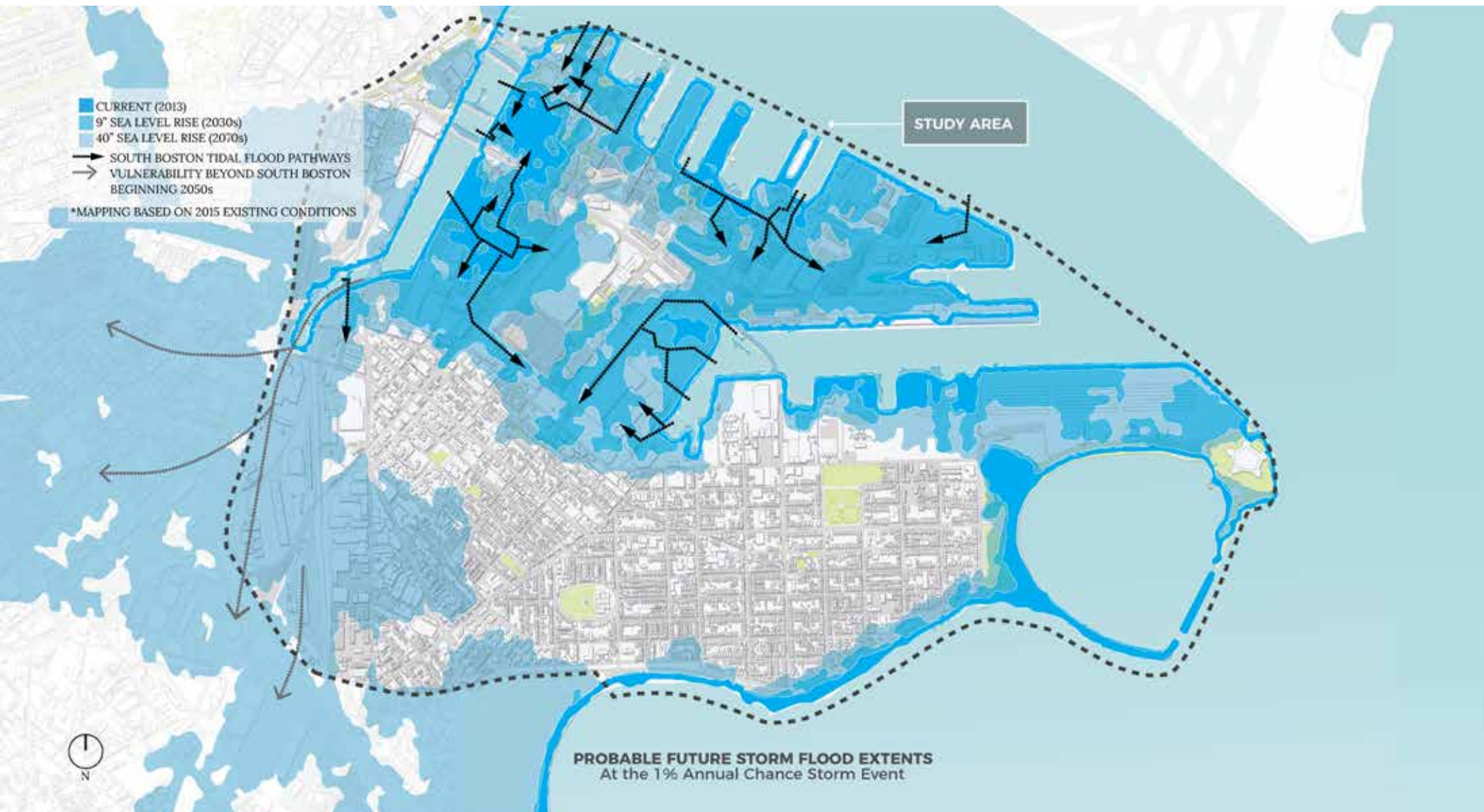
FEMA uses the 1-percent annual chance as a standard to assess flood risks and solutions. This table shows how the 1-percent annual chance and other probability flood depths will increase with 9 inches and 40 inches of sea level rise. These example depths are located at a spot along the Fort Point Channel.

		FLOOD DEPTH (FEET ABOVE EXISTING GROUND)		
ANNUAL CHANCE (%)	ANNUAL ODDS	CURRENT (2000s)	+9 INCHES SLR (2030s)	+40 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	2.3	5.5
1	1 in 100	1.1	2.2	4.8
2	1 in 50	0.7	1.9	4.5
5	1 in 20	dry	1.4	4.2
10	1 in 10	dry	1.0	3.6
20	1 in 5	dry	0.4	3.0
25	1 in 4	dry	dry	2.8
30	1 in 3	dry	dry	2.7
50	1 in 2	dry	dry	2.2
100	1 in 1	dry	dry	1.7

Data source: Boston Harbor Flood Risk Model.

Both flood depth and the area expected to flood (the extent) will increase. The 1-percent annual chance flood elevation with no sea level rise is now about 6 inches to 1 foot above grade in areas expected to flood, with some isolated locations at 2.5 or more feet. With 9 inches of sea level rise, those same areas could expect up to 2.5 feet of flooding, with extremes up to 3.5 feet in some places. With 40 inches, the current floodplain in South Boston in a 1-percent annual chance flood event could expect 3.5 to 10 feet of flooding, depending on the area.

There are distinct flood pathways associated with present-day flood risk (2013) along Fort Point Channel and Seaport Boulevard that can be addressed with near-term actions along the shoreline. As sea levels rise higher, these flood pathways begin to merge with more widespread flooding in the South Boston neighborhood and, later in the century, reach beyond the district into other parts of the City.



South Boston faces extensive current and future flood risk. The gradations of blue in the map show how the 1-percent annual chance flood changes through time. As the climate changes and sea level increases, the extent of flooding due to storm events also evolves. The colors do not indicate depth of flooding. Arrows indicate key flood pathways. If no action is taken, flood pathways from the South Boston neighborhood will eventually extend into other parts of the City, including the South End via the Fort Point Channel.

TIDAL FLOOD RISK: PLANNING AND DESIGN IMPLICATIONS

We explored whether coastal flood protection should be at the shoreline or further inland. Stakeholders wanted to know how often shoreline properties would flood without action, and if moving flood protection further inland could result in cost savings. If properties on the waterfront flood often, the potential for long-term loss of use is high as flood waters would inhibit access even with protected structures. If there is no higher ground inland to limit the scale of flood protection, there would not be much cost savings.

Climate Ready Boston mapped expected average monthly high tides for 9, 21 and 40 inches of sea level rise. The average monthly high tide can be expected to occur more than once a month during some months and not at all in other months. Properties flooded this often would need adaptation to avoid long-term loss of use.

Tidal flood maps showed widespread flooding and loss of Harborwalk use with sea level rise. Because most of the waterfront is flat filled land, stakeholders decided shoreline protection was the best approach in South Boston.

Stakeholders also wanted to understand whether it might be possible to have lower levels of flood protection at the shoreline, with higher levels of protection further inland. We performed an analysis

to understand flood protection needs for average monthly high tides under the various sea level rise scenarios. In order to prevent overtopping with 40 inches of sea level rise, most of the waterfront would require coastal flood protection of some kind. In some areas, this coastal flood protection would need to be 4 feet above existing grade.

This level of protection represents significant economic investment. Furthermore, incremental increases in height could mitigate losses from higher magnitude, lower frequency storms. Although inland areas of South Boston can be made more resilient against coastal and inland flooding over time, particularly as other capital improvements are made and with new development (see Regulatory Resilience Strategies), inland resilience will not negate the need to maximize protection at the shoreline and adapt it to higher elevations over time.

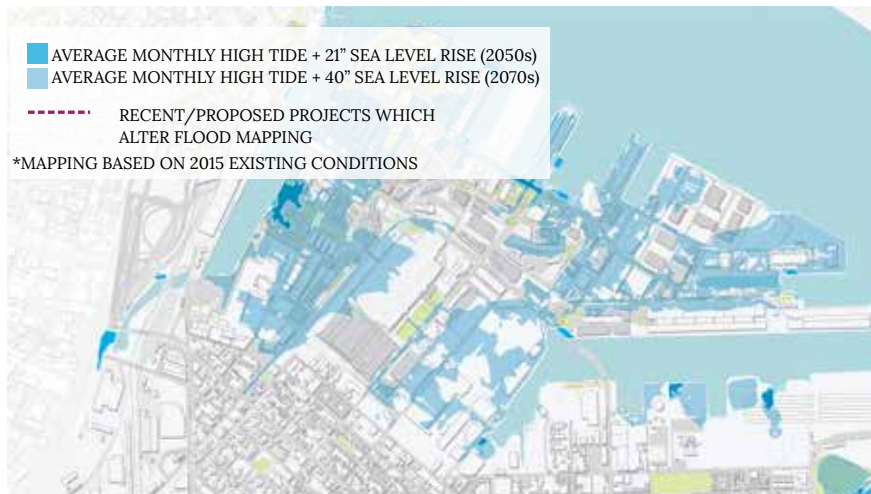
FREEBOARD

“Freeboard is a factor of safety usually expressed in feet above a flood level for purposes of floodplain management. Freeboard tends to compensate for the many unknown factors that could contribute to flood heights greater than the height calculated for a selected size flood and floodway conditions, such as wave action, bridge openings, and the hydrological effect of urbanization of the watershed.” - FEMA

The Climate Ready Boston evaluation also considered flood hazards from high tides and sea level rise alone—meaning “blue sky” conditions, without storms. Because the Boston area has a large tide range, a combined sea level rise and high tide exposure evaluation must also consider the frequency of occurrence of tide levels. In 2016, Climate Ready Boston calculated the average monthly high tide to answer the question: “what could happen less frequently than every day, but frequently enough to cause significant and chronic community disruption?”

“Average monthly high tide” means the average of the highest tide experienced each month in 2015. Average monthly high tide is approximately 2 feet higher than the commonly used mean higher high water (MHHW, the average of the higher high water levels of each tidal day), and lower than king tides (the twice-a-year high tides that occur when the gravitational pulls of the sun and the moon are aligned).

Since tide ranges fluctuate seasonally, daily tides could rise above the average monthly high tide multiple times some months and not at all in other months. Nevertheless, areas vulnerable to flooding at average monthly high tide level will experience greater loss of use and value than those areas affected only by storms.



Without action, several areas in the district could expect flooding from the monthly high tides around mid-century. Later in the century, most of the filled areas of the district could expect frequent flooding. The pink dotted lines represent recent renovations that are not depicted on the flood maps and would reduce recurrent flood impacts in those areas.



9" SLR - 2030s: The waterfront would need to be up to 2 feet higher in some areas of South Boston in order to prevent the minimal overtopping expected to occur at the very edge of the waterfront during the average monthly high tide with 9 inches of sea level rise



21" SLR - 2050s: These areas of the waterfront would require up to three feet of protection above existing grade in order to prevent overtopping during the average monthly high tide with 21 inches of sea level rise plus 1 foot of freeboard.



40" SLR - 2070s: Additional areas of the waterfront would require up to four feet of protection above existing grade in order to prevent overtopping during the average monthly high tide with 40 inches of sea level rise plus 1 foot of freeboard.

“Of all Boston focus areas, South Boston consistently faces the greatest or near-greatest exposure and potential losses to coastal flooding across all sea level rise conditions and flood events.”

- Climate Ready Boston, 2016

POTENTIAL IMPACTS

Coastal flooding to the South Boston neighborhood could damage:

- » 11 Massachusetts Bay Transportation Authority (MBTA) stations
- » I-90 tunnel entrances
- » Emergency medical services (EMS) and healthcare centers
- » Police and fire stations
- » Densely populated high rises
- » Evacuation routes
- » Trucking routes
- » Stormwater pump stations
- » Power supply, including the K Street Substation
- » Many community assets
- » Raymond L. Flynn Cruise Terminal
- » Commercial and industrial manufacturing and processing facilities
- » Maritime and ship maintenance facilities
- » Businesses and residences

Flooding in South Boston would also impact commerce, transit, and jobs. The study area encompasses a commercial fishing industry and container port, as well as ship maintenance, seafood processing, commercial manufacturing, brewing, and more. Recurrent and chronic flooding in the area will result in loss of beaches and Harborwalk throughout the district. Most of the current population lives on high ground in the historic South Boston neighborhood. Nevertheless, residents of the historic neighborhood could experience disruption of access to the neighborhood, public transportation, public services, enjoyment of waterfront parks, and employment.

SOUTH END

The South End is not a waterfront community, but parts of the South End could be vulnerable to coastal flooding from Fort Point Channel as early as mid-century. With 40 inches of sea level rise, 67 percent of South End's current population could be exposed to the 10 percent (1 in 10) annual chance flood elevation without action. Significant infrastructure would also be at risk later in the century due to flood pathways from South Boston, including:

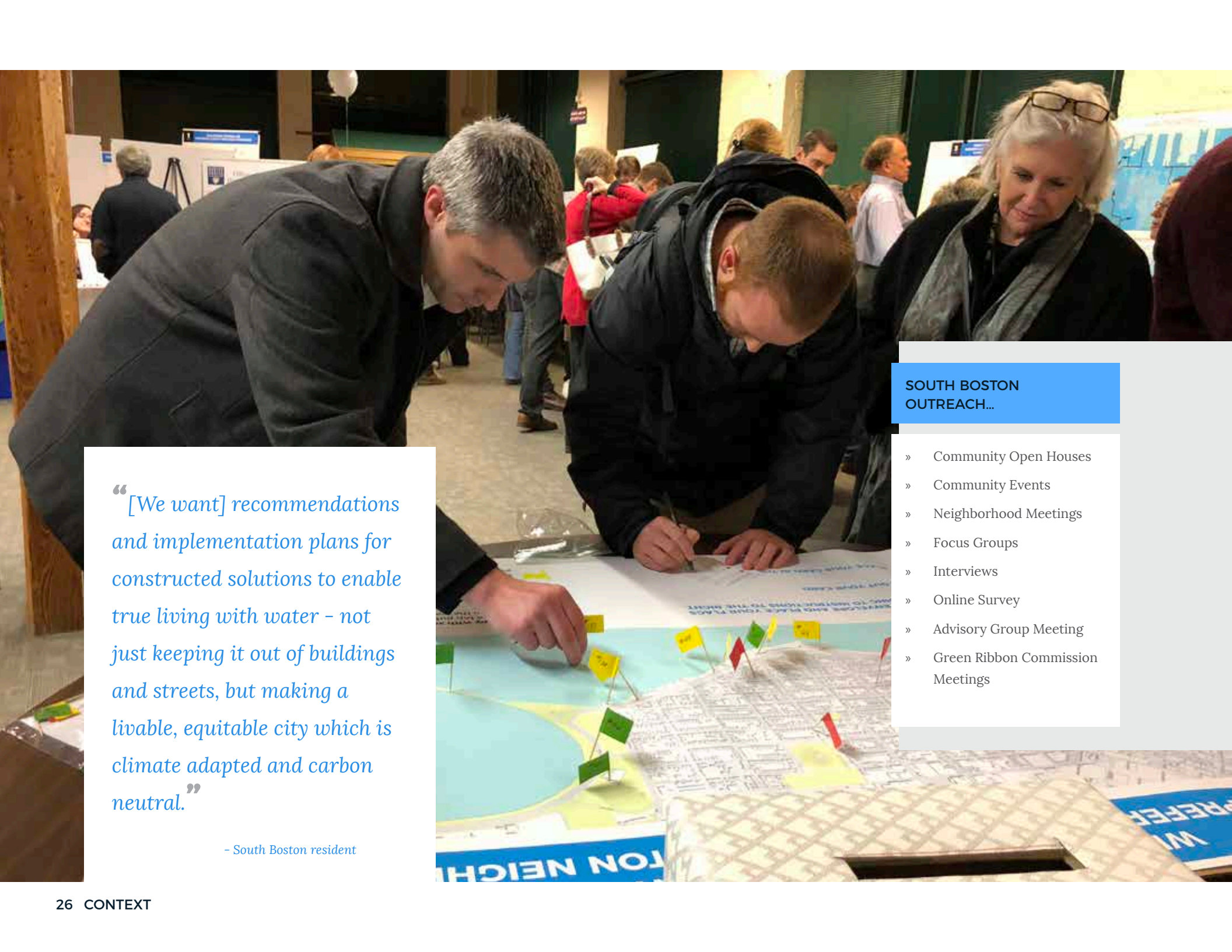
- » Five Massachusetts Bay Transportation Authority (MBTA) stations
- » I-93 North Tunnel entrance
- » Emergency medical services (EMS) Headquarters
- » Pump stations and electrical substations
- » Community and healthcare facilities
- » Multiple fire stations
- » A police station
- » Schools
- » 90 percent of South End's current buildings

Exposure and Expected Impacts

Exposure and expected impacts to the 1-percent annual chance flood elevations with 0, 9, 21, and 40 inches of sea level rise. Exposure and expected impacts are relative to specific flood elevations, and not specific flood events. It is very rare that flood elevations are even across a landscape during any given event.⁵

	1-PERCENT ANNUAL CHANCE ELEVATION WITH NO SEA LEVEL RISE	1-PERCENT ANNUAL CHANCE ELEVATION WITH 9 INCHES OF SEA LEVEL RISE	1-PERCENT ANNUAL CHANCE ELEVATION WITH 21 INCHES SEA LEVEL RISE	1-PERCENT ANNUAL CHANCE ELEVATION WITH 40 INCHES SEA LEVEL RISE
NUMBER OF PEOPLE EXPOSED	980	2,500	7,300	40,200
NUMBER OF BUILDINGS EXPOSED	60	280	920	5,140
EXPECTED DIRECT PHYSICAL DAMAGES AND RELOCATION COSTS	\$140 million	\$1.2 billion	\$2.8 billion	\$8.1 billion

⁵ We used several assumptions about flood protection measures implemented in other areas of the City to arrive at these statistics. All statistics and damage costs include flooded areas outside of South Boston, when appropriate, assuming that flood pathways from Moakley Park and the Charles River have been mitigated. Furthermore, we also assume that flooding into the South End and Downtown through Masspike will be mitigated by a floodwall or similar flood protection measure. Benefits within areas that would be mitigated by these other measures have not been included in the analysis in order to avoid possible future double counting of project benefits.



“[We want] recommendations and implementation plans for constructed solutions to enable true living with water – not just keeping it out of buildings and streets, but making a livable, equitable city which is climate adapted and carbon neutral.”

– South Boston resident

SOUTH BOSTON OUTREACH...

- » Community Open Houses
- » Community Events
- » Neighborhood Meetings
- » Focus Groups
- » Interviews
- » Online Survey
- » Advisory Group Meeting
- » Green Ribbon Commission Meetings

PLANNING APPROACH

ENGAGEMENT OVERVIEW

Over 650 people participated in the coastal resiliency design process through meetings, community events, one-on-one interviews, focus groups, open houses, and an online survey. South Boston residents, property owners, office workers, public officials, non-profit leaders, and others shared their desire for effective and long-lasting solutions to keep them safe, maintain and enhance waterfront access, and protect property and their workplaces. They worry about how floods will threaten their safety, property, and livelihoods; residents are most concerned with their inability to move freely and use public transit, workers worry about risks to their workplaces and safety, business owners and managers want to avoid property destruction, and those who visit or have an interest in South Boston focused on life safety. Additionally, many shared a strong desire for solutions to address other concerns that affect them every day. Those concerns include affordable housing, parking access, protection of industrial areas and water-dependent businesses, and open space.

The factors most important when comparing different flood protection strategies included effectiveness, environmental benefits, and longevity of resiliency design. The understanding that the South Boston Waterfront provides thousands of jobs in the City led many to express interest in protecting the utilities

and transportation infrastructure that keeps residents and workers safe. This concern includes a desire for strategies that honor and retain existing uses and business activities, wherever possible. From an implementation perspective, stakeholders expressed concern that any funding strategies should be fair and transparent when considering contributions from residents, workers, and property owners.

Additionally, due to the scale and nature of flood risk in the area, there was overwhelming acceptance of the need for collective action. In other words, the actions of single property owners could affect the broader community and a collective, coherent strategy for the neighborhood is critical to flood risk reduction and quality of life long term.

Some property owners, public services, and infrastructure providers in South Boston are already taking action to reduce flood risk. These actions are being planned and implemented for existing and future planned development. Examples include the purchase and deployment of deployable flood protection along the South Boston Waterfront, independent flood risk and resilience assessments in process along Fort Point Channel, infrastructure coordination and resilience improvements in the Raymond L. Flynn Marine Park, and the development of higher standards the City's Department of Public Works.



Stakeholders also favored approaches that solve multiple problems, maximize both the effectiveness of flood risk reduction and improvements to public space, create solutions with the ability to adapt to changing circumstances, consider the near-, mid-, and long-term future, and reconsider policies and programs that were created to address narrow or singular problems and may not consider climate adaptation (see Section 04 Regulatory Resilience Strategies).

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 South Boston. Illustrations provide an overview of near-, mid-, and long-term actions. 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 include elevated waterfront parks, enhanced Harborwalk, improved connections to the waterfront, natural wetland buffers, and site amenities such as hardscaped seating stairs and furnishings that serve social and flood protection functions while enabling commercial activities.

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.

EVALUATION CRITERIA

In order to guide the planning process and be aligned with other Climate Ready Boston initiatives, we developed a set of evaluation criteria similar to those used in previous Climate Ready Boston plans, with input from stakeholders. Residents provided feedback

on the categories most important to them in online surveys and at the first project open house. Residents chose effectiveness as the most important category, followed by environmental impacts, design life, and feasibility.

NEAR-TERM, MID-TERM, AND LONG-TERM ACTIONS

All mid- and long-term actions and most near-term actions are designed to provide effective flood protection from the 1-percent annual chance flood with 40 inches of sea level rise now, and all may be adapted to address higher magnitude flooding over time. All actions require urgency as much of the South Boston waterfront is at risk to 9 inches of sea level rise (by the 2030s).

Near-term Actions
(As soon as possible)

- » Address most urgent, current flood pathways
- » Should begin and be completed as soon as possible (by 2025)

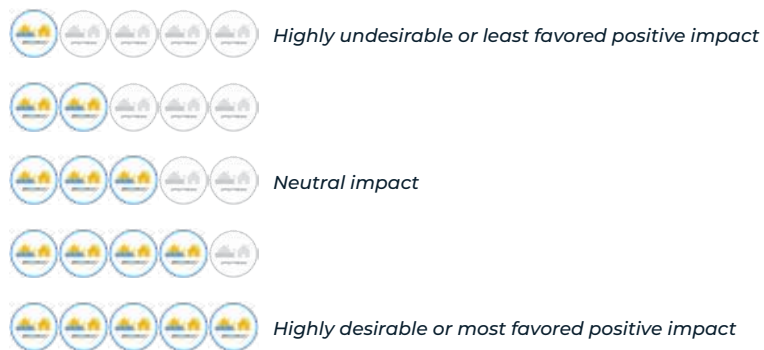
Mid-term Actions
(Next 25 years)

- » Maximize flood risk reduction and minimize cost
- » Leverage partnerships and existing projects
- » Do not preclude future action
- » Should be completed over the next 25 years

Long-term Actions
(2050 and beyond)

- » Represent overall resilience goals for the area
- » May integrate more complex, challenging, resource-intensive, or time consuming elements
- » May be adaptable to higher magnitude flood events even further into the future
- » Should be completed in the 2050s or beyond

Evaluation Criteria Help Guide and Rank Proposed Climate Resilience Strategies



Each action was weighed for its performance against each evaluation criterion.

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

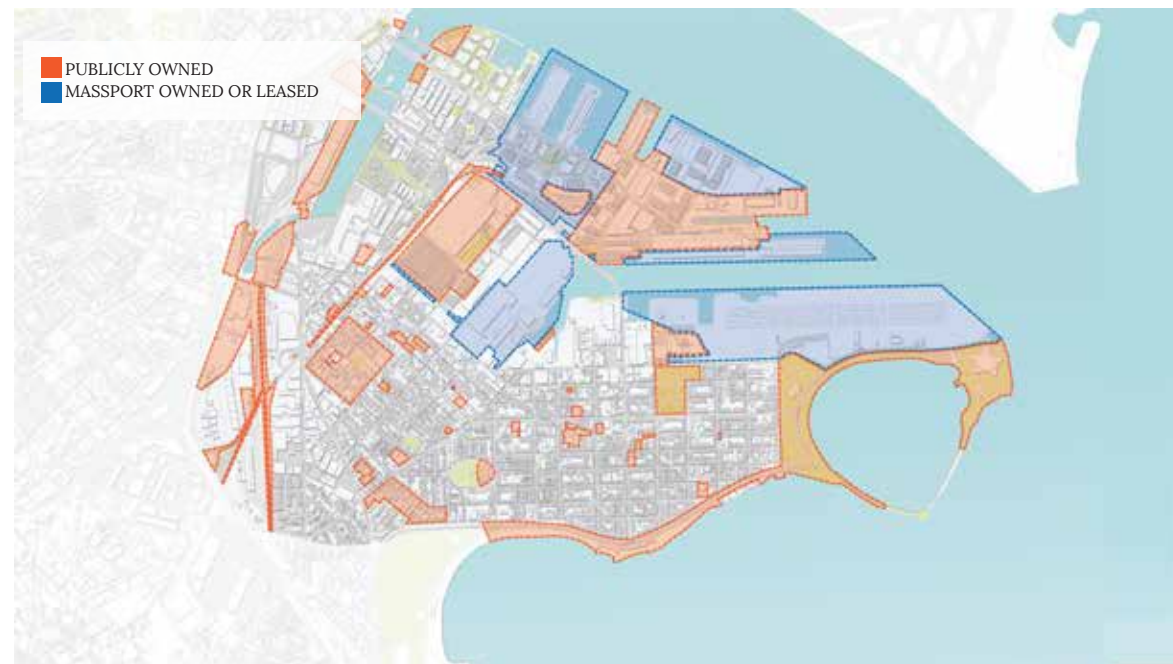
COASTAL RESILIENCE PLANNING

The **Fort Point Channel** and **South Boston Waterfront** are dominated by private land ownership. Stakeholders emphasized public access and amenities. Regulatory coordination will be required during design in order to balance space constraints for flood protection and desire for public space enhancement.

The majority of the land along **Seaport Boulevard**, in the **Raymond L. Flynn Marine Park**, and along the **Reserved Channel** is owned by Massport and the City, though private property owners and tenants are also important partners. Strategies in this area will

have to balance the need for flood protection with maintenance of operations, the desire for expansion of public space, and the need to maintain a safe operating environment.

The **South Boston Neighborhood** consists of William J. Day Boulevard, Pleasure Bay, and South Boston residential areas. These areas are dominated by residents and Commonwealth of Massachusetts / Department of Conservation and Recreation (DCR) land ownership. Stakeholders emphasized amenity retention for the South Boston residents.



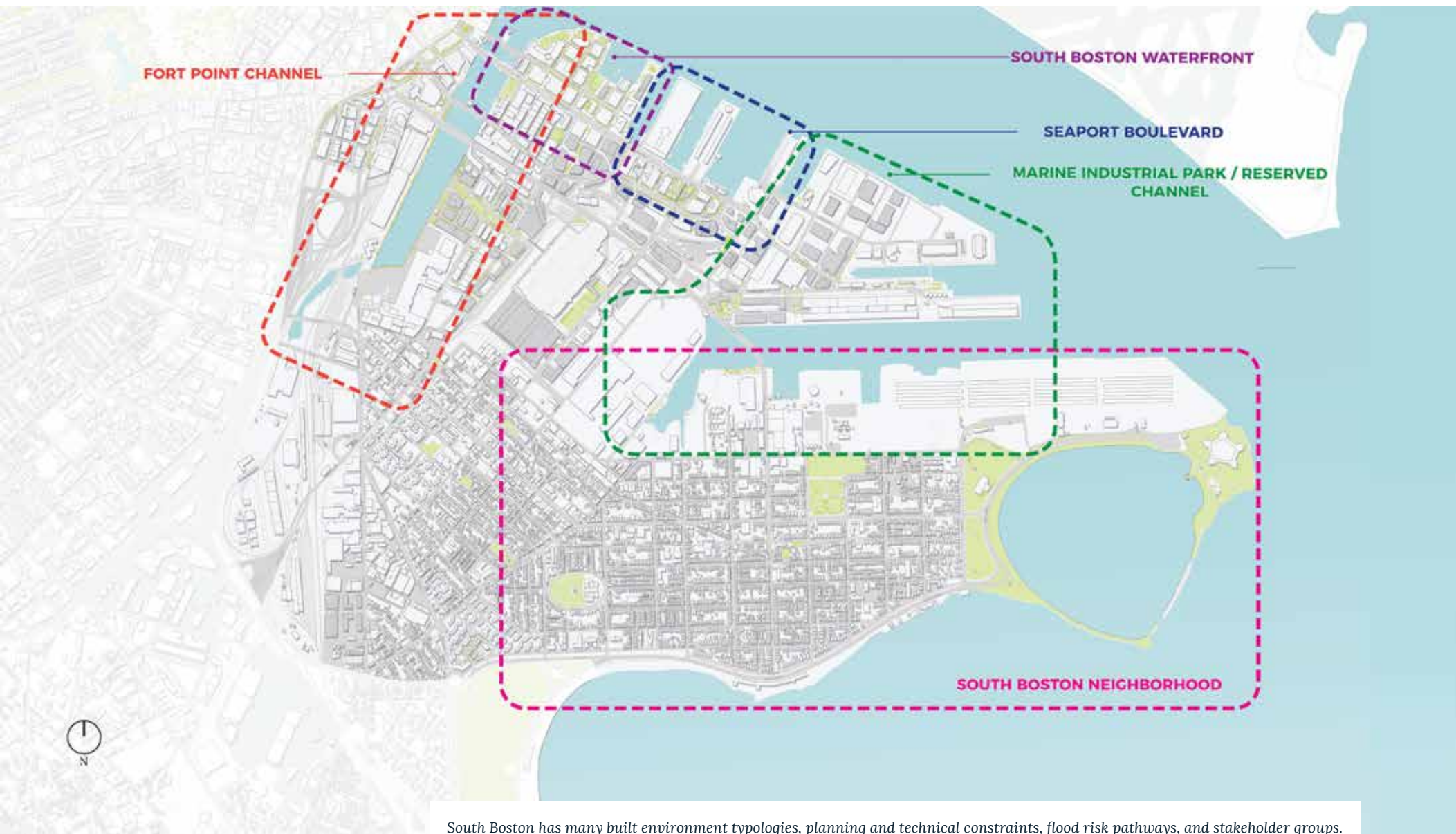
Over 75 percent of the property in the South Boston district is tax-exempt or publicly owned. This map represents publicly owned and Massachusetts Port Authority (Massport) property.

Most of the district with the exception of the historical South Boston residential neighborhood will have a 5-percent annual chance (1 in 20) of flooding with nine inches of sea level rise (2030s). Nevertheless, areas of Fort Point Channel and Seaport Boulevard represent the most urgent need. These areas include both near-term proposed actions that represent an immediate need, and mid-term alternatives that should be implemented by 2030–2040.

STRATEGIES

In some areas, designs emphasize accessibility, recreation, connections, views, social spaces, and ecological features, while reserving space for appropriate mixed-use redevelopment and more access for public use of waterfronts. In other areas, designs emphasize business continuity and access, and still others optimize limited space available for flood protection. In the Fort Point Channel, for example, evaluation criteria favor coastal flood protection systems integrated with open space or an enhanced Harborwalk.

All flood protection options complement inland and regulatory layers of resilience, providing redundancy in the system to protect against potential damages from failure in any one element.



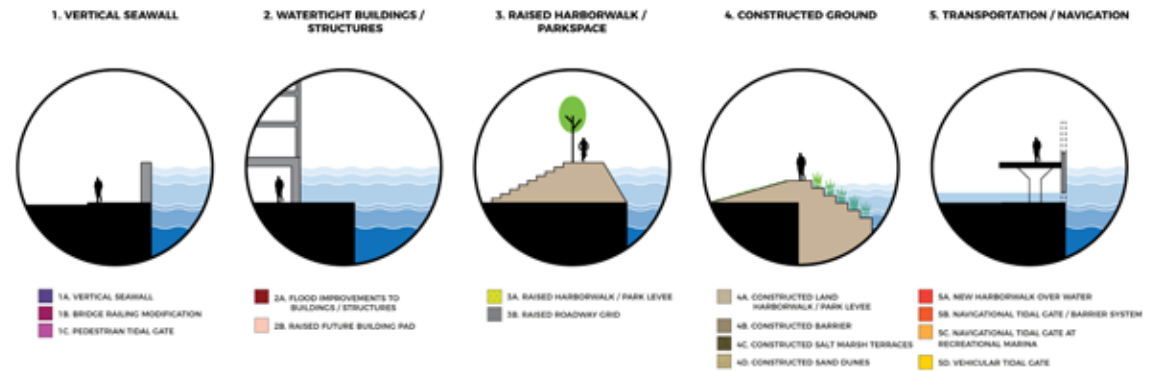
South Boston has many built environment typologies, planning and technical constraints, flood risk pathways, and stakeholder groups.

Three technical elements combine to form coastal resilience design strategy:

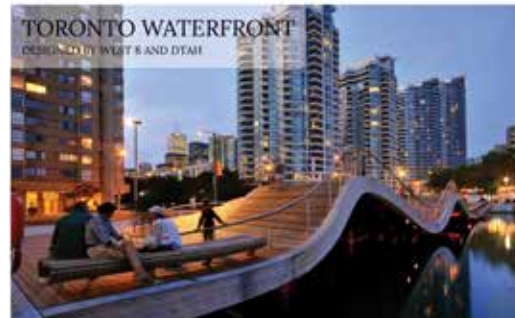
- » The technical approach
- » Location, or alignment, of the technical approach (e.g., along the shoreline or at the mouth of the Fort Point Channel)
- » The look, feel, and experience of the technical approach

The relationship between these three elements can provide long-term protection from rising sea levels and coastal flooding, and create social, environmental, and economic benefits.

COASTAL RESILIENCE DESIGN TOOLKIT



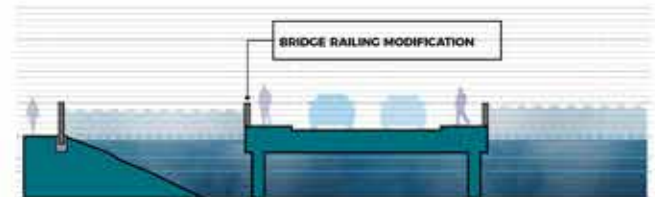
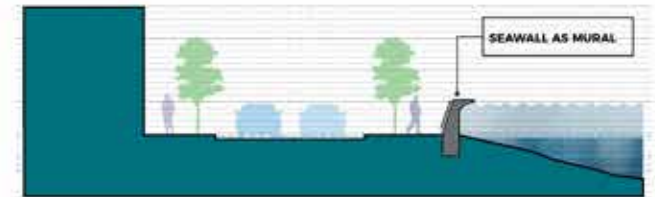
Coastal Resilience Solutions for South Boston used a toolkit of options to provide coastal resilience and other benefits.



Opportunities to enhance public space exist along the waterfront. These pictures provide examples from around the world of this concept in motion.



1. VERTICAL SEAWALL



Examples of coastal resilience design technical approaches



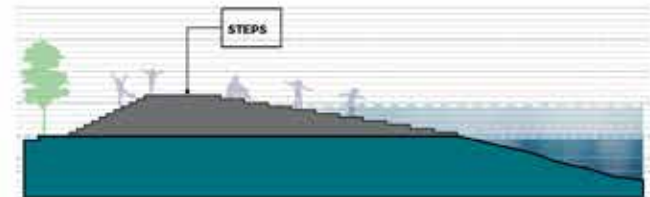
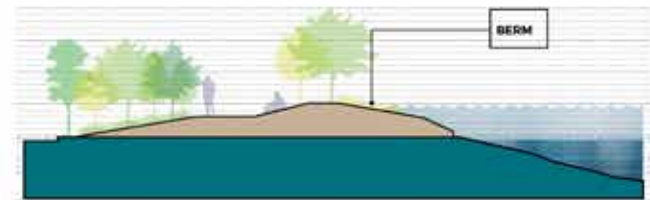
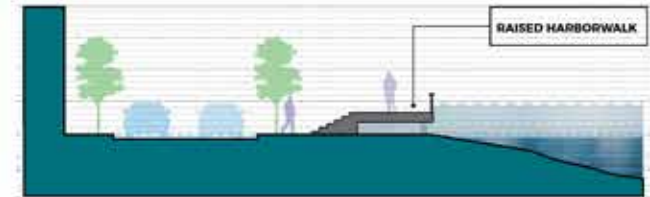
2. WATERTIGHT BUILDINGS / STRUCTURES



Examples of coastal resilience design technical approaches



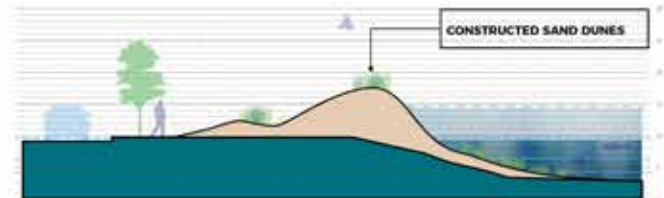
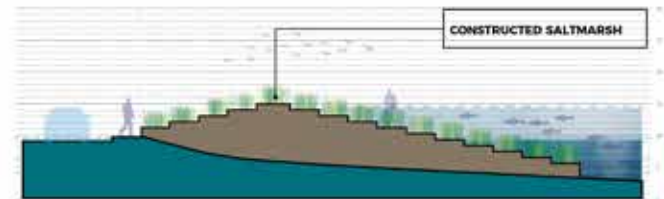
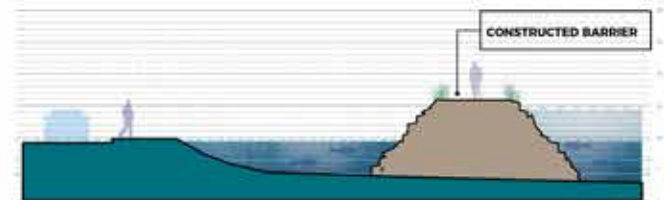
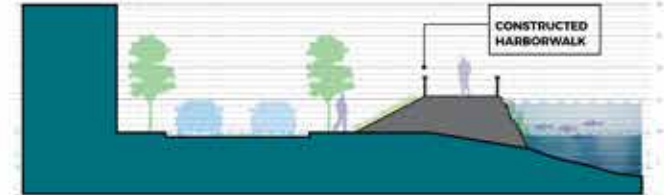
3. RAISED HARBORWALK / PARKSPACE



Examples of coastal resilience design technical approaches



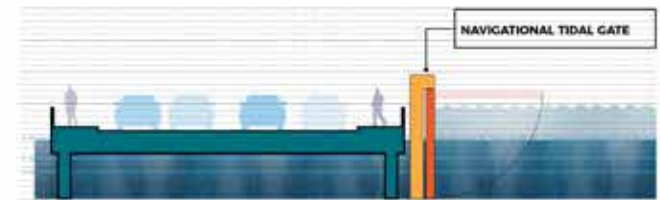
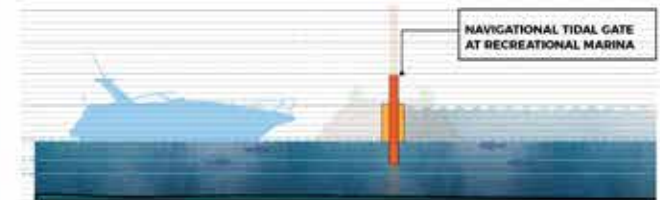
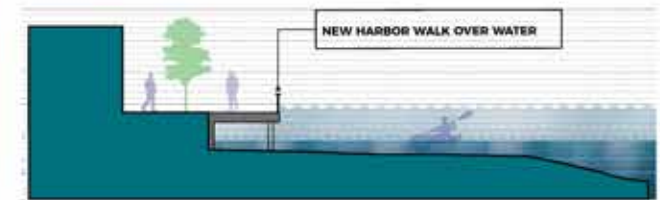
4. CONSTRUCTED GROUND



Examples of coastal resilience design technical approaches



5. TRANSPORTATION / NAVIGATION



Examples of coastal resilience design technical approaches

OPEN SPACE AND ENHANCED PUBLIC SPACE STRATEGIES

Where open space and enhanced public space strategies might be appropriate, these strategies score high in 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 in areas where it is feasible to integrate soft shoreline solutions, and create or enhance 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. These activities bring the community together and increase cohesion.

Park designs might 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 could also reserve space for new stormwater pumping infrastructure that may be needed to control street flooding from extreme rainfall.

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. Enhanced 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.



This report presents alternative flood protection options across South Boston that are capable of being knit together to provide a single coherent district level coastal resilience strategy.

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. 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 deep-water 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.

“I think anything that gets built should not detract from the natural beauty of our harbor.”

- South Boston resident

Projected Sea Level Rise and 1% Annual Chance Flood Elevations

Flood elevations vary across the district and across the City. The example here shows how elevations change over time as a result of sea level rise in South Boston at one location along Fort Point Channel.

Data sources: Climate Ready Boston projections and Boston Harbor Flood Risk Model (BH-FRM). Elevations are reported with respect to the North American Vertical Datum of 1998 (NAVD88). NAVD88 elevations are 6.46 feet lower than Boston City Base.

RELATIVE SEA LEVEL RISE

1 % ANNUAL CHANCE FLOOD ELEVATION AT EXAMPLE LOCATION

1 % ANNUAL CHANCE FLOOD DEPTH ABOVE GROUND AT EXAMPLE LOCATION

CURRENT (2013)	2030S	2050S	2070S
0 inches	9 inches	21 inches	40 inches
9.1 feet	10.2 feet	11.3 feet	12.8 feet
1.1 feet	2.2 feet	3.3 feet	4.8 feet

EFFECTIVENESS AND ADAPTABILITY

Risk can never be eliminated, only reduced. Therefore, “level of protection” should not be considered as providing absolute protection, only the limit to which flood mitigation actions are expected to be effective.

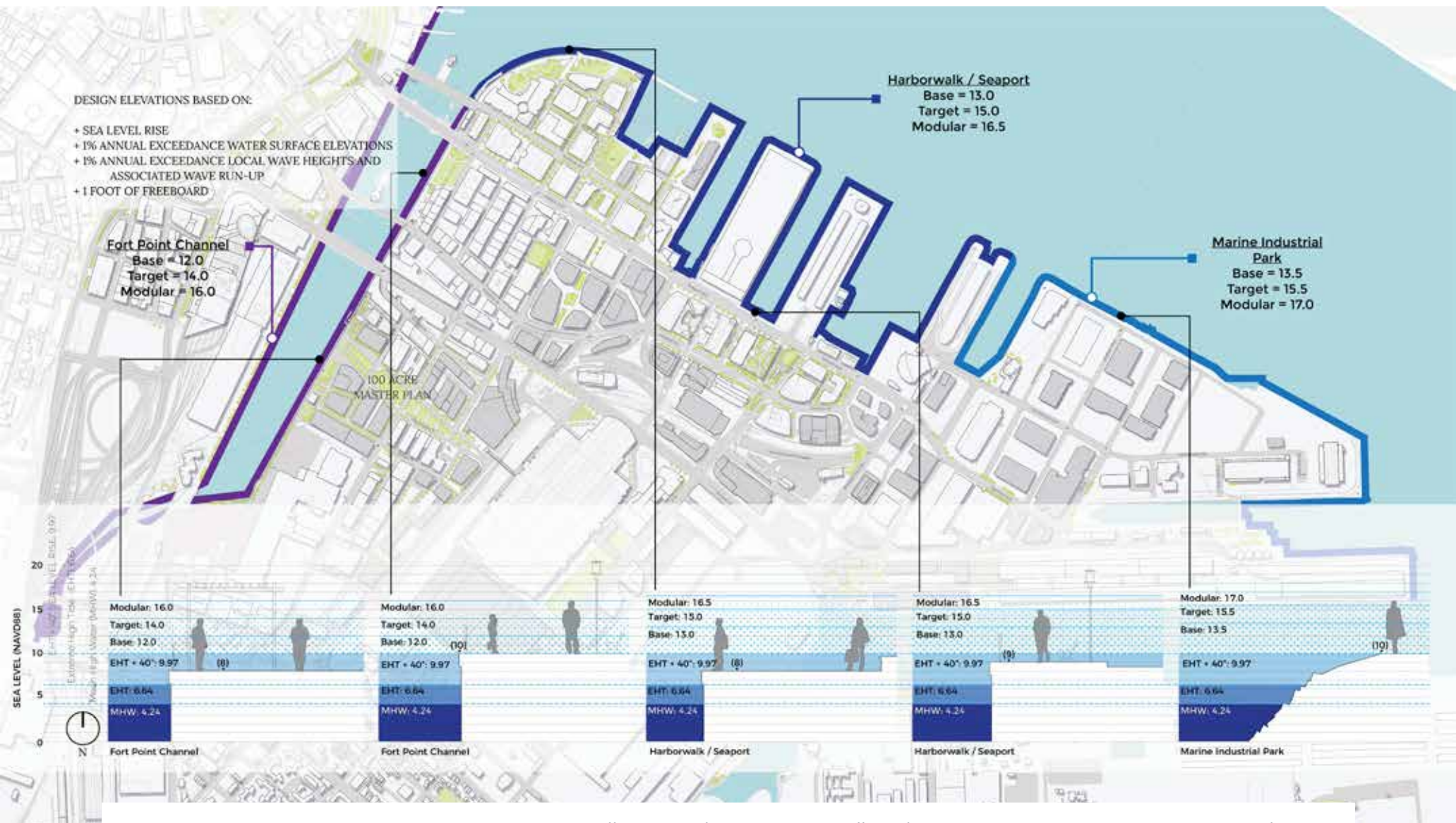
Most designs in this report are adaptable to even greater sea level rise. Parks and pathways reserve space that can be built higher, if needed in the future. At least 2 feet of extra flood protection is possible within current contemplated footprints, which could extend effectiveness for an estimate 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, for example.

Near- and mid-term flood protection actions

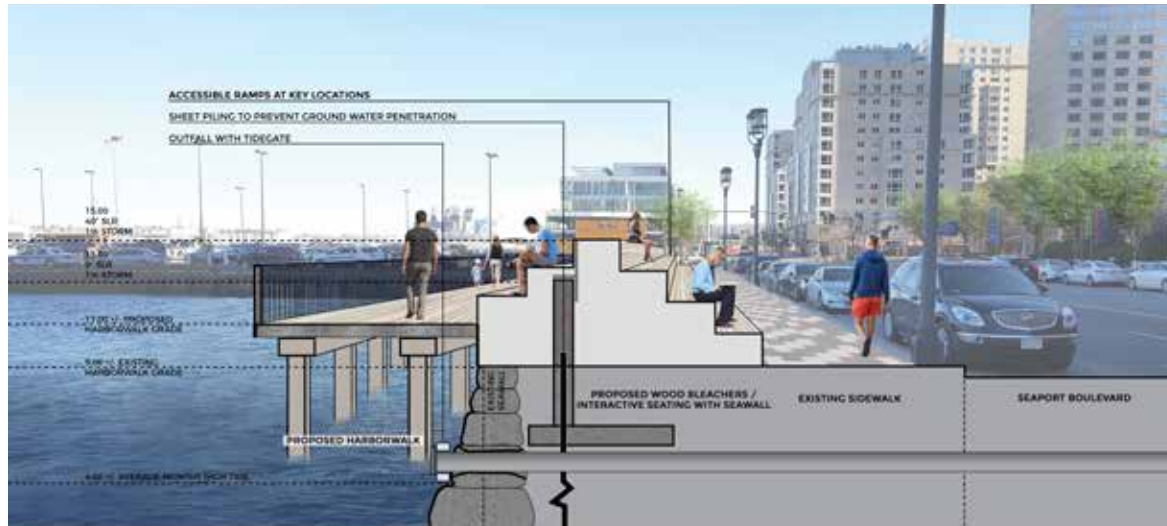
As in Coastal Resilience Solutions for East Boston and Charlestown, most strategies should be designed to the target elevation. In some cases, it may be appropriate to design to the base elevation in the near term, as long as the design would be adaptable to higher elevations in the mid- to long-term.

BASE (MINIMUM) ELEVATION: 12 – 13.5 FEET NAVD88 (+2-5 FEET ABOVE GRADE)	TARGET ELEVATION (NEAR-, MID-, AND LONG-TERM GOAL): 14 – 15.5 FEET NAVD88 (+4-7 FEET ABOVE GRADE)	MODULAR ELEVATION (LONG- TERM ADAPTATION GOAL): 16 – 17 FEET NAVD88 (+6-8.5 FEET ABOVE GRADE)
1-percent annual chance flood elevation with 9 inches sea level rise, plus 1 foot of freeboard	1-percent annual chance flood elevation with 40 inches of sea level rise, plus one foot of freeboard	0.1-percent annual chance flood event with 40 inches of sea level rise plus one foot of freeboard

Elevations are reported with respect to the North American Vertical Datum of 1998 (NAVD88). NAVD88 elevations are 6.46 feet lower than Boston City Base.



Exposure to wave action varies across South Boston. This means that different parts of the coast line need differing flood protection elevations to achieve the same level of protection. These elevations also mean varying heights above grade. Elevations are provided in NAVD88; add 6.46 feet for Boston City Base.



Coastal flood protection systems can be further elevated using integrated seating, planters, and/or seat walls, as demonstrated for Seaport Boulevard. This area is space constrained and is a high priority area subject to current flood risk. In the near-term, a short glass or concrete flood wall could be integrated into the existing built environment. Over time, the height of the flood protection system could be increased through a stepped system and expanded Harborwalk. Other example solutions are provided in Section 03 Coastal Resilience Design Strategies. The numbers shown are elevations in feet NAVD88.

Subsurface public utility conduits, especially stormwater outfalls, are numerous in the area, and may be unidentified or unregistered in municipal utility maps. These conduits allow precipitation runoff to drain; as the sea has risen, they add to flood risk. During elevated tidal conditions, water can backflow and flood streets, even on cloudless days. The City and its partners are working to identify, map, and mitigate these outfall locations. Mitigation measures can include installation of flap gates that only allow one-way water flow, or permanent closure of abandoned conduits.

In addition, porous soil can lead to seawater infiltration below grade. Any coastal resilience design solutions will need to consider and address the risk of infiltration and flooding from beneath the solution. This can be addressed through the use of sheet piling, soil mixing, or other related measures that block flow below grade, or clay caps used with berms at grade.

REGULATORY RESILIENCE STRATEGIES

South Boston requires a holistic and layered approach to increasing flood risk. This includes inland and regulatory resilience strategies that complement the design strategies and reduce risk in the case that any coastal flood protection should be overtopped or fail. Inland resilience strategies include continued investment in and implementation of stormwater management infrastructure design and maintenance, transportation infrastructure improvements, and electrical infrastructure improvements, for example. Regulatory changes may also be needed to implement some of the proposed coastal resilience designs in South Boston.

Alignment with Climate Ready Boston Roadmap Strategies

Climate Ready Boston Roadmap Strategy
Strategy 6 “Coordinate investments to adapt infrastructure to future climate conditions.”
Strategy 7 “Develop district-level energy solutions to increase decentralization and redundancy.”
Strategy 8 “Expand the use of green infrastructure and other natural systems to manage stormwater, mitigate heat and provide additional benefits”
Strategy 9 “Update zoning and building regulations to support climate readiness”
Strategy 10 “Retrofit existing buildings against climate hazards”

REGULATORY AND PERMITTING STRATEGIES TO FACILITATE COASTAL RESILIENCE DESIGN SOLUTIONS

Near-, mid-, and long-term solutions for flood protection must meet the requirements of city, state, and federal regulations and policies. Regulators have participated throughout the planning process to confirm regulatory and permitting pathways and identify potential barriers to implementation.

Many regulations were written decades ago and did not anticipate the potential impacts of sea level rise, nor the range of solutions that might be required to reduce flood risk. To implement proposed resiliency measures, some existing regulations and permitting requirements may need modification to consider the impacts of sea level rise and flood protection projects. Specific recommendations for long-term changes to regulations and policies are presented in Section 04.

Example current regulatory challenges to coastal resilience design strategies:

- » *Categorical restrictions on fill may limit options in space-constrained areas of South Boston*
- » *Impacts to wetlands resources and mitigation requirements present permitting challenges for large-scale fill projects*
- » *There is a possible conflict between protection of environmental resources and permitting a fill project for flood protection*
- » *The Massachusetts Building Code, Wetlands Act, and Flood Overlay Zoning requirements rely on historic FEMA flood zones based on past, not future, flooding*
- » *Climate change resilient or flood protection projects don’t fit into current project categories under many regulations related to the use of fill*

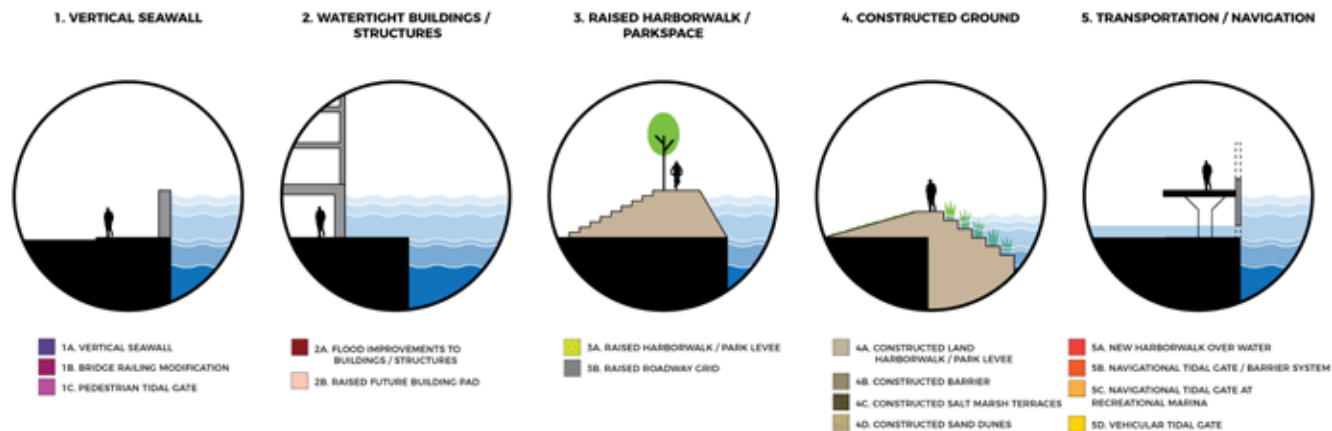
SOUTH BOSTON'S COASTAL RESILIENCE PERMITTING AND REGULATORY FRAMEWORK

Below are the key required permits and sequence for the permitting process estimated for the coastal resilience design strategies for South Boston.

Permitting and Regulating Coastal Resilience Design Strategies

The types of permitting and regulatory timeframes depend on the following factors:

- » The technical design solution, or the technical approach (see Coastal Resilience Design Toolkit)
- » Impact to the existing waterfront (e.g., along the shoreline, over the water, in the water, whether the solution requires fill). Strategies which are built over the water or create land will take longer and may require more permits than those built on the existing shoreline
- » Property ownership (e.g., public or private). Any work taking place on private property will require access agreements or easement rights from private property owners
- » The regulatory designation of the existing area (e.g., historic, water dependent use). Areas subject to wetlands protection or chapter 91 (water dependent use), or considered historic will require additional permitting time



REGULATION	REVIEW BODY	SUMMARY	REGULATION	REVIEW BODY	SUMMARY
State Regulation Chapter 91, the Massachusetts Public Waterfront Act (M.G.L. c. 91)	Implementing legislation 310 CMR 9.00: Massachusetts Department of Environmental Protection (MassDEP) Waterways Program	Chapter 91 protects the public's right to access and use of tidelands and waterways in the Commonwealth, and regulates water-dependent uses	Federal Regulation Section 401 of the Clean Water Act, Water Quality Certification (M.G.L. c. 21)	Implementing Legislation 314 CMR 9.00: DEP Wetlands	Dredge or fill material must meet wetland-specific water quality standards
State Regulation The Wetlands Protection Act (M.G.L. c. 131 Section 40)	Implementing legislation 310 CMR 10.00: MassDEP Wetlands and Boston Conservation Commission	Regulates wetlands resources, including land under the ocean, designated port areas, and land subject to coastal storm flowage (LSCSF). Projects must obtain an Order of Conditions from the Conservation Commission with conditions designed to protect resource areas from the impacts of development	State Regulation Coastal Zone Management Act Consistency Review	Implementing Legislation: 301 MCR 20.00	The Massachusetts Office of Coastal Zone Management (CZM) reviews federal activities to ensure they meet state standards. Federal consistency review is required for projects that require federal licenses or permits, receive federal funds, or are reasonably expected to affect a use or resource of the Massachusetts coastal zone
Federal Regulation Section 404 of the Clean Water Act, Dredged or Fill Materials	Administered by US Army Corps of Engineers	Regulates the discharge of dredged or fill materials into waters of the United States, including wetlands. No discharge of dredged or fill material may be permitted if a less damaging practicable alternative exists. Discharge of fill material requires mitigation to offset any damage to protected resources	State Regulation Section 106 of the National Historic Preservation Act of 1966 (36 CFR 800); M.G.L. c. 9 §§ 26-27C; Chapter 772 of the Acts of 1975	950 CMR 71.00 Administered by the Massachusetts Historical Commission and the Boston Landmarks Commission	Any new construction projects or renovations to existing buildings and infrastructure that require funding, licenses, or permits from any state or federal government agencies must be reviewed by the Massachusetts Historical Commission and the Boston Landmarks Commission for impacts to historic and archaeological properties

REGULATION	REVIEW BODY	SUMMARY
State Regulation Massachusetts Environmental Policy Act (MEPA) (M.G.L. c. 30 Section 61)	Implementing legislation 310 CMR 11.00: Massachusetts Office of Energy and Environmental Affairs MEPA Office	Provides opportunities for public review of the potential environmental impacts for applicable projects, and encourages all feasible means to avoid, minimize, and mitigate damage to the environment
State Regulation Massachusetts Building Code (M.G.L.143 §§ 93- 100)	780 CMR: MA Amendments to the International Building Code Board of Building Regulations and Standards (BBRS)	Establishes a uniform building code for all cities, towns and state agencies in Massachusetts setting forth the minimum requirements to safeguard public health, safety and general welfare through building design and construction
City Regulation Article 68, the South Boston Neighborhood District	The Boston Planning and Development Agency (BPDA) reviews development. Boston Zoning Commission approves changes	South Boston applicable land use zoning code

CHAPTER 91 CONSIDERATIONS FOR COASTAL RESILIENCE DESIGN STRATEGIES IN SOUTH BOSTON

Coastal resilience design strategies for South Boston may be inconsistent with existing Chapter 91 licenses. Project proponents would need the cooperation of current licensees and may require an amendment to the existing license. Additionally, there is a need to maintain public access to the water through the flood protection barrier, regardless of type, in order to meet current Chapter 91 regulations.

Where fill is required, there is a need to determine legal ownership of the submerged land and rights to fill that area prior to filing permits. Chapter 91's categorical restrictions on fill requiring minimization of fill below the high water mark may be overcome by demonstrating that the project will not achieve the same purpose without the fill; nevertheless, the solution must also be the Least Environmentally Damaging Practicable Alternative per the U.S. Army Corps of Engineers (USACE) regulations. Consideration must also be given to a project's potential for removal of wetlands resource areas.

Where design strategies reduce the lot size of a permitted parcel, the parcel may no longer be in compliance with the zoning setback requirements. See Section 04 for more on this topic.



1. Vertical Seawalls

Vertical seawalls are a viable resilience strategy across much of South Boston. Permitting requirements will vary by location. The following assumptions apply to South Boston coastal resilience design strategies that include vertical seawalls:

- » All seawalls will be at least partially seaward of the high-water mark
- » Existing seawalls may be able to be expanded or modified dimensionally (height raised) to meet resilience needs in some areas
- » Some existing seawalls in South Boston are on the National Register of Historic Places
- » Some South Boston seawalls may be wholly or partially on privately owned or leased property
- » Seawalls are licensed structures and are required to be maintained. The licensee is required to maintain authorized fill
- » The Massachusetts Department of Environmental Protection (MassDEP) may allow in some instances new seawalls/bulkheads outboard of old structures as part of maintenance procedures without being classified as new fill



2. Watertight Buildings and Structures

Despite the fact that most alignment options are along the waterfront, there are several structures, such as those along Seaport Boulevard, that would remain outside of alignment and would require independent flood protection unless final

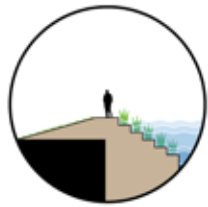
flood protection extends into the water. There are also structures that would have to be independently floodproofed in the case that inland options are selected. In all cases, buildings and structures that will be floodproofed will require engineering evaluation for structural soundness and must meet the building code. Alternate options include “tight” or “sister” walls that are built immediately adjacent to structures and can provide additional reinforcement.



3. Raised Harborwalk / Raised Park Space

Raised Harborwalk or raised park space are viable resilience strategies across much of South Boston. Permitting requirements will vary by location. The following assumptions apply:

- » Some Harborwalk may be all or partially seaward of the high-water mark
- » Some Harborwalk may be built on new fill material
- » Some existing Harborwalk may be expanded or elevated
- » Harborwalk may be partially or wholly on privately owned or leased property



4. Constructed Ground (Landfill)

In areas where existing space is limited, options for new land constructed in the water demonstrate the potential for multi-purpose resilient infrastructure that provides co-benefits, such as open space for recreation, stormwater retention, and

aesthetic value. Raised Harborwalk and raised park space are proposed for multiple areas across South Boston. Permitting requirements will vary, based on the specific locations identified in the report. The following assumptions apply:

- » Volume and boundaries of landfill must still be determined
- » Mitigation for filled land will be required
- » A portion of the harbor/water will be filled to create a higher elevation and flood protection (as well as providing other benefits to the community). The primary purpose, however, is flood protection
- » Landfill may be considered a flood protection water-dependent use, which includes: shore protection structures and associated fill necessary to protect an existing structure, and flood control facilities (310 CMR 9.12(12))



5. Transportation/Navigation

Options for transportation/navigation solutions, such as flood gates, are presented for consideration in areas such as Fort Point Channel and the South Boston Waterfront. Permitting requirements will vary, based on location. The following assumptions apply:

- » This will be a mechanical system located in the water
- » System would need to be distinct and separate from bridge structure

MECHANICAL FLOOD GATE OPTIONS IN FORT POINT CHANNEL AND SOUTH BOSTON WATERFRONT

The detailed design process must ensure that solutions will not impede navigation, including water transportation. As mechanical gate solutions would likely need to be closed more often as the century progresses, water quality in these areas will be an important consideration during detailed design and permitting should these options proceed.

PRIVATE PROPERTY AND INFRASTRUCTURE RESILIENCE STRATEGIES

South Boston needs a multi-layered approach that also increases the resilience of inland systems and property. Increasing the resilience of private property and infrastructure systems, at various scales, decreases the likelihood of damage in the case of a flood event.

Stormwater

South Boston will see the greatest increase of any Boston district in land area exposed to stormwater flooding as sea levels rise and precipitation events become more extreme. Final designs for coastal resilience strategies will need to take inland stormwater management into account, to ensure that stormwater can be discharged or stored properly during a storm. When stormwater can't be discharged by gravity due to extreme high tides, other measures will need to be taken including increasing pumping facilitates or storage areas. Additionally, rising seas must be prevented from backing up into the existing storm systems. Inland stormwater solutions include tide gates on both public and private outfalls, stormwater storage techniques (both green and gray infrastructure), and enhanced stormwater system maintenance.

Boston Water and Sewer Commission (BWSC) is in the process of putting backflow preventers on their facilities, as well as developing a maintenance process for these assets moving forward. Other outfalls are

also owned by the Massachusetts Department of Transportation (MassDOT), Economic Development Industrial Corporations (EDIC), private landowners, and Massport. BWSC is also working on inundation modelling and stormwater storage projects.

Transportation and Power Infrastructure

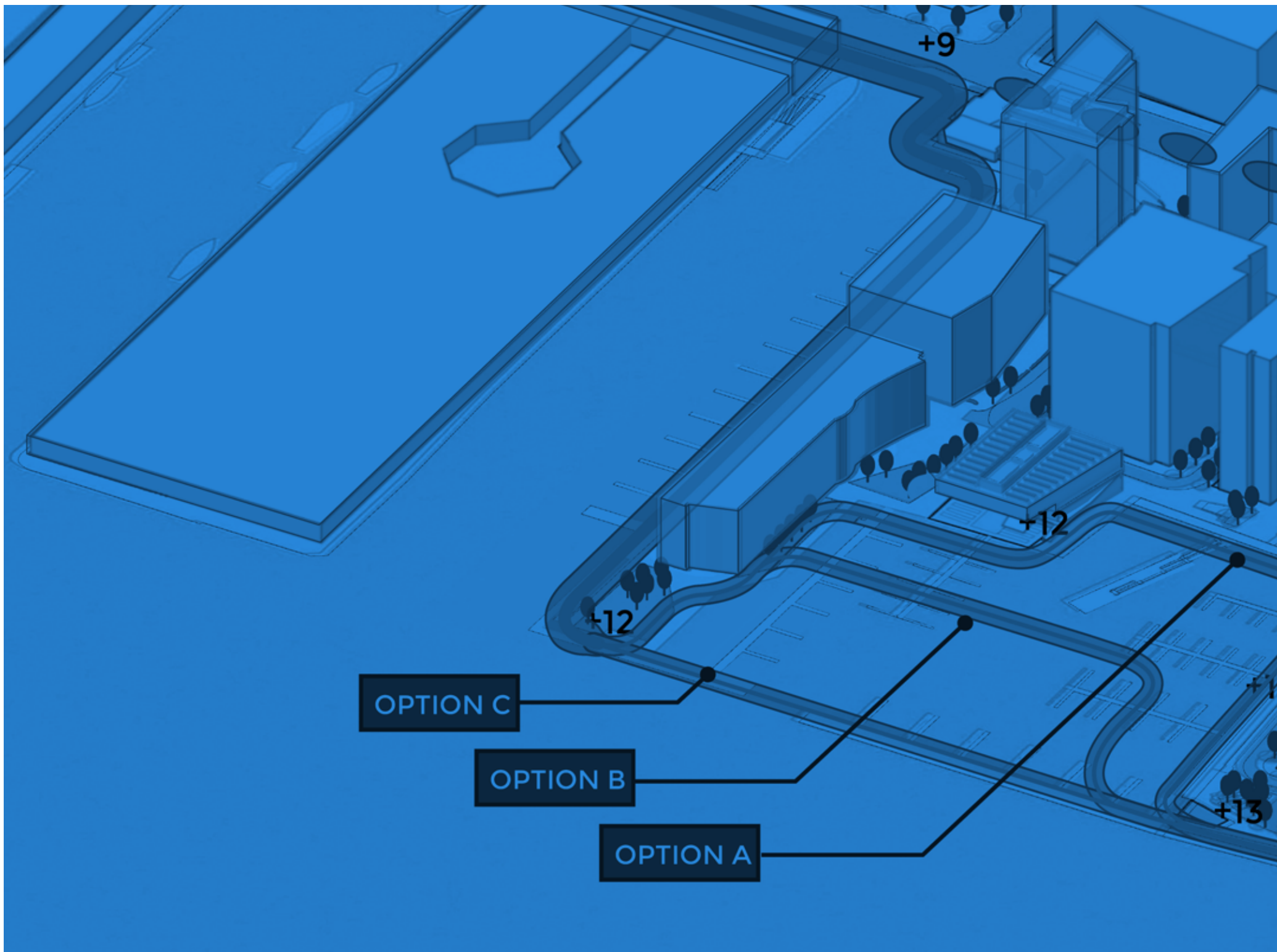
MBTA, Massport, MassDOT, the City, Eversource, and other transportation and power providers have critical assets in South Boston that flood events could damage. Commuter access—as well as truck routes and marine operations—is critical to continued economic productivity and vitality. Transportation and power infrastructure improvements can serve a second line of defense inland of shoreline solutions. Work on micro-grids in the Raymond L. Flynn Marine Park is being explored.

“During the winter storms, the water wasn’t just coming from the harbor or the channel, it was coming up from the drains and surrounding us from behind.”

– South Boston resident

Site-specific property protection

Retrofit programs promote improvements to existing buildings on a neighborhood or district-level scale. Recent examples include energy efficiency programs such as Renew Boston and Mass Save.



03 COASTAL RESILIENCE DESIGN STRATEGIES



COASTAL RESILIENCE DESIGN STRATEGIES

We propose coastal resilience design strategies along the perimeter of South Boston in the near-term to mitigate urgent flood risk and strengthen enjoyment and connectivity to the waterfront. Over time, regulatory resilience solutions, such as those that will raise structures and infrastructure, are also required to provide long term resilience in South Boston. Regulatory resilience solutions are described in Section 04.

FORT POINT CHANNEL

FLOOD RISK
ENGAGEMENT FEEDBACK
RESILIENT COASTAL DESIGN

SOUTH BOSTON WATERFRONT

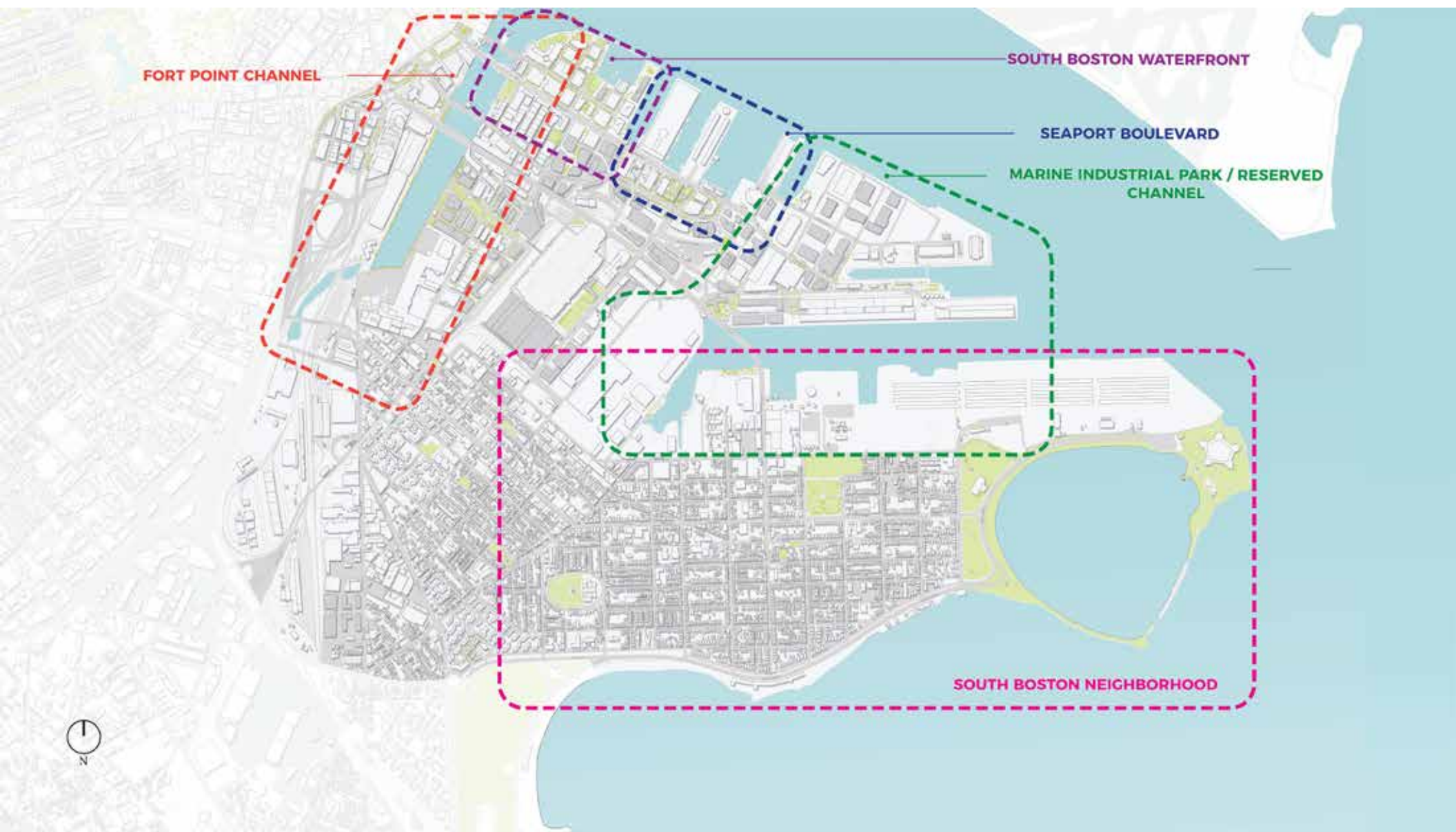
FLOOD RISK
ENGAGEMENT FEEDBACK
RESILIENT COASTAL DESIGN

SEAPORT BOULEVARD, RAYMOND L. RAYMOND L. RAYMOND L. FLYNN MARINE PARK, RESERVED CHANNEL

FLOOD RISK
ENGAGEMENT FEEDBACK
RESILIENT COASTAL DESIGN

SOUTH BOSTON NEIGHBORHOOD

FLOOD RISK
ENGAGEMENT FEEDBACK
RESILIENT COASTAL DESIGN



FORT POINT CHANNEL

“South Boston... will be challenged early in the century even with relatively moderate increases in sea levels. In this neighborhood, significant portions of the waterfront serve as flood entry points, so developing strategies to increase protection would require more significant investments in infrastructure or more complex coastal flood resilience planning...”

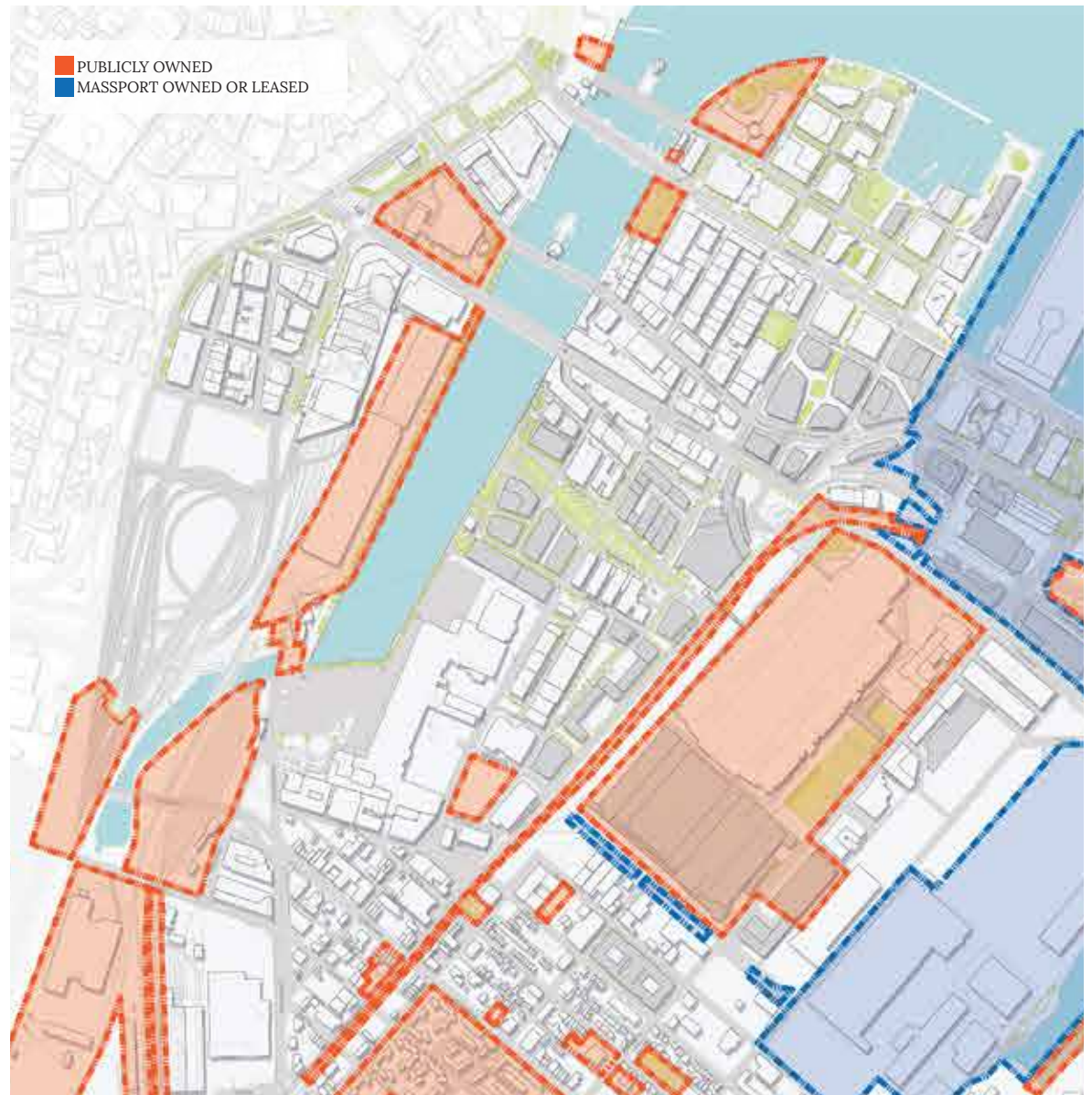
- Climate Ready Boston



Photos: Fort Point Channel

The east side of the **Fort Point Channel** planning zone is dominated by private land ownership including large and small businesses, non-profit organizations, cultural groups and landmarks, as well as connections to critical transportation routes and infrastructure. The west side of the Fort Point Channel is a mix of ownership with the largest property owners including the Commonwealth of Massachusetts and the United States government.

First developed in the 1830s by the Boston Wharf Company, the Fort Point area was one of the nation's leading marketplaces for wool. Manufacturing and warehouse buildings have been preserved as a Landmarks District and artists have converted many of them to studios and lofts. The South Boston Manufacturing Center is located at the southern end of the Channel. The Boston Children's Museum is located toward the northern end of the channel. Other cultural attractions, such as the Boston Fire Museum, the Boston Tea Party Museum, and art galleries are also located in the area.



“The 2002 Fort Point Channel Watersheet Activation Plan looks at ways to activate the calm water along the channel through public realm improvements and the development of water dependent uses. The 100 Acres Master Plan provides a framework for transforming the existing surface parking lots around the Proctor & Gamble/Gillette (“P&G/Gillette”) plant, the USPS facility, and Fort Point historic structures to a vibrant 24-hour, mixed-use neighborhood anchored by over 11 acres of new public open space and almost 5.9 million square feet of development.”

- Boston Planning and Development Agency (BPDA) website

PLANNED PROJECTS



Areas along the Fort Point Channel's east shoreline are undergoing transformative redevelopment. General Electric is planning the new GE Headquarters Facility, known as Innovation Point.



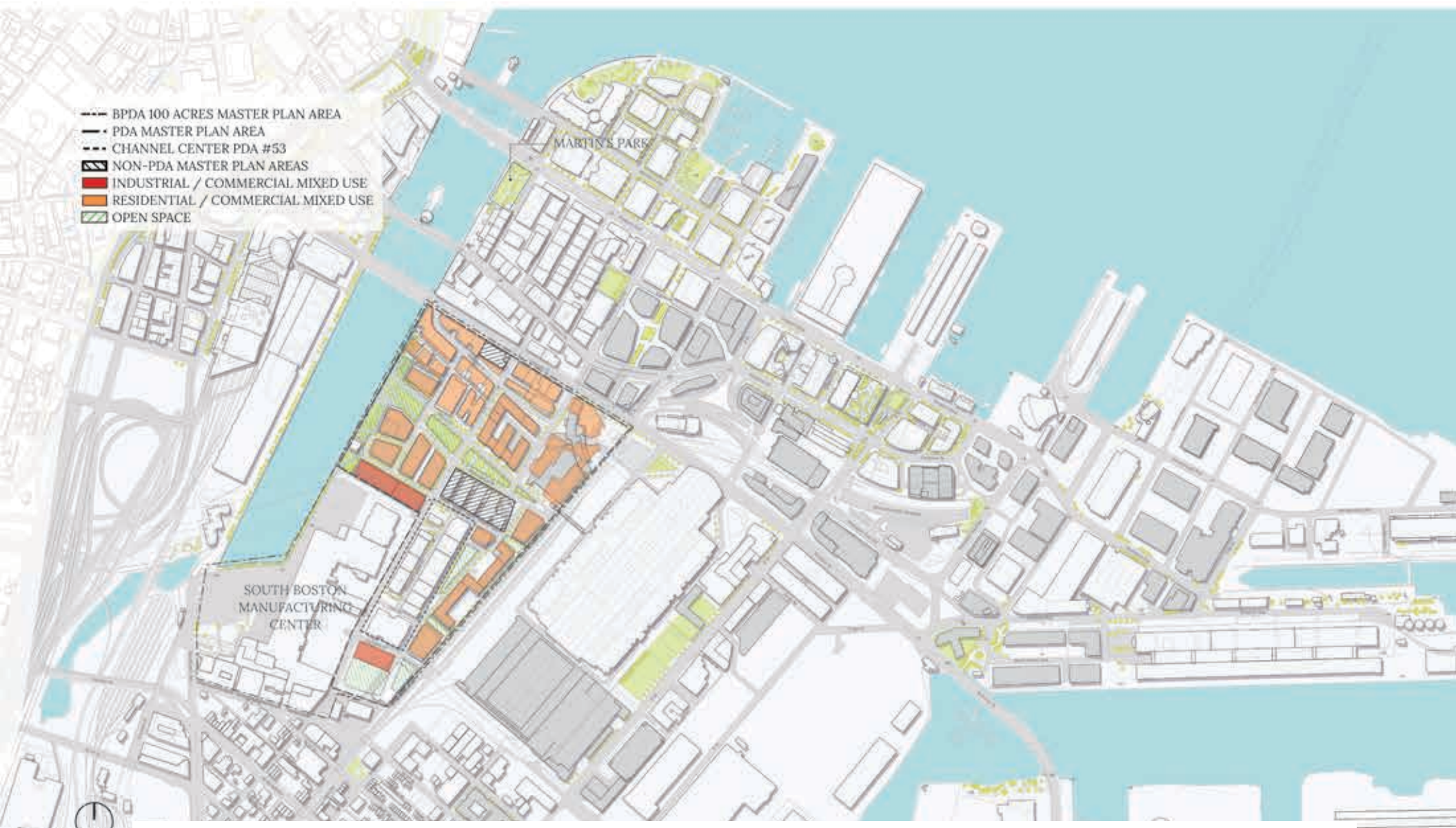
GE Innovation Point Development site

'Martin's Park' breaks ground this week, honoring youngest marathon bombing victim

Updated Aug 16, 2017. Posted Aug 16, 2017



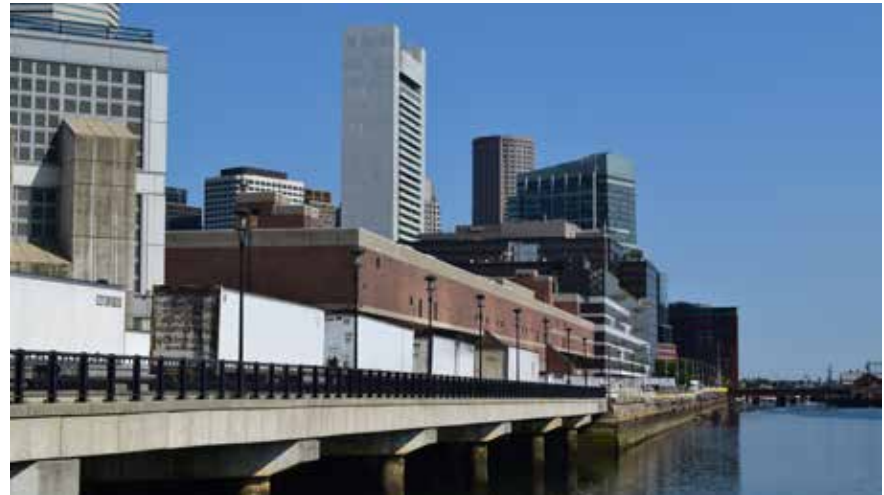
The open space adjacent to the Boston Children's Museum is currently being transformed into Martin's Park, an accessible park and playground. The design of Martin's Park was reviewed as part of Coastal Resilience Strategies for South Boston, and the process recommended flood mitigation improvements to the design.



The 100 Acres Master Plan is bordered by Summer Street at the north, the South Boston Bypass Road to the east, and West Second Street and Dorchester Ave to the south. The Plan includes industrial, commercial, and residential mixed use with significant open space enhancements along the waterfront and peppered throughout the Plan area.

WEST SIDE OF THE FORT POINT CHANNEL

The west side of the Fort Point Channel is characterized by governmental and institutional land use from the southern end to mid-channel with the United States Postal Service property, South Station, and the Federal Reserve. The northern end of the channel on the west side includes residential and office uses, restaurants and hotels, as well as the U.S. Coast Guard and Department of Homeland Security located at the northern end.



Commuter Rail crossing Fort Point Channel



Views of the west side of Fort Point Channel

FLOOD RISK

The east side of the Fort Point Channel will face exposure to flooding from average monthly high tides by mid- to late-century. This means that inundation is expected at average monthly high tide without any storm conditions.

Although Fort Point Channel has been spared significant damage to date, action is needed now to prevent direct physical damage and loss of use to the area in the future.

The most critical flood pathway is associated with the 100 Acres Master Plan area. The flood pathway presently overtops the waterfront during astronomical high tides and coastal storm events. Over time, flood waters will extend further inland toward the Boston Convention and Exhibition Center. This area is the lowest along the channel and will have a 20-percent (1 in 5) annual chance of flooding during a coastal storm event with 9 inches of sea level rise (2030s).

Another flood pathway starts between the Summer Street and Congress Street bridges. A third flood pathway enters just to the south of the Seaport Boulevard bridge. These two flood pathways effectively surround the Boston Children's Museum property and extend inland, converging with the pathway from the 100 Acres Master Plan area, to inundate Boston Wharf Road. While less urgent than the flood pathway in the 100 Acres Master Plan area, these flood pathways also currently have at least a 1-percent annual chance of flooding.

The fourth flood pathway is associated with longer-term (2050s) risk and originates at the northern end of the Massachusetts Bay Transportation Authority's (MBTA) multi-acre Cabot Yard and Cabot Maintenance Facility. The facility is slated for significant improvements, including rebuilding of the existing facility, site work, track work, structural and architectural work, signal and communications work, and new equipment. This flood pathway exposes inland sections of the South Boston residential neighborhood to the 10-percent annual chance of flooding with 21 inches of sea level rise (2050s). Through this flood pathway, the South End would be exposed to a 10-percent annual chance of flooding with 40 inches of sea level rise (2070s).

Later in the century (2070s) this flood pathway at the base of the Fort Point Channel may connect with pathways emerging from the Charles River Dam and Dorchester, as described in *Climate Ready Boston*, and contribute to flooding in the South End.

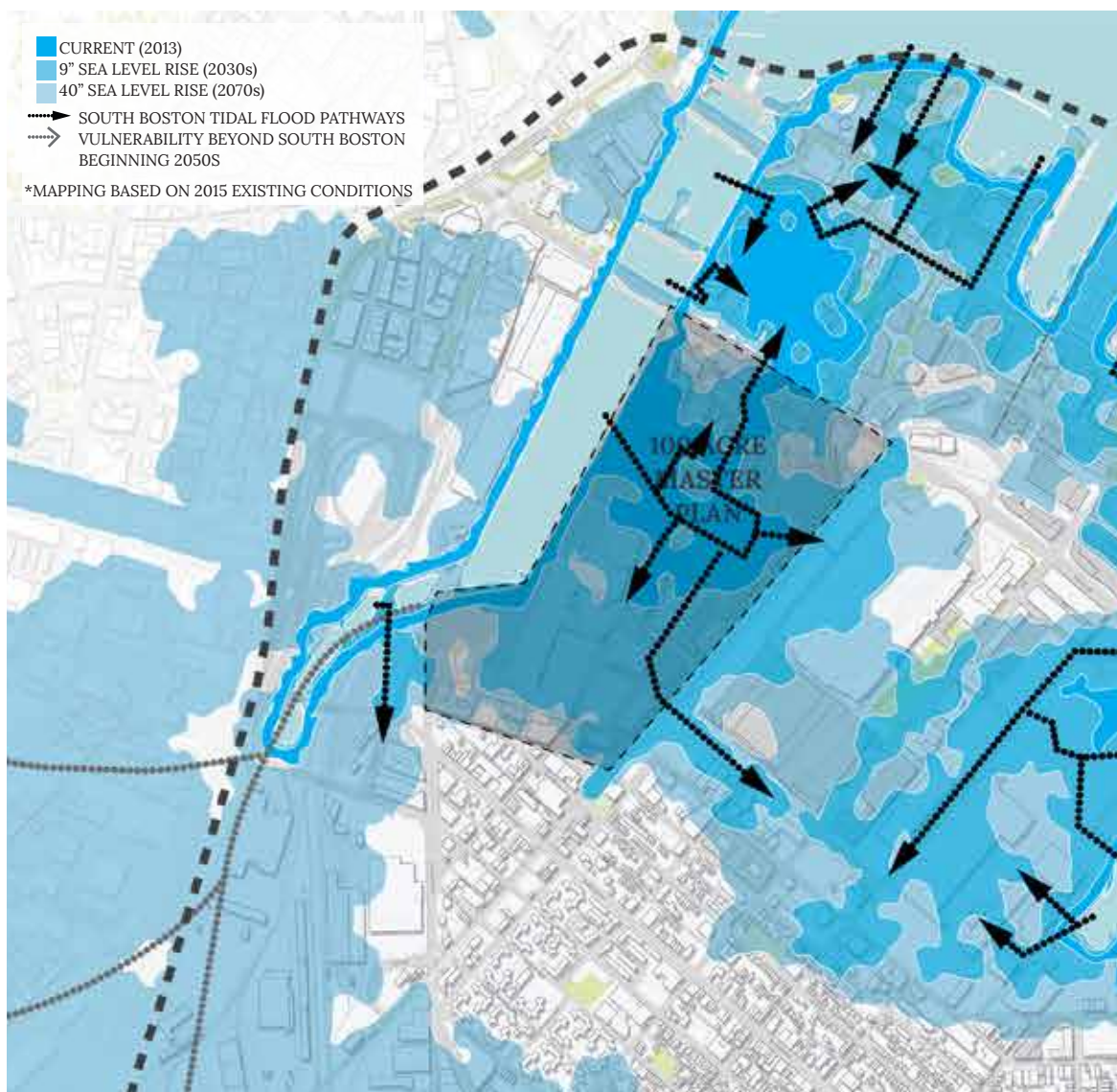
"Average monthly high tide" means the average of the highest tide experienced each month in 2015. Since tide ranges fluctuate seasonally, daily tides could rise above the average monthly high tide multiple times some months and not at all in other months.

The west side of the Fort Point Channel will not likely be affected by flooding until 40 inches of sea level rise. Even then, flooding would be limited and could be addressed through site-specific coastal resilience solutions, except at the base of the Channel.

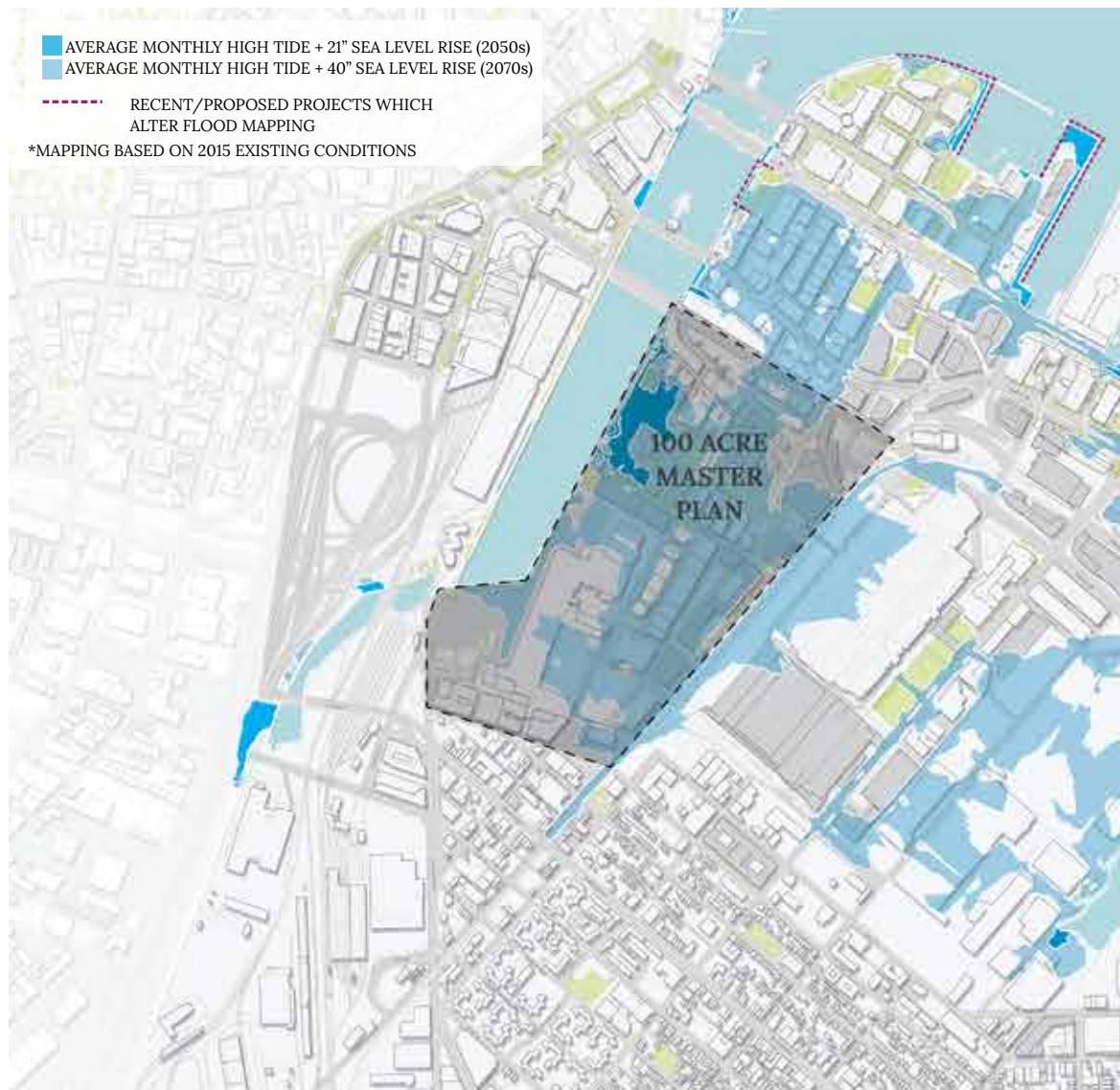
Without action, flood pathways on the east side of the Fort Point Channel at the 1-percent annual chance flood elevation with 9 inches of sea level rise (2030s) risk over \$317 million in direct physical damage, displacement, and relocation costs. This flood elevation potentially impacts 101 structures and 1,120 people.

Flood risk is lower on the west side of Fort Point Channel; a 1-percent annual chance flood elevation with 9 inches of sea level rise (2030s) risks \$5.6 million in physical damage and displacement, impacting two structures, but no residents.

The significant anticipated losses from widespread flooding at such an early stage of sea level rise make Fort Point Channel an ideal location for implementation of near-term coastal resilience solutions. At higher flood levels, flood pathways associated with the Fan Pier area, Seaport Boulevard, the Raymond L. Flynn Marine Park, and Reserved Channel could combine with the flood pathways in the Fort Point Channel. Action in each of these areas before mid-century will be required to maintain full effectiveness of any resilience actions taken along the east side of the Fort Point Channel.



The gradations of blue in the map show how the flood extent from the 1-percent annual chance flood event changes from 2013 to 9 inches of sea level rise (2030s) and 40 inches of sea level rise (2070s). The colors do not indicate depth of flooding. Arrows indicate key flood pathways. Over time, the flood pathways originating in the Fort Point Channel converge and extend into other parts of the City, through Widett Circle south and west to the South End and Dorchester.



Tidal flood maps showed widespread flooding and loss of Harborwalk use with sea level rise. Because most of the waterfront is flat filled land, stakeholders decided shoreline protection was the best approach in South Boston.

The east side of the Fort Point Channel is at significant risk to average monthly high tides by mid to late century. The first area expected to flood at least monthly originates at the waterfront associated with the 100 Acres Master Plan. With 9 inches of sea level rise, there is isolated risk of average monthly high tide flooding along both sides of the channel. This is most prominent at the base of the channel along Frontage Road adjacent to the Public Works Department.

ENGAGEMENT FEEDBACK

Community engagement helped to clarify expectations and vision for the future of the east side of the Fort Point Channel, priorities in building resilience, and coastal resilience, design strategies in the area.

Participants provided feedback regarding evaluation criteria, locations and types of strategies, desired relationship with the waterfront (particularly with regard to sight lines), and possible funding sources.

Concerns included the desire to prevent water from entering properties without losing existing sight lines, access and egress, the ability to manage heavy rainfall or snow along with sea level rise scenarios, and water quality in the channel. The most important criterion is effectiveness.

Because collective action is required across the waterfront throughout South Boston to achieve resilience goals, geographic focus groups helped to build consensus around options, and to develop a sense of ownership about implementation. The participants consisted of property owners, tenant and resident associations, and non-profit organizations with interests around the channel.

A survey question asked participants “As a resident, what are your priorities for improvements to these areas?” The top three priorities for the Fort Point Channel, according to survey participants were: Transportation (33%), Parks and Open Space (33%) and Arts/Cultural (32%).

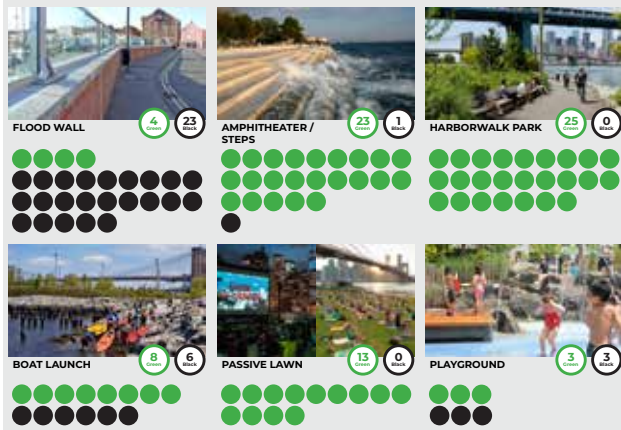
Stakeholders provided clear reactions:

- » Current sight lines to the water are critical to maintain, and it is also critical to ensure that the Harborwalk and waterfront properties are protected for present and future enjoyment. Any flood protection actions will need to be along the waterfront, but also should at least maintain, but preferably enhance, public enjoyment of the area and connectivity within the community.
- » Property owners in the area are prepared to work together to provide a continual line of defense to protect both their own properties and those further inland. The flatness of the project area presents an urgent need for a continuous line of protection to prevent ‘flanking’.
- » Some uses could tolerate recurrent flooding more than others. Owners who expected to have elevated office space in the area, for example, could maintain operations off-site in the case of a flood event, and return with little disruption. Manufacturing uses, restaurants, and residential uses along the channel are intolerant of recurrent flooding and need a high level of effectiveness to reduce risk.
- » Some stakeholders valued effectiveness, passivity of the solution (no human action required during a flood event), and speed of possible implementation above the need for enhanced public enjoyment. Other stakeholders initially expressed the desire to explore movable flood protection solutions to avoid disrupting the current relationship with the waterfront, but acknowledged the added risk with moving parts.
- » Stakeholders were concerned about fairness in contributing to the cost of the flood protection solution. Most, if not all, stakeholders expressed a willingness to contribute, but were concerned that all those benefiting should contribute to its implementation. Stakeholders also thought that funding could be more readily gathered for solutions that enhance public enjoyment of the area.

FORT POINT CHANNEL

WHICH FLOOD PROTECTION ELEMENTS AND AMENITIES DO YOU PREFER?

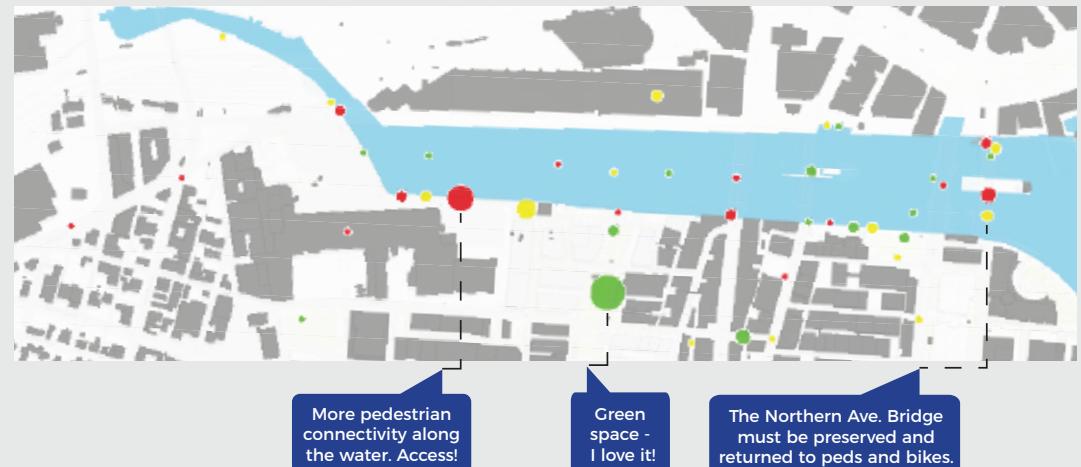
● = Want ● = Do Not Want



WHAT ARE YOUR WATERFRONT PUBLIC SPACE PREFERENCES?

● = something you love
● = something you want to change
● = something you want to add

*Larger circle size denotes clustering of public comments



Open House Summary for Fort Point Channel Planning Zone, 12/11/17

COMMENTS

We need flood resistant construction and planning. Limiting development and preserving historic buildings should also be prioritized

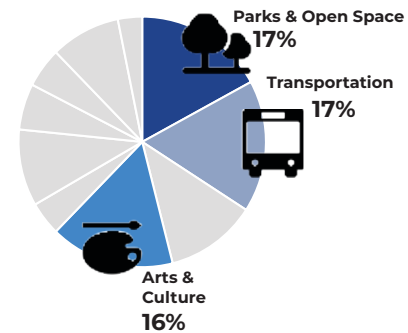
Water management.

I live 2 blocks from Fort Point Channel and am concerned about a storm surge.

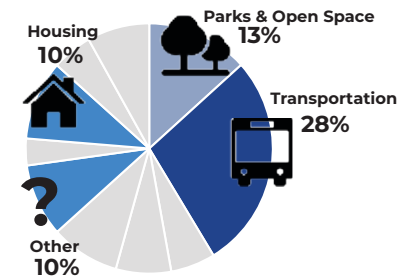
PRIORITIES

Respondents were asked to choose up to two top priorities for improvement. The following pie chart percentages indicate top categories selected for the Fort Point Channel.

RESIDENT PRIORITIES



NON-RESIDENT PRIORITIES



Online Survey Results for Fort Point Channel Planning Zone, 9/28/17 - 12/31/17

Estimated Costs for Alignment Options A and B

OPTION A

ESTIMATED COST	\$108 - 139 million*
ESTIMATED MAINTENANCE COST	\$1.6 - \$2.1 million** per year

*This cost represents only the east side of the Fort Point Channel. Similar actions on the west side of the Fort Point Channel will not be required until the 2060s.

**Maintenance costs are expected to be 1.5 percent of the implementation costs.

OPTION B

ESTIMATED COST	\$171 - 197 million
ESTIMATED MAINTENANCE COST	\$2.6 - \$3.0 million per year*

*Maintenance costs are expected to be 1 percent of the total cost to implement the solution.

MID-TERM AND LONG-TERM COASTAL RESILIENCE SOLUTION OPTIONS

We examined two practical alignment options for the Fort Point Channel:

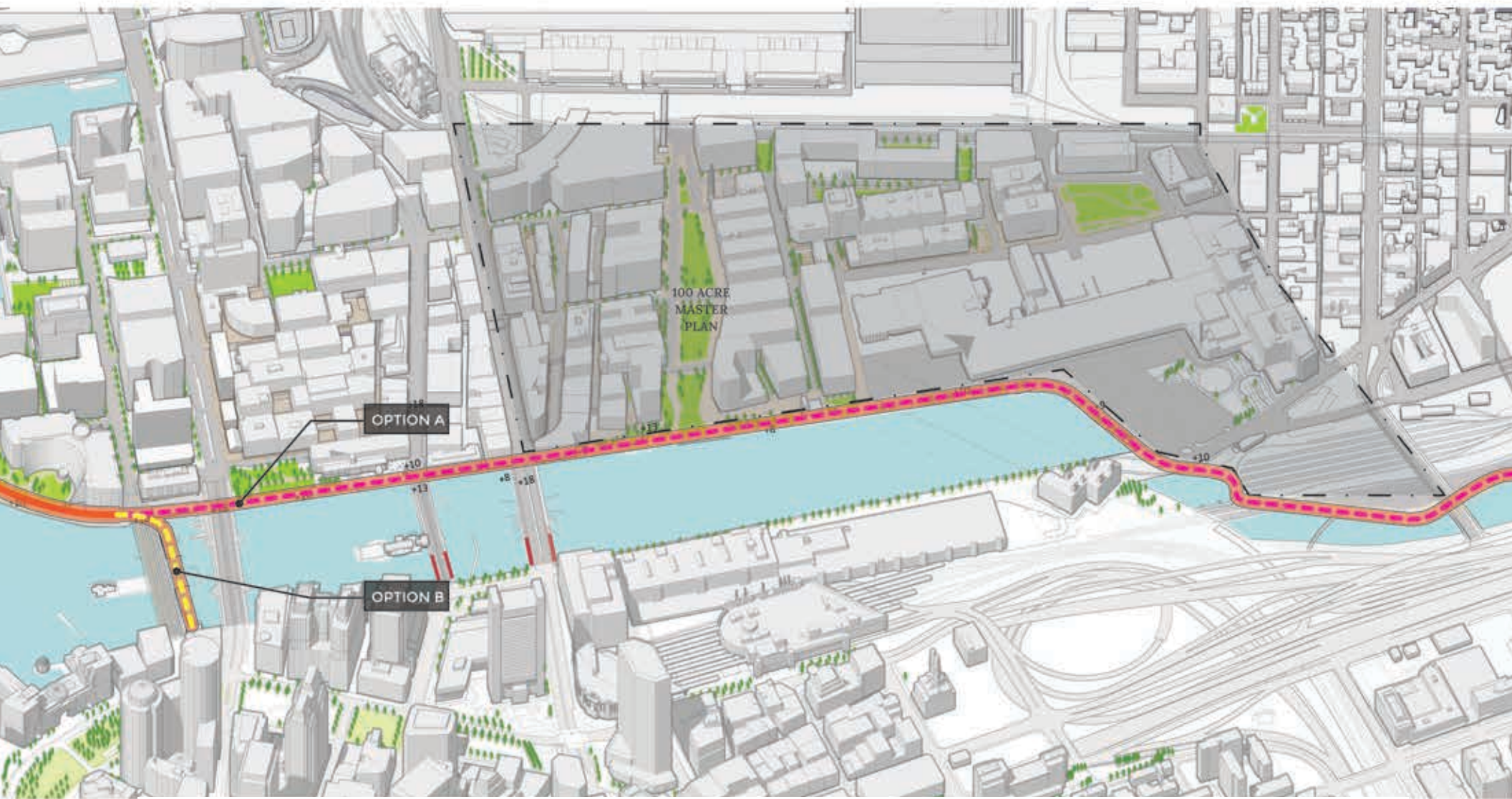
Option A. Flood protection along the perimeter of the Fort Point Channel.

Option B. Flood protection at the mouth of the Fort Point Channel.

For each option, there are minor variations possible for the alignments. For each alignment, there are multiple technical approach options and a variety of possible design concepts. For example, southern areas of the channel include more open space, which could allow for an array of features such as stepped seawalls, berms, floodwalls, or a combination thereof. Fewer adaptation options are available for areas where space is limited, unless new land is added. Static elements, such as levees, walls, or other elevated waterfront features are more reliable than features such as deployable barriers or floodgates. In many cases, moveable features are impossible to avoid; however, each operable feature within a system poses an additional weak link should it fail during deployment. Likewise, operable features require increased amounts of manpower and funding to properly maintain and deploy.

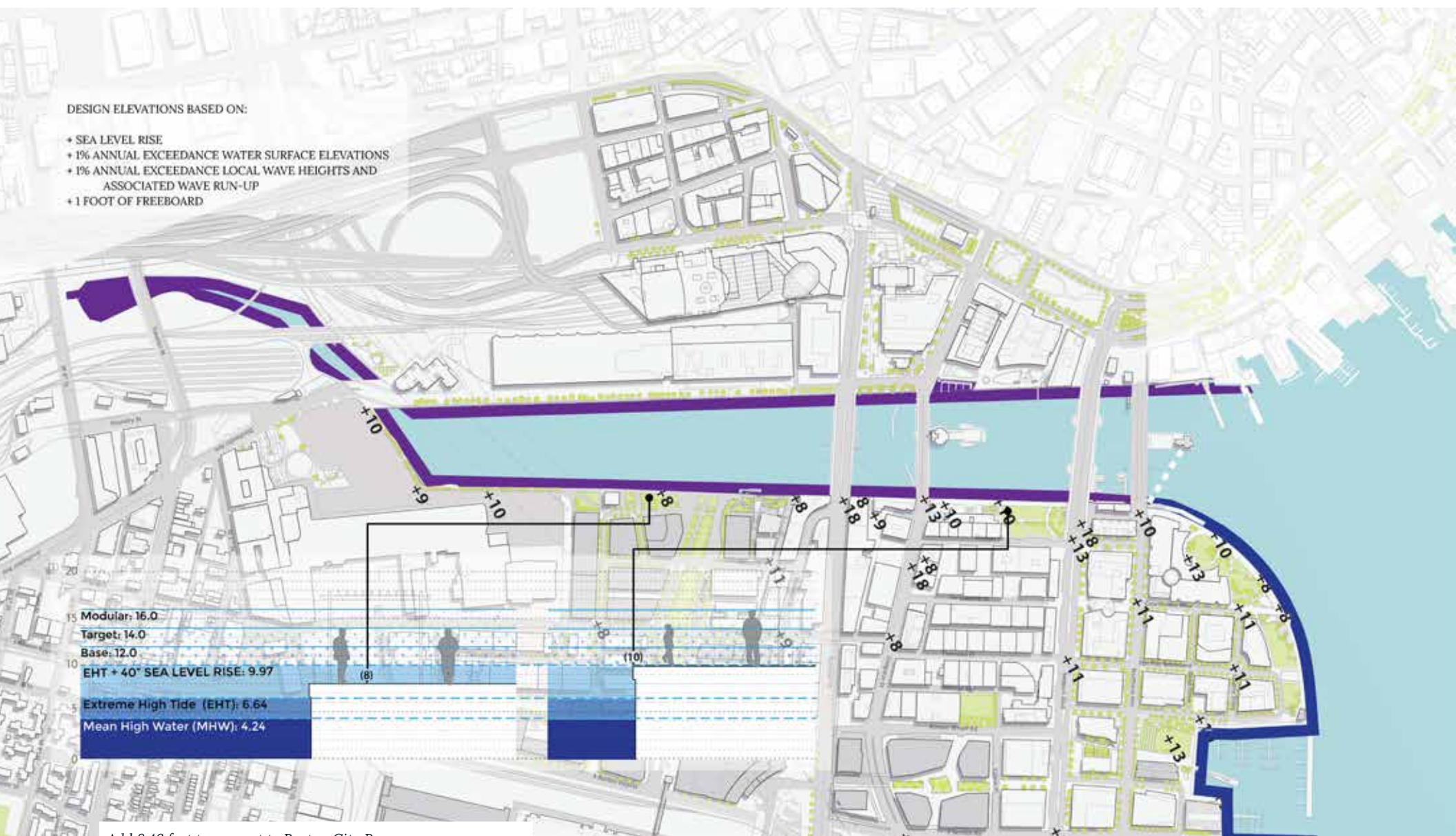
POSSIBLE COMBINATION OF LONG-TERM ALIGNMENT ALTERNATIVES

In the long-term, it would be possible to combine the alignment options by providing a lower level of protection at the shoreline (to mitigate recurrent flooding) and the flood protection system at the mouth of the channel (to address more significant flood events). Such an approach would extend the useful life of the flood protection system at the mouth of the Fort Point Channel, allow for urgent and immediate action at the shoreline, and possibly lower the necessary height of the perimeter shoreline flood protection system by the 2040s. Such an approach would not significantly lower the cost of the perimeter shoreline flood protection system in this time frame, because too much of the cost is associated with constructing the first few feet of height. We have not explored the combination of these options in detail.



Option A is a flood protection solution aligned with the perimeter of the Fort Point Channel. Option B is a flood protection solution aligned with the mouth of the Fort Point Channel.

Both long term options propose a minimum of 14 feet NAVD88 as the design elevation, which is about 6 feet above existing grade. Option A could be adapted to modular or higher design elevations.



Add 6.46 feet to convert to Boston City Base

Reduced Exposure and Losses as a Result of Alignment Options A and B

Options A and B could equally reduce exposure and expected impacts to the 1-percent annual chance flood elevations with no sea level rise and 9 inches of sea level rise. Higher flood elevations are likely to impact properties from behind due to pathways originating in other areas. With no sea level rise (2013), coastal resilience flood protection strategies on the east side of the Fort Point Channel could reduce risk to 570 people, 43 structures, and mitigate \$84 million in expected direct physical damage and relocation / displacement costs due to flood impacts to existing structures at the 1 percent annual chance flood elevation. With 9 inches of sea level rise, these numbers climb to 1,120 people, 101 buildings, and \$318 million in expected damages and relocation / displacement at the 1-percent annual chance flood elevation. With 21 and 40 inches of sea level rise, Coastal resilience measures on the east side of Fort Point Channel could be flanked from other flood pathways and must be combined with coastal resilience measures in South Boston Waterfront, Seaport Boulevard, Raymond L. Flynn Marine Park, and Reserved Channel to remain effective.

In the near-term, structures on the west side of the Channel that are vulnerable to flooding can be addressed through dry floodproofing or other site-specific actions. With 21 inches of sea level rise, coastal resilience design strategies on the west side of the Fort Point Channel could mitigate risk to 1,980 people, 243 buildings, and \$413 million in direct physical damages and relocation / displacement costs at the 1-percent annual chance flood elevation. These figures assume that flood pathways through Masspike would be blocked from deployable barriers or other methods. With 40 inches of sea level rise, coastal resilience measures on the west side of the Fort Point Channel could be flanked from other flood pathways and must be combined with measures on the east side of the Fort Point Channel and along the Charles River.

ALIGNMENT OPTION A. FLOOD PROTECTION OPTIONS AT THE SHORELINE OF THE FORT POINT CHANNEL

Shoreline strategies include earthen berms and open park space whenever possible. The existing Harborwalk includes two building arcades where strategies include incorporating building structures into the line of defense or building new barriers in the water. Bridge guardrails along the alignment would be converted to floodwalls. The many stormwater outlets along the channel will require tide gates.




































Principal causes of cost variation include:

- » Whether the flood protection alignment occurs on existing land or within the water
- » Whether the structure is a wall or earthen feature
- » The number of penetrations of the protection feature (for example, requiring flap gates or surface openings with closeable flood gates)

Current unknowns include:

- » The number, type, and condition of existing outfalls along the channel
- » The number, type, and condition of buried subsurface utilities (electric, gas, stormwater, wastewater, fiber, etc.)

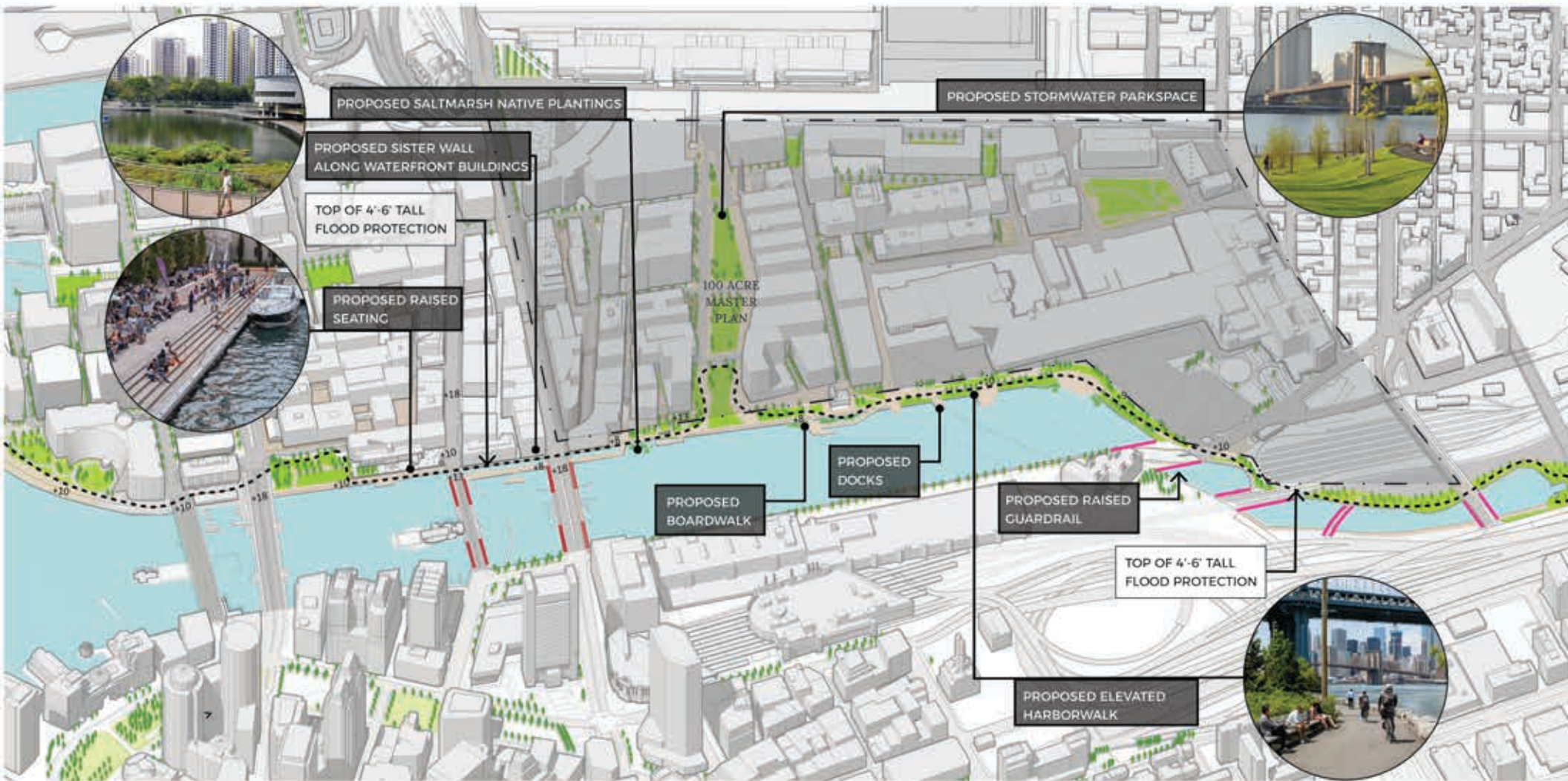
EVALUATION CRITERIA PERFORMANCE

EFFECTIVENESS					
ENVIRONMENTAL IMPACT					
DESIGN LIFE AND ADAPTABILITY					
FEASIBILITY					
EQUITY					
SOCIAL IMPACT					
VALUE CREATION					

KEY CONSIDERATIONS:

- » Limited space, water quality concerns, and permitting issues (described in Section 4) present technical and planning challenges
- » Option A can be implemented in phases to address most urgent flood risk areas in the near-term
- » Option A could potentially be leveraged to improve stormwater storage
- » Can be designed to address 40 inches of sea level rise now and may be adapted to address higher flood levels at a later time
- » Requires collective action from property owners along the perimeter of the channel in order to provide complete flood protection

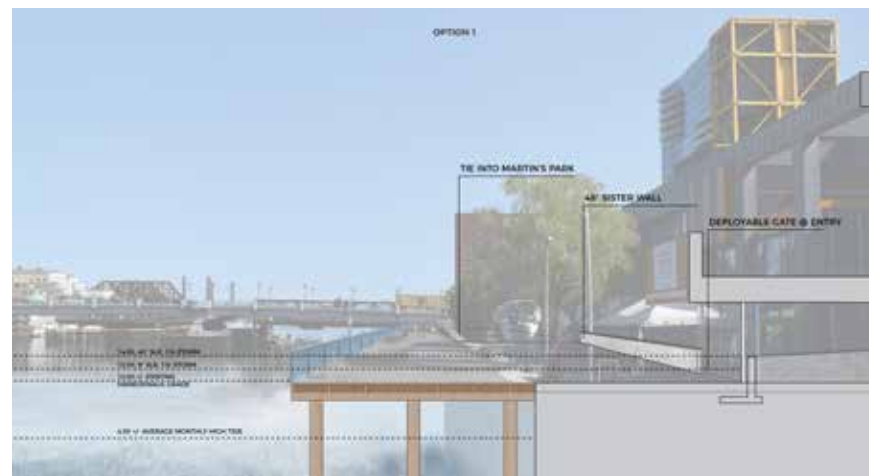
- » Subsurface soil permeability conditions and the necessity for seepage cutoff measures such as sheeting, grout walls, or other treatments
- » Ability to permit in-water construction and the presence of contaminated soils
- » Availability of materials and labor and material costs



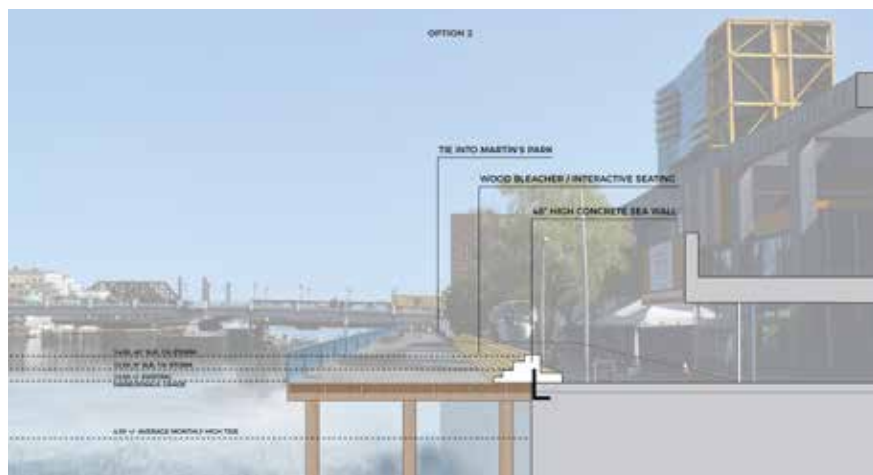
Design concept prototypes for Alignment Option A uses both planned development as well as opportunities for recreation to increase flood protection along Fort Point Channel.



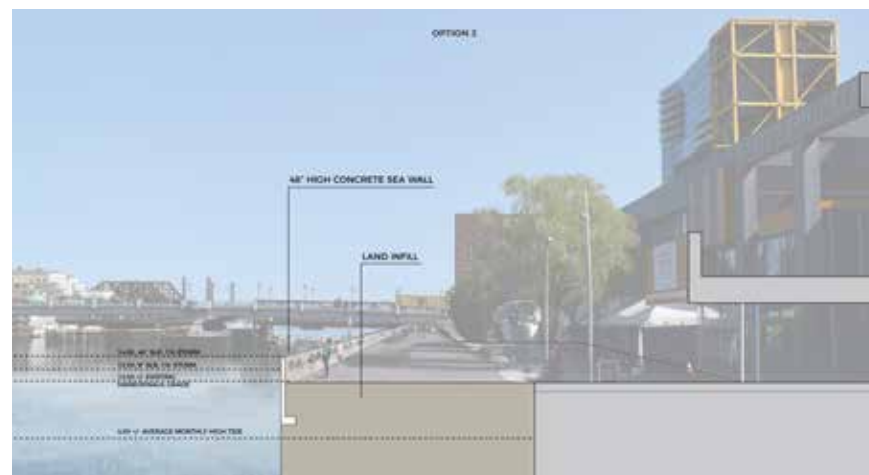
Existing Conditions



A short cheek wall is one flood protection option



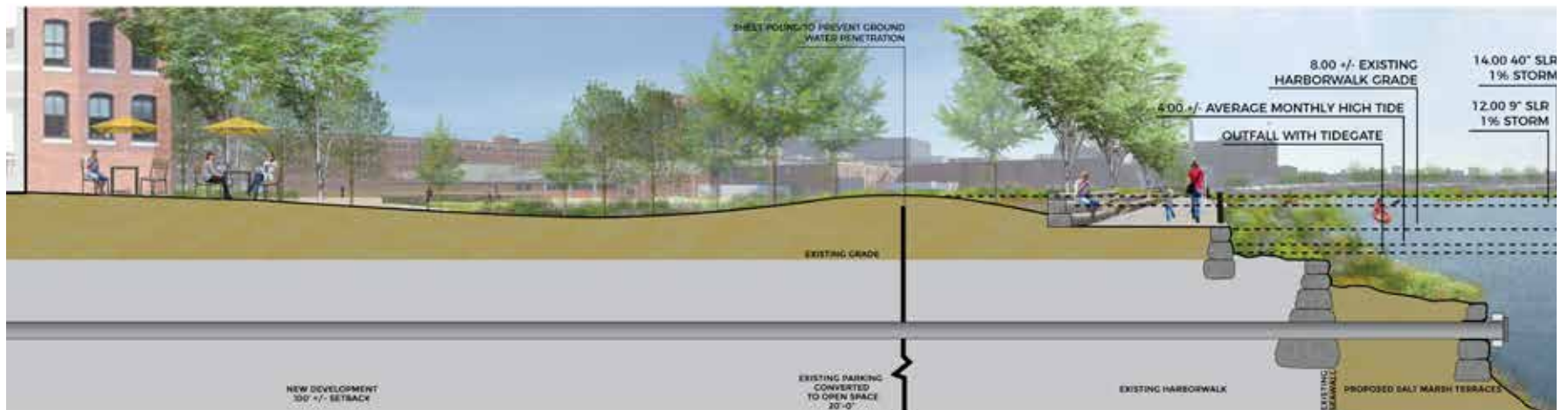
A concrete sea wall along the shoreline could be integrated into the existing Harborwalk through the use of interactive seating.



Extending landfill under the existing Harborwalk and installing a floodwall at the edge is a long-term option that would likely face regulatory hurdles.



Fort Point Channel Focus Group participants expressed a clear preference for green solutions and additional public space, although there are significant policy and environmental constraints if the final design requires fill. Additionally, this area of the Fort Point Channel is deep and a large amount of fill would be required. Filling in some portion of the channel could limit the amount of stormwater that could be discharged through outfalls. Nevertheless, design concepts are available to add or enhance recreational space, maximize flood protection effectiveness, and address technical constraints. As an example, an extended Harborwalk could substitute for added land.



Over the long term, elevation of the Harborwalk will be necessary to retain use of this space. For example, the Harborwalk could be elevated on pilings over the water, or be elevated on grade over time. This image provides an example design prototype for Option 4 in an area further south into Fort Point Channel.


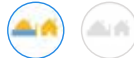





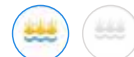



























ALIGNMENT OPTION B. FLOOD PROTECTION OPTIONS AT THE MOUTH OF THE FORT POINT CHANNEL

A possible adaptation strategy at the mouth of the Fort Point Channel would be installation of a gate or series of gates able to be closed for a short duration in anticipation of an approaching high water event. Flood control gate features would be constructed within the channel's banks and would remain open for the majority of the time to ensure proper stormwater evacuation and daily tidal exchange. Many arrangements and combinations of gate number and type are possible in this location, and ultimate selection would be driven by balancing requirements for flow exchange and navigation. For the purposes of this report, a single barge gate was assumed. In the long term, a flood protection system at the mouth of the channel may need to convert to locks or to a levee.

Principal causes of cost variation include:

- » The primary driver of cost will be the selection of gate type. There are many viable designs suitable for this location, each with its own cost and operational tradeoffs. A requirement to maintain vessel navigation would drive higher costs
- » Operational frequency will also influence gate type selection. Certain gates, such as vertical lift gates or sector gates, can be opened and closed at a faster rate than hinged swing barge gates

EVALUATION CRITERIA PERFORMANCE

EFFECTIVENESS					
ENVIRONMENTAL IMPACT					
DESIGN LIFE AND ADAPTABILITY					
FEASIBILITY					
EQUITY					
SOCIAL IMPACT					
VALUE CREATION					

Principal factors that contribute to cost uncertainty include:

- » Requirement for navigation and the design channel dimensions
- » Required opening area for water exchange
- » Required operation (opening and closing) frequency
- » Design features
- » Relationship to existing infrastructure, such as the Northern Ave. bridge

KEY CONSIDERATIONS:

- » Fully reliant on mechanical or human action, as well as fully functioning power supply, to ensure effectiveness
- » Must be constructed as structurally independent from any vehicular bridge structure
- » Near-term project or incremental solution not possible with this option
- » Can be designed to address 40 inches of sea level rise now, but unlikely to be adaptable to higher flood level later without significant additional investment
- » Increased closure frequency with sea level rise could limit effectiveness, introduce opportunity for failure, and have environmental impacts.
- » Will have impacts on water quality and navigation.



Design concept prototypes for the mouth of the Fort Point Channel

Alignment Option Comparison Across Evaluation Criteria




































CRITERION	COMPARISON	CRITERION	COMPARISON
EFFECTIVENESS	Option B requires mechanical action to be effective, whereas Option A could be designed without gates or entry points that would require intervention. The number of properties expected to benefit from the solution is the same for both options by the 2040s, but will vary based on adaptation in the long term.	ENVIRONMENTAL BENEFITS	Both options will face similar regulatory constraints because they are expected to harm the water quality of the channel.
FEASIBILITY	Both flood protection options are common. Option B would require more specialized engineering. The up front investment required for Option B may be a challenge, but the work would take place on public property. Option A can be implemented incrementally, and so the funding would also be incremental. Nevertheless, the majority of action must take place on private property, historical design considerations will be required, and these actions must knit together seamlessly to provide a complete line of defense.	SOCIAL IMPACT	The possible recreational, cultural, and aesthetic benefits that could be provided through Option A range from an expanded Harborwalk and green space to new seating, docks, kayak launches, educational opportunities and more. While Option B can be designed to provide social benefits, the options are more limited and the area is much smaller.
DESIGN LIFE AND ADAPTABILITY	Option A could be effective sooner, as it is possible to implement it incrementally, and will remain effective for longer without significant investment to adapt to higher sea levels. Option B will require more frequent closure over time as sea levels rise, limiting effectiveness and increasing potential environmental impacts. Option B would eventually require conversion to locks or another system that would prevent highly recurrent flooding at the shoreline, or shoreline protections would need to be installed.	EQUITY	Option A would provide new and enhanced access to the waterfront, and may be combined with educational opportunities and community partnerships.
		VALUE CREATION	Depending on the design configuration of Option B , a flood protection system at the mouth of the Fort Point Channel could become a popular spot to recreate and also tour as a modern example of flood protection in the United States. Through the addition and enhancement of public space along the perimeter of the Fort Point Channel, Option A will add considerable value to specific properties and increase value in the area.

RECOMMENDED NEAR-TERM COASTAL RESILIENCE SOLUTIONS

Flood protection along the perimeter of the Fort Point Channel could be completed both in pieces or distinct “chunks” around the perimeter and vertically, adding height over time. It would not be possible to implement an incremental or near-term action flood protection solution at the mouth of the Fort Point Channel. The numbered steps in the image to the right represent the order in which pieces of Option A could be completed. Steps 1, 2, and 3 should be completed in the near-term, before 2025.

The cost to complete steps 1, 2, and 3 are between \$3 and \$16 million, not including any improvements that may be necessary to the Arcade in the mid-term. Steps that include the addition of park space can also be completed incrementally. For example, the height of a near-term earthen berm or flood wall could be raised in the long term as sea level rises. These increments are what ultimately increase the costs from \$3 million to \$16 million, depending on ultimate design selections and other factors (see Option A cost considerations).

EVALUATION CRITERIA PERFORMANCE

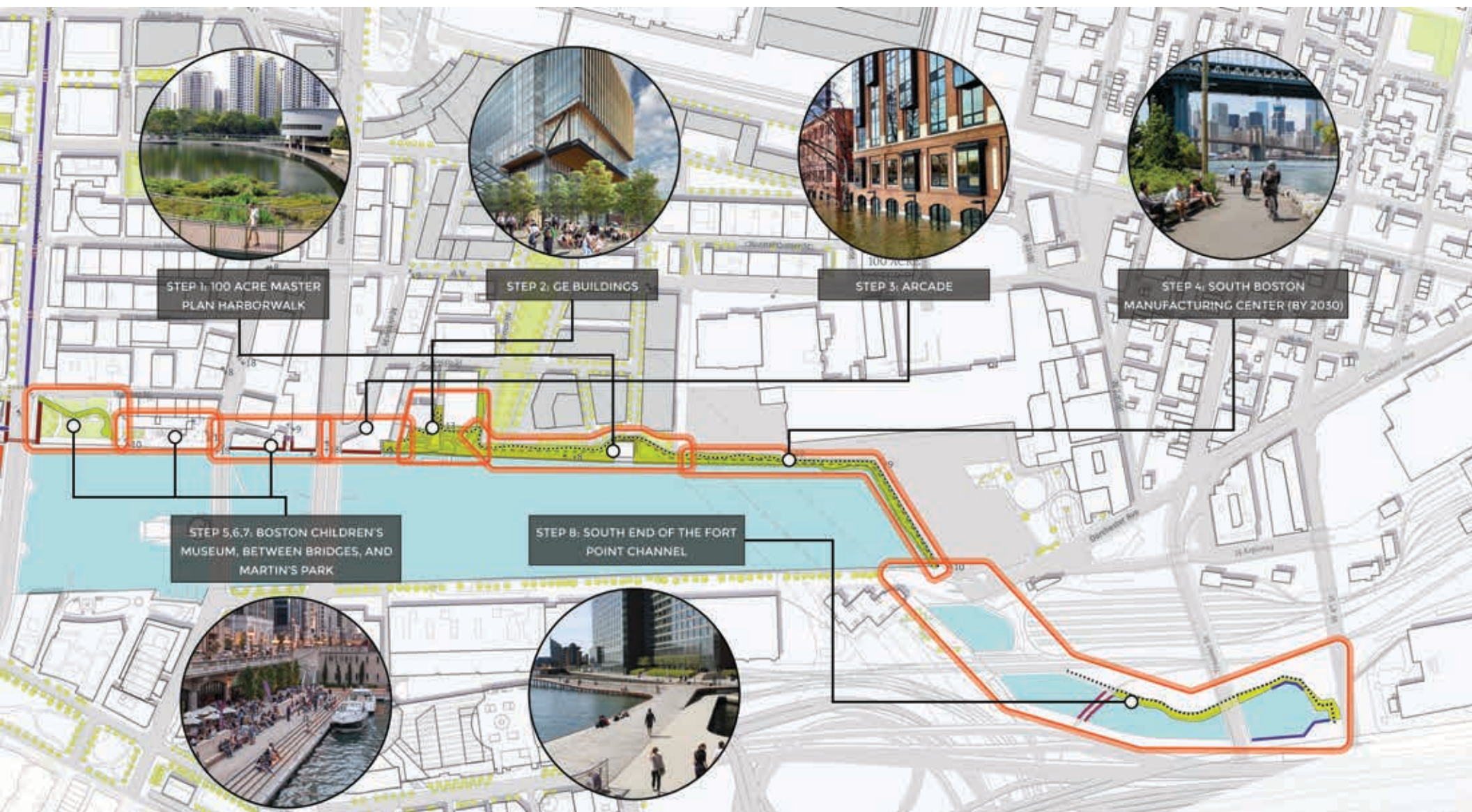
EFFECTIVENESS					
ENVIRONMENTAL IMPACT					
DESIGN LIFE AND ADAPTABILITY					
FEASIBILITY					
EQUITY					
SOCIAL IMPACT					
VALUE CREATION					

A more detailed engineering analysis is required to understand the structural integrity of the buildings and the nature of the flood protection solution in area 3. A separate flood wall is likely needed immediately adjacent to the building facade. A design elevation higher than the base elevation (1-percent annual chance event with 9 inches of sea level rise) may require significant modification to the structure. This is the only area in Fort Point Channel where near-term action is expected to be lower than the target elevation.

These near-term improvements could prevent tens of millions of dollars in direct physical damage and displacement costs during a large flood event.

KEY CONSIDERATIONS:

- » Flood resilience and public space improvement actions may integrate with new development
- » Owners of properties currently at risk in the area are motivated to act to reduce flood damage; coordinated efforts will be more efficient
- » Limited space, water quality concerns, and the permitting constraints present technical and planning challenges
- » Most areas can be designed to address 40 inches of sea level rise, now, and may be adapted to address higher magnitude flooding over time, with the exception of the building arcade. Mid-term action at the building arcade is likely to be effective against up to 9 inches of sea level rise, but longer-term action will be required to protect against more significant flooding over time



Design concept prototypes for flood protection alignment option at the mouth of the Fort Point Channel

NEAR-TERM COASTAL RESILIENCE SOLUTION STEPS

STEP 1. 100 Acres Master Plan Harborwalk:

Create a 40-50 foot wide Harborwalk park with an earthen berm land side of the Harborwalk.

STEP 2. GE Building:

Use new development to provide continuous line of protection along the waterfront.

STEP 3. Building/Arcade as Seawall:

Assess the structural soundness of the existing buildings to withstand flooding.

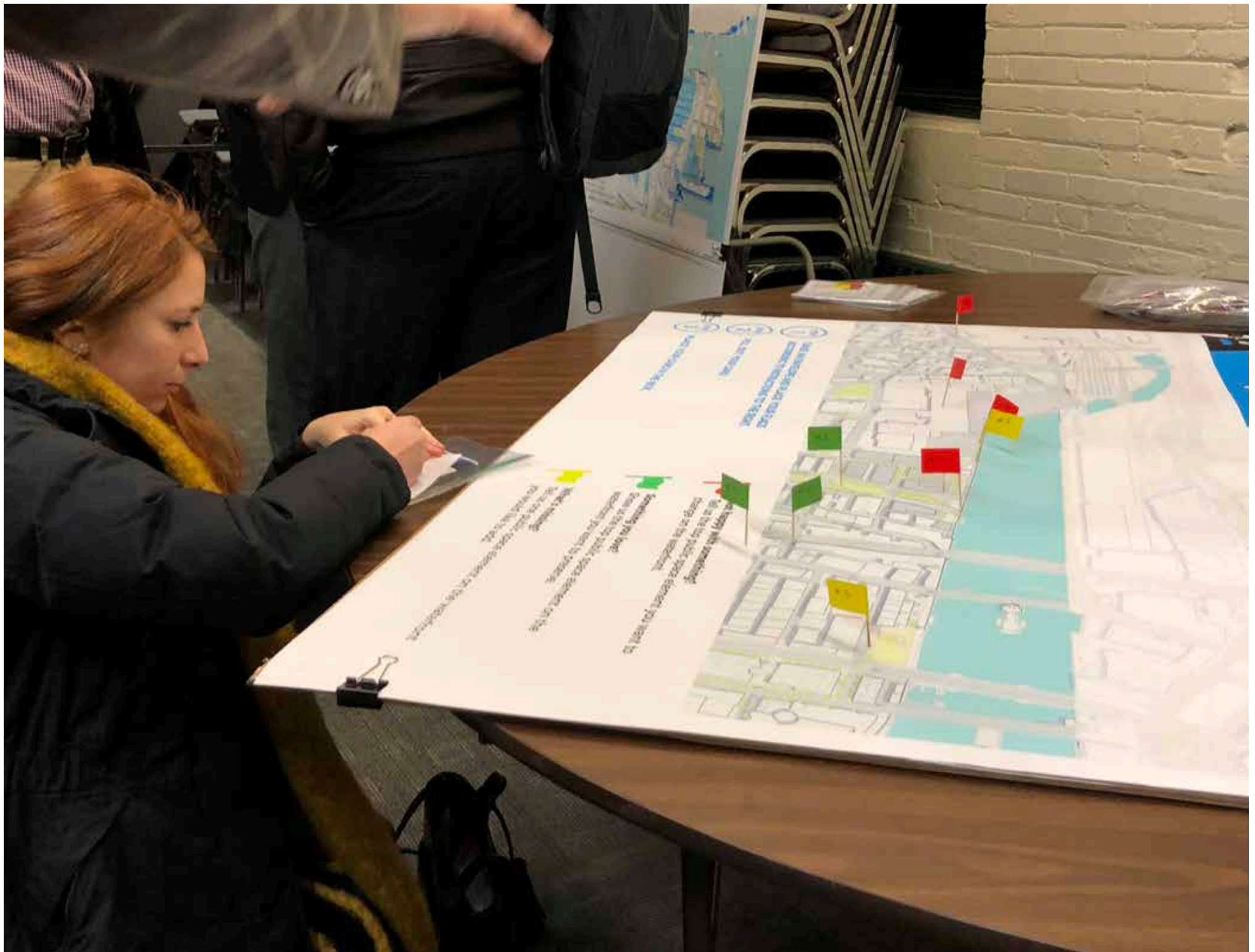
Considerations in the Fort Point Channel Landmark District

The Fort Point Channel Landmark District encompasses roughly 55 acres across the Fort Point Channel from downtown Boston. The Fort Point Channel area is Boston's largest, most cohesive, and most significant collection of late 19th and early 20th century industrial loft buildings. Development of the Fort Point Channel area began in 1836 and continued until 1882. The Boston Wharf Company erected nearly all of the buildings in the area from the designs of their own staff architects.

All proposed exterior work visible from a public way is subject to the review of the Landmarks Commission. The Commission reviews any reconstruction, restoration, replacement, alteration or demolition to buildings in this area. Alterations or additions that may be needed to assure the continued use of the historic structure or site should not radically change, obscure or destroy character defining spaces, materials, features or finishes. The commission encourages new uses that are compatible with the historic structure or site and that do not require major alterations or additions.

Replacement of historic seawalls along Fort Point Channel is allowable provided that new seawalls are capped with reclaimed granite. Renovations or retrofits for floodproofing of historic buildings would require use of materials similar to the historic buildings materials already used. Historic preservation design requirements could have significant cost implications for coastal resilience design solutions. The implications of these guidelines, and potential adjustments to facilitate coastal resilience design, are explored in [Section 4 Regulatory Resilience Strategies](#).





SOUTH BOSTON WATERFRONT

“From 2010–2013, the South Boston Waterfront was the fastest growing urban area in the Commonwealth, adding approximately ten million square feet of development.”

– Climate Ready Boston



Photos: South Boston Waterfront

The **South Boston Waterfront** has been an area of rapid growth in recent years and is expected to become an increasingly mixed-use neighborhood. Seaport Square and Fan Pier represent recent large development projects. This area also includes the John Joseph Moakley United States Courthouse, the Institute of Contemporary Art, and a mix of restaurants and new residential space.

While many new buildings were designed and constructed to meet higher standards and reduce flood risk, further actions are needed to address sea level rise. Space constraints in the area make it technically challenging to protect existing properties using available land.





Photo Source: Boston Pictorial Archive

“Over the past 150 years, the South Boston Waterfront has undergone a series of transformations. It’s evolved from a muddy spot in Boston Harbor (much of it was covered by water until the late 1800s), to a thriving shipping area that in the early part of the 20th century received raw materials like wool and leather for local textile factories, to parking lots and abandoned warehouses in the mid-1900s, to its most recent iteration: a hotbed of construction and urban infill. Today, cranes seem to rise every other week, erecting office buildings, condominiums, retail stores, and restaurants. And those amenities, coupled with the location – across from downtown, right off the highway, and just a short T ride to the airport – have made the Seaport a prime spot for growth.”

– Boston Magazine, “The Rise of the Seaport”, 2012

FLOOD RISK

Recent development improvements, such as those completed at Pier 4, have reduced the frequency and extent of current flooding in South Boston Waterfront structures. Nonetheless, the area remains vulnerable to sea level rise.

Three flood pathways originate in this area. Two adjacent flood pathways begin in the area of the Fan Pier Park and extend through Courthouse Way and Fan Pier Boulevard. These two streets provide access to the Harborwalk and flank newly elevated open space and development. The Harborwalk, Courthouse Way, and Fan Pier Boulevard remain below the recommended target elevation of 15 feet NAVD88 for the area. These features denote the entrance of a flood pathway into the South Boston Waterfront. With 9 inches of sea level rise, this pathway will connect to others further inland.

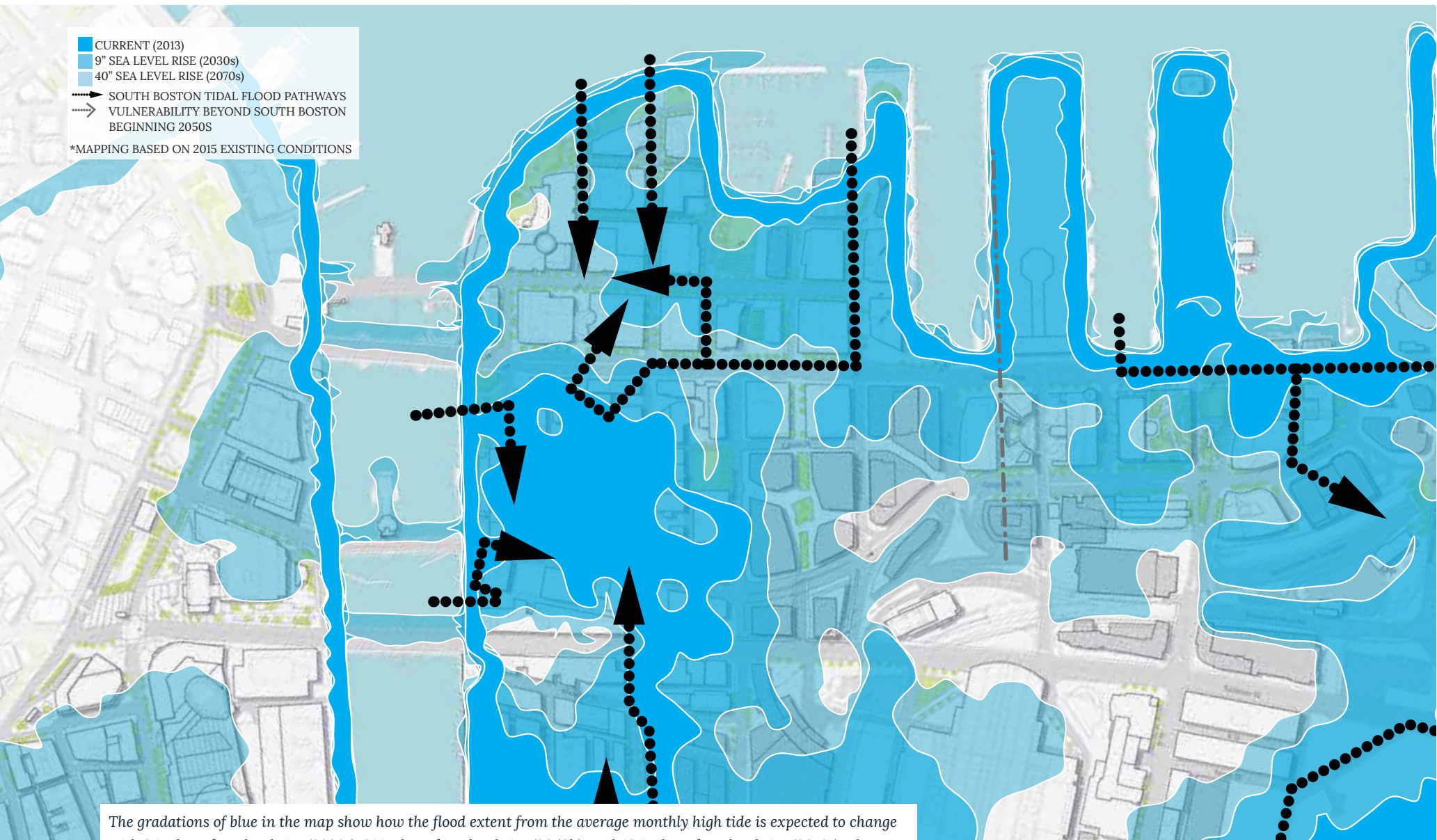
The third flood pathway originates in the area between the Institute of Contemporary Art and Pier 4. This pathway flows landward from Pier 4, where flooding extents reach Seaport Boulevard and surround existing buildings. The pathway exposes the area from Pier 4 to Courthouse Way, seaward of Seaport Boulevard, with 9 inches of sea level rise (2030s).

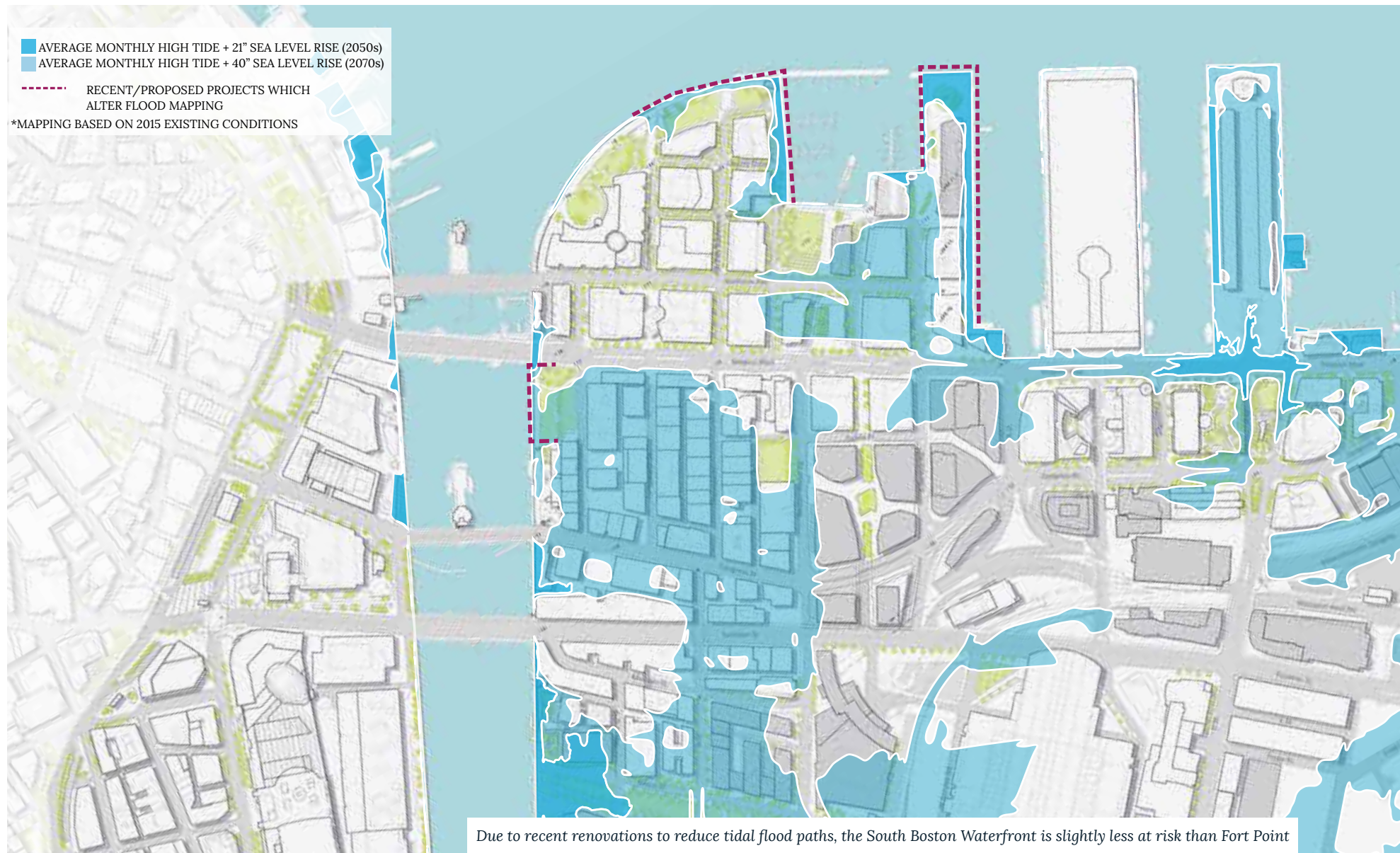
Flood pathways originating in the South Boston Waterfront may connect with another pathway originating between Pier 4 and the World Trade Center north of Seaport Boulevard (see Coastal Resilience Design Strategies – Seaport Boulevard). Later in the century, flooding will extend west from Pier 4 to the federal courthouse and to the shoreline near the Northern Avenue and Seaport Boulevard bridges. With 40 inches of sea level rise later in the century, South Boston Waterfront flood pathways could connect with flood pathways originating from the Fort Point Channel.

Losses in the form of direct physical damage to buildings, as well as their contents and inventory, and displacement and relocation costs could reach over \$200 million on the South Boston Waterfront as a result of unmitigated flooding with sea level rise.

Elevations are reported with respect to the North American Vertical Datum of 1988 (NAVD88). NAVD88 elevations are 6.46 feet lower than Boston City Base.

“Average monthly high tide” means the average of the highest tide experienced each month in 2015. Since tide ranges fluctuate seasonally, daily tides could rise above the average monthly high tide multiple times some months and not at all in other months.





ENGAGEMENT FEEDBACK

Community engagement feedback regarding flood risk and strategies for South Boston Waterfront provided an opportunity to align community needs and vision with resilience goals.

The most important criteria were effectiveness, social impact, and value creation.

A survey question asked, “As a resident, what are your priorities for improvements to these areas?” The top three priorities for the South Boston Waterfront were: Parks and Open Space (23%), Transportation (21%), and Parking (12%).

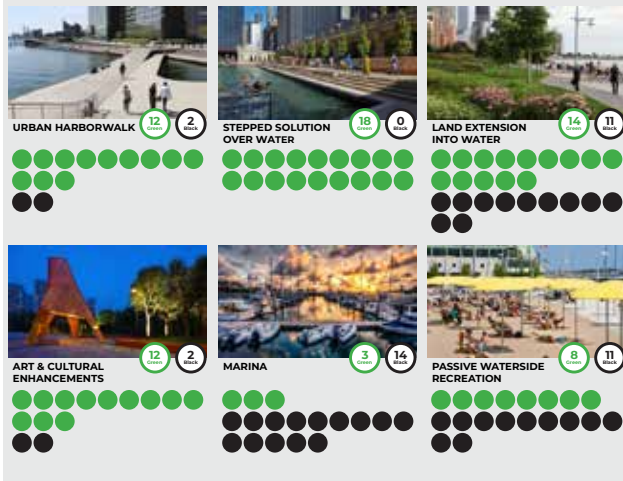
Stakeholders provided clear reactions:

- » Adjacent properties are interdependent; there is a need for collective action and coordination
- » Views are a critical element of the South Boston Waterfront
- » The relationship of the storefront to people walking at grade is critical to maintain. In other words, people must be able to enter properties from the grade at which they are walking
- » Protect property to the maximum extent possible and improve park space and public amenities to offset any changes to the existing sight line to the water
- » “Grass is better than concrete”
- » Both short and long term solutions are needed
 - In the short term, many property owners have already purchased aqua fences and other flood response tools to mitigate flood loss
 - In the long term, a unified solution is superior to building-by-building solutions
- » A desire to be engaged and at the table through each step
- » Policy changes that ease regulatory burdens to move the project forward are welcome
- » Recent renovations along the waterfront due to new development have reduced flood risk in the area and increased the value of the area to the city
- » Protect access and egress for workers and emergency vehicles
- » Stormwater infrastructure is needed to manage precipitation events

SOUTH BOSTON WATERFRONT

WHICH FLOOD PROTECTION ELEMENTS AND AMENITIES DO YOU PREFER?

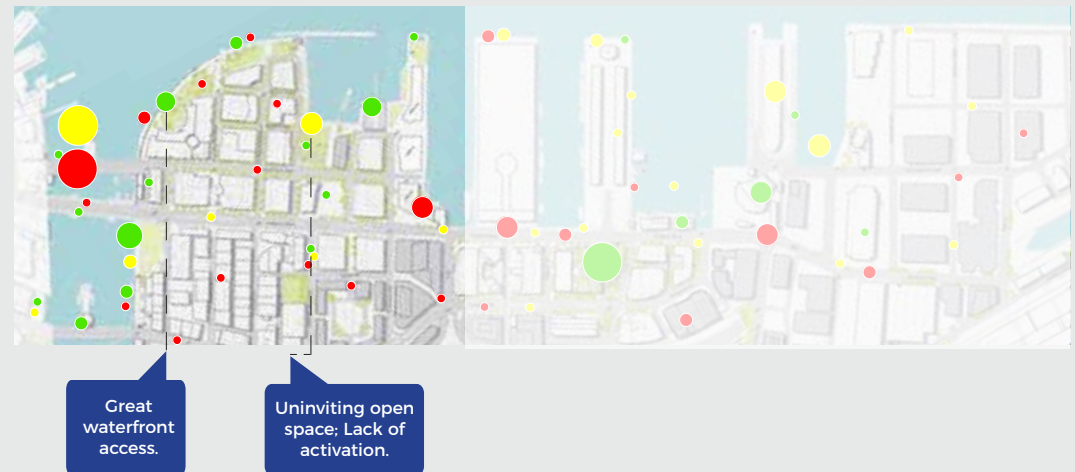
● = Want ● = Do Not Want



WHAT ARE YOUR WATERFRONT PUBLIC SPACE PREFERENCES?

● = something you love
● = something you want to change
● = something you want to add

*Larger circle size denotes clustering of public comments



Open House Summary for South Boston Waterfront and Seaport Boulevard, 12/11/17

COMMENTS

Elevate the Harborwalk to make a flood barrier/recreational "Dry Line."

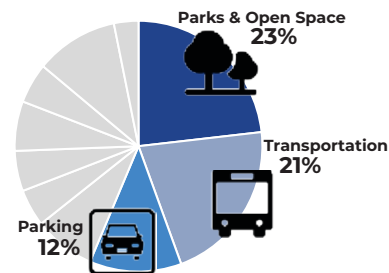
We need a sea wall to protect Boston from storm surges. One dollar spent in protection from these storms saves 9 dollars in clean up.

Preservation of its historical integrity.

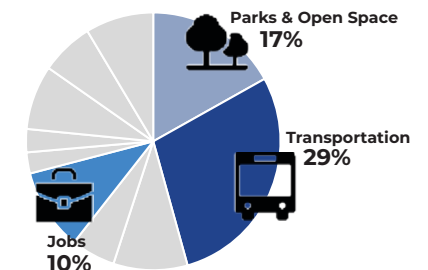
PRIORITIES

Respondents were asked to choose up to two top priorities for improvement. The following pie chart percentages indicate top categories selected for the South Boston Waterfront.

RESIDENT PRIORITIES



NON-RESIDENT PRIORITIES



Online Survey Results for South Boston Waterfront, 9/28/17 - 12/31/17

Estimated Costs for Alignment Options A, B, C and D

OPTION A

ESTIMATED COST	\$53 - \$61 million
ESTIMATED MAINTENANCE COST	\$800,000 - \$900,000 per year*

*Maintenance costs are expected to be 1.5 percent of the implementation cost.

OPTION B

ESTIMATED COST	\$91 - \$106 million
ESTIMATED MAINTENANCE COST	\$1.4 - \$1.6 million per year*

*Maintenance costs are expected to be 1.5 percent of the implementation cost. Principal causes of cost variation include those identified for Option A.

OPTION C

ESTIMATED COST	\$130 - \$150 million
ESTIMATED MAINTENANCE COST	\$2 - \$2.3 million per year*

*Maintenance costs are expected to be 1.5 percent of the total cost to implement the solution.

OPTION D

ESTIMATED COST	\$25 - \$29 million
ESTIMATED MAINTENANCE COST	\$370,000 - \$430,000 per year**

*The cost to floodproof existing buildings would add \$137 to \$158 million.
**Maintenance costs are expected to be 1.5 percent of the implementation cost.

MID-TERM COASTAL RESILIENCE SOLUTION OPTIONS

We examined four alignment alternatives for the South Boston Waterfront:

Option A would provide flood protection along the perimeter of the South Boston Waterfront, making use of existing available space.

Option B is similar to Option A and provides flood protection along the perimeter of the South Boston Waterfront, but fills in a portion of the marina to expand public space and recreation areas.

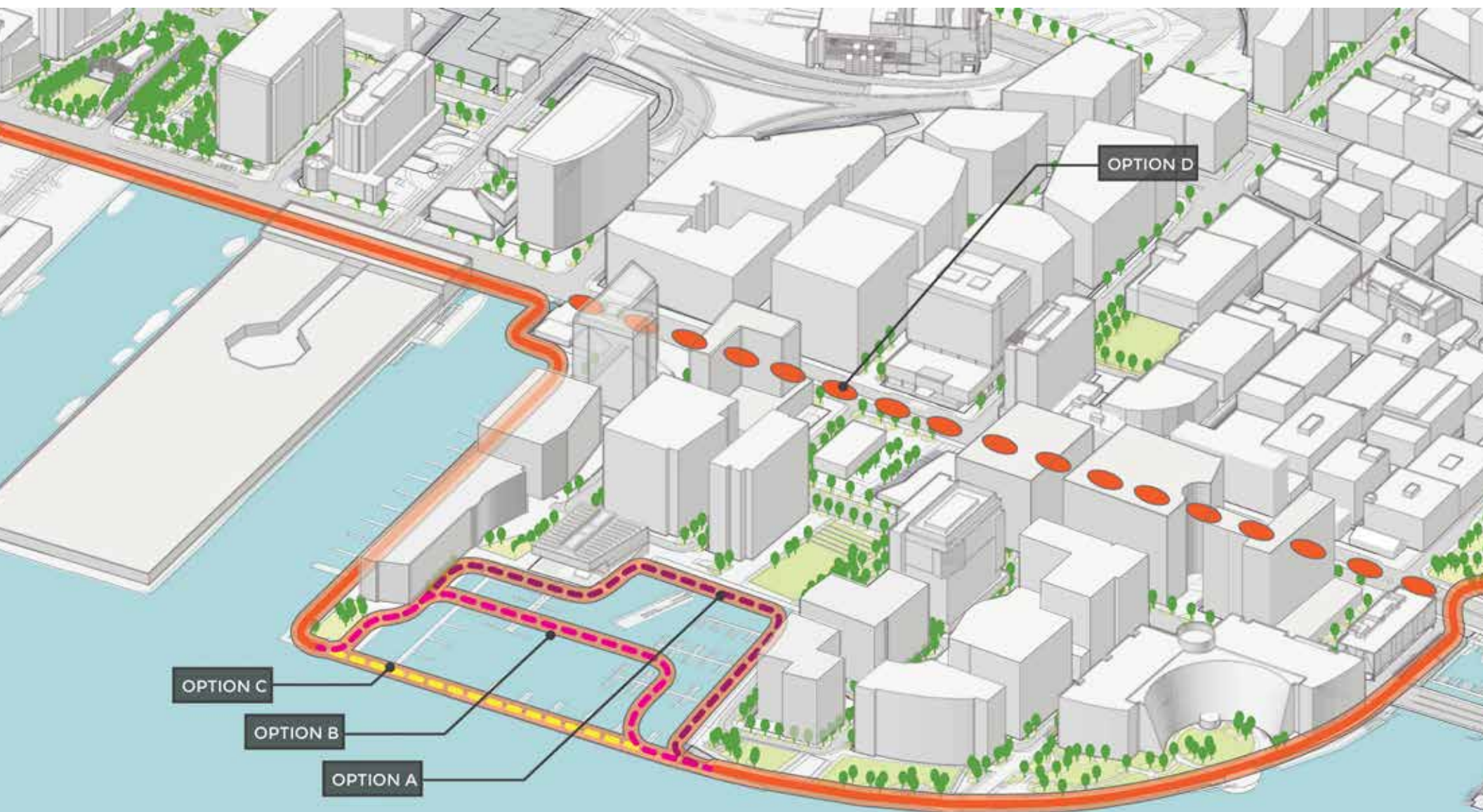
Option C is similar to Option A and provides flood protection along the perimeter of the South Boston Waterfront, but includes a new Harborwalk or levee across the marina entrance with a floodgate for boat entry and exit.

Option D would use Seaport Boulevard as a floodwall in the form of a raised center roadway with planters. Option D would require floodproofing of structures on the waterside of the roadway, as well as mechanical or manual gates at road crossings.

For each option, there are minor variations possible for the alignments, and for each alignment, there are multiple technical approach options and a variety of possible design concepts.

Option D is not a stand alone option because it provides no independent benefit. This means that other coastal resilience design solutions would be requires to help mitigate flood risk. Additionally, Option D requires numerous gates across intersections, which introduce opportunities for failure if they are not closed in time during a flood event.

We also evaluated the merits of developing a flood protection system by reinforcing buildings and connecting the structures through deployable flood walls. This method proved to be complex from a regulatory and flood insurance perspective, as well as introduced numerous points of failure deemed unacceptable by stakeholders.



Four practical alignments received detailed technical evaluation. Option A is a flood protection solution aligned with the existing shoreline of the South Boston Waterfront. Option B expands available space for flood protection by adding fill in the marina. Option C is a variation of perimeter flood protection that adds a gate at the mouth of the marina. Option D, which was identified as a not stand alone option early in the evaluation, would use Seaport Boulevard as flood protection.

All alternatives propose 15 feet NAVD88 as the design elevation, which ranges from 3 to 7 feet above existing grade, depending on the location. Options A and B could be adapted to modular or higher design elevations over time for relatively low cost. Options C and D would be significantly more costly to adapt to higher design elevations over time.



Add 6.46 feet to convert to Boston City Base

EFFECTIVENESS

Flood pathways generated from other parts of the district limit the effectiveness of all options. One flood pathway, for example, could open up between the South Boston Waterfront and the World Trade Center. If unaddressed, this flood pathway could affect the Institute of Contemporary Art and neighboring properties from behind. The South Boston Waterfront flood pathways could also connect with flood pathways from the Fort Point Channel and the World Trade Center. With 40 inches of sea level rise, this could occur over twelve times per year by late century (2070s). The area near the Federal Courthouse is on slightly higher ground, but could also expect to experience coastal flooding from behind later in the century.

Some areas along the South Boston Waterfront are already at or near the base elevation. Coastal resilience design strategies in South Boston Waterfront actions are designed to meet the target elevation. Options A and B can most easily be adapted in the future to the modular, or goal, elevation level.

Reduced Exposure and Losses as a Result of Alignment Options A, B and C

Options A, B, and C will all provide independent flood mitigation to the structures in the South Boston Waterfront until the 1-percent annual chance flood elevation with 9 inches of sea level rise is exceeded. Beyond this elevation, flood pathways from Fort Point Channel will begin to flood South Boston Waterfront properties from behind. By the 40 inches of sea level rise, flood pathways from Seaport Boulevard, Raymond L. Flynn Marine Park, and Reserved Channel will also flood South Boston Waterfront from behind if action is not taken to prevent flooding in those areas. Option D does not provide independent effectiveness against flooding and was removed from consideration as a standalone option in this area, but could be combined with other options.

Based on the benefitting area and proposed design elevation, 135 people will experience reduced risk as a result of coastal resilience design strategies at the 1-percent annual chance elevation with no sea level rise. With 9 inches of sea level rise at the 1-percent annual chance flood elevation, this number climbs to close to 250 people with \$85 million in avoided direct physical damages and relocation / displacement costs. Actual effectiveness will also depend on factors related to engineering, construction, and long-term maintenance. This does not include exposure or expected losses avoided for any structures outside of the alignment that must be independently floodproofed.

ALIGNMENT OPTION A. FLOOD PROTECTION OPTIONS AT THE SHORELINE OF THE SOUTH BOSTON WATERFRONT

Shoreline strategies include earthen berms and open park space whenever possible. Vertical seawall will be used in areas near Pier 4, where space is limited. The Harborwalk would be extended over water in the area of the Institute of Contemporary Art to retain waterfront connectivity.

Principal causes of cost variation include:

- » Whether wall or earthen features are used
- » The number of penetrations in the protection feature, whether they be outfalls requiring tidal gates, backflow preventers, or surface openings requiring closeable flood gates
- » Existing ground elevation and the level of protection required

Current unknowns include:

- » The number, type, and condition of existing outfalls along the channel
- » The number, type, and condition of buried subsurface utilities (electric, gas, stormwater, wastewater, fiber, etc.) within the proposed project footprint

EVALUATION CRITERIA PERFORMANCE

EFFECTIVENESS



ENVIRONMENTAL IMPACT



DESIGN LIFE AND ADAPTABILITY



FEASIBILITY



EQUITY



SOCIAL IMPACT



VALUE CREATION



- » Subsurface soil permeability conditions and the necessity for seepage cutoff measures such as sheeting, grout walls, or other treatments
- » Availability of materials and labor and material costs

KEY CONSIDERATIONS:

- » Existing green space: berms and grading will be used to minimally interrupt the landscape
- » Can be designed to address 40 inches of sea level rise now and may be adapted to address higher flood levels at a later time
- » Requires collective action from property owners along the perimeter of the waterfront in order to provide complete flood protection
- » Over-water Harborwalk could be used to avoid impacts to existing waterfront relationship, but sight lines could still be interrupted in the long term due to limited space for gradual grade change



Design concept prototypes for flood protection alignment Option A along the shoreline of the Waterfront. Option A makes use of existing space to reduce flood risk.




































ALIGNMENT OPTION B. FLOOD PROTECTION ALIGNED ACROSS THE MIDDLE OF THE MARINA

Option B is similar to Option A but would build out into the existing marina to expand public space and recreational areas.

Current unknowns include those identified for Option A, plus:

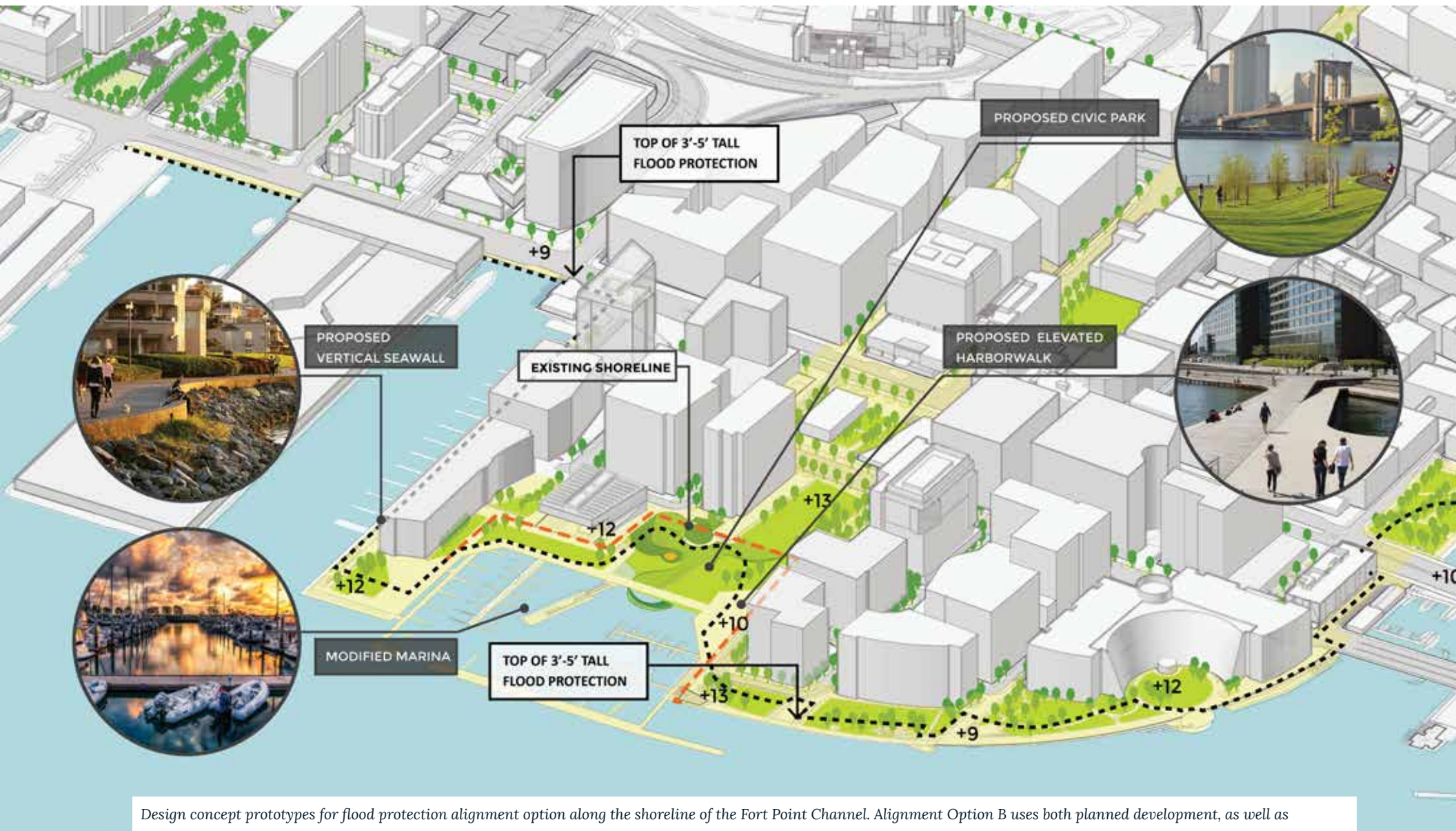
- » The amount and source of fill required
- » Ability to permit in-water construction and the presence of contaminated soils

EVALUATION CRITERIA PERFORMANCE

EFFECTIVENESS					
ENVIRONMENTAL IMPACT					
DESIGN LIFE AND ADAPTABILITY					
FEASIBILITY					
EQUITY					
SOCIAL IMPACT					
VALUE CREATION					

KEY CONSIDERATIONS:

- » *Completely passive solution; would require no mechanical or human effort to be effective*
- » *Optional living / green shoreline at water's edge*
- » *Making land presents a permitting challenge*



Design concept prototypes for flood protection alignment option along the shoreline of the Fort Point Channel. Alignment Option B uses both planned development, as well as opportunities for recreation to increase flood protection along Fort Point Channel.

ALIGNMENT OPTION C. FLOOD PROTECTION ALIGNED AT THE MOUTH OF THE MARINA

Option C is similar to Option A but would include a new Harborwalk/levee across the marina entrance with a floodgate for boat entry and exit, instead of providing flood protection along the perimeter inside the marina.

Principal causes of cost variation include those identified for Option A, plus:

- » The primary driver of cost will be the gate type. Many viable designs are suitable for this location, each with its own cost and operational tradeoffs. The requirement to maintain vessel navigation would drive higher costs
- » Operational frequency will also influence gate type selection. Certain gates, such as vertical lift gates or sector gates, can be opened and closed at a more rapid rate than styles such as a hinged swing barge gates

Current unknowns include those identified for Option A, plus:

- » Requirement for navigation and the design channel dimensions
- » Required opening area for water exchange
- » Required operation (opening and closing) frequency
- » Design features

EVALUATION CRITERIA PERFORMANCE

EFFECTIVENESS



ENVIRONMENTAL IMPACT



DESIGN LIFE AND ADAPTABILITY



FEASIBILITY



EQUITY



SOCIAL IMPACT

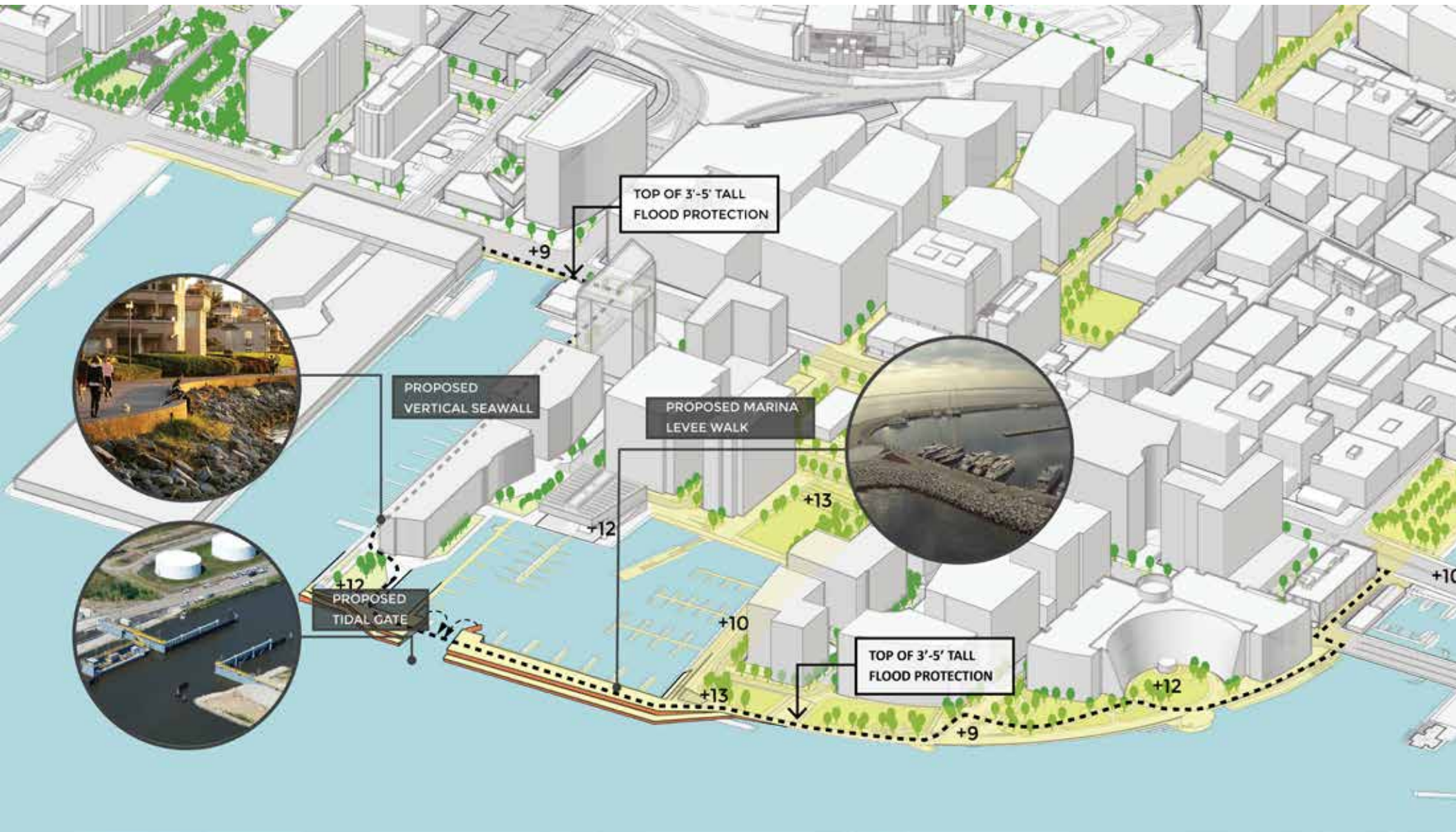


VALUE CREATION



KEY CONSIDERATIONS:

- » Reliant on mechanical or human action, as well as functioning power supply, to ensure effectiveness
- » Near-term project or incremental solution not possible
- » Existing Harborwalk does not change along inner marina or to the west
- » Water flow in marina could be limited, affecting water quality
- » Can be designed to address 40 inches of sea level rise now, but unlikely to be adaptable to higher flood level later without significant additional investment
- » Increased closure frequency with sea level rise could limit effectiveness, introduce opportunity for failure, and have environmental impact



Design concept typologies for flood protection across the mouth of the marina at the Waterfront

ALIGNMENT OPTION D. FLOOD PROTECTION THROUGH SEAPORT BOULEVARD AND FLOODPROOFING OF SEAWARD STRUCTURES

Option D uses improvements to Seaport Boulevard to form a floodwall in the form of a raised center roadway and constructed planters. This option requires floodproofing of all structures seaward of the roadway, as well as mechanical or manual gates at road crossings.

The estimated cost for Option D would be between \$25 and \$29 million, with the cost to floodproof existing buildings adding an additional \$137 to \$158 million. The estimated maintenance cost would be between \$370,000 and \$430,000 per year.

Principal causes of cost variation include:

- » Whether sister walls or floodproofing methods are used for structures seaward of Seaport Boulevard
- » The number of penetrations of the protection feature, whether they be vehicular flood gates or floodproofing gates
- » Existing ground elevation and the level of protection required

EVALUATION CRITERIA PERFORMANCE

EFFECTIVENESS



ENVIRONMENTAL IMPACT



DESIGN LIFE AND ADAPTABILITY



FEASIBILITY



EQUITY



SOCIAL IMPACT



VALUE CREATION



Current unknowns include:

- » The type and design of vehicular travel gates
- » Structural integrity and design requirements associated with structures to be floodproofed
- » Subsurface soil permeability conditions and the necessity for seepage cutoff measures such as sheeting, grout walls, or other treatments
- » Availability of materials and labor and material costs

KEY CONSIDERATIONS:

- » In the long term, solution is likely to take center lanes and median out of service.
- » Automatic or manual floodgates are required at each cross street intersection which introduces multiple potential points of failure.
- » Leaves multiple buildings unprotected; assumes dry floodproofing or other solution for these structures, but unprotected exit areas are a concern.
- » Flood protection is limited by the ability to protect and floodproof individual structures.



Design concept prototypes for flood protection along Seaport Boulevard and dry floodproofing of seaward structures

Alignment Option Comparison Across Evaluation Criteria

CRITERION	COMPARISON	CRITERION	COMPARISON
EFFECTIVENESS	Options C and D, and to a lesser extent A , require mechanical action to be effective. Any mechanical action is a possible point of failure. Option B could be designed without gates or entry points that would require intervention to be effective. By the 2040s, the number of properties expected to benefit is the same for all options, but will vary with each proposed long-term adaptation strategy. Options A and B are the most adaptive to higher elevations. Option C would require significant modification to be adaptive to higher elevations. Option D will be constrained by the structural integrity and individual flood protection measures of properties seaward of Seaport Boulevard. Additionally, flood protection for Option D is limited by the ability to protect and floodproof individual structures.	FEASIBILITY	All options are commonly implemented. Options C and D require more specialized engineering, but this is not expected to complicate feasibility. Funding strategies for each option are equally complex. All the options can be implemented incrementally, with the exception of the gate in Option C , and so the funding ask would also be incremental. The majority of action must take place on private property, and these actions must knit together seamlessly to provide a complete line of defense.
DESIGN LIFE AND ADAPTABILITY	Options A and B could be effective sooner, as it is possible to implement them incrementally. These option will also remain effective for a longer period without significant investment to adapt to higher sea levels. Option C will require more frequent closure over time as sea levels rise, limiting effectiveness and increasing potential environmental impacts. Option C would also eventually require conversion to locks or another system that would prevent highly recurrent flooding at the shoreline, or shoreline protections would need to be installed. Option D could be implemented incrementally, but would be a significant undertaking by the 2040s and poses access and egress concerns for existing structures. In the long term, Option D would likely take the center lanes and median out of service on the roadway.	SOCIAL IMPACT	The possible recreational, cultural, and aesthetic benefits that could be provided through Options A and B are significant and range from an expanded Harborwalk and green space to educational opportunities, and more. While Option C can be designed to provide social benefits, the options are more limited and the area is much smaller.
ENVIRONMENTAL BENEFITS	Option B is expected to have additional regulatory constraints due to making land in the water. Option C presents potential water quality issues, depending on design and long-term adaptation.	EQUITY	Options A and B would provide new and enhanced access to the waterfront, and may be combined with educational opportunities and community partnerships. Option B will also require some sacrifice of marina slips from property owners, unless the marina can be extended further into the water. Option C could be joined with some enhanced enjoyment of the waterfront by combining the solution with a Harborwalk. Option D would require most structures to mitigate risk independently, resulting in varied levels of protection and implementation timeframes.
		VALUE CREATION	Depending on the design configuration of Option C , a flood protection system at the mouth of the Fort Point Channel could become a popular spot to recreate and also tour as a modern example of flood protection in the United States. Nevertheless, through the addition and enhancement of public space along the perimeter of the Waterfront, Options A and B are expected to add considerable value to specific properties and increase enjoyment in the area. Option D is not expected to add value.

POSSIBLE COMBINATION OF LONG-TERM ALIGNMENT ALTERNATIVES

Early in the technical evaluation process, we evaluated options to elevate all roadways leading to the waterfront, as well as the associated infrastructure. Such an approach would pose significant technical difficulties and complicate access to and egress from existing buildings. Perhaps most importantly, the schedule to implement raising of roadways is unlikely to meet the mid-term urgency.

The singular option of raising Seaport Boulevard and associated interior roadways was presented to stakeholders. As a standalone option, raising roadways was not the recommended solution because it would not be effective in protecting property seaward of the raised roads.

In the long term, it would be possible to combine raising the elevation of Seaport Boulevard and the elevation of other roadways, with a perimeter coastal flood protection solution. Elevation of interior roadways and other infrastructure is likely to be appropriate in the long term as other capital improvements are made. We have not explored the costs or implications of this approach in detail.

NEAR-TERM COASTAL RESILIENCE SOLUTIONS

Some near-term action has already been taken to increase flood protection in the area through development. As an example, the area surrounding the marina ranges from 10.3 to 12 feet NAVD88, and the area adjacent to Pier 4 along the waterfront ranges from 11 to 12.4 feet NAVD88. This would require flood protection actions of one to three feet to meet the base elevation of 13 feet NAVD88 by the 2040s (more permanent action would be required to meet the proposed target elevation of 15 feet NAVD88 for this area). The exception is the area around Fan Pier Civic Park which dips to around 9 feet NAVD88 on the Harborwalk and forms a flood pathway into the South Boston Waterfront at 11 feet NAVD88.

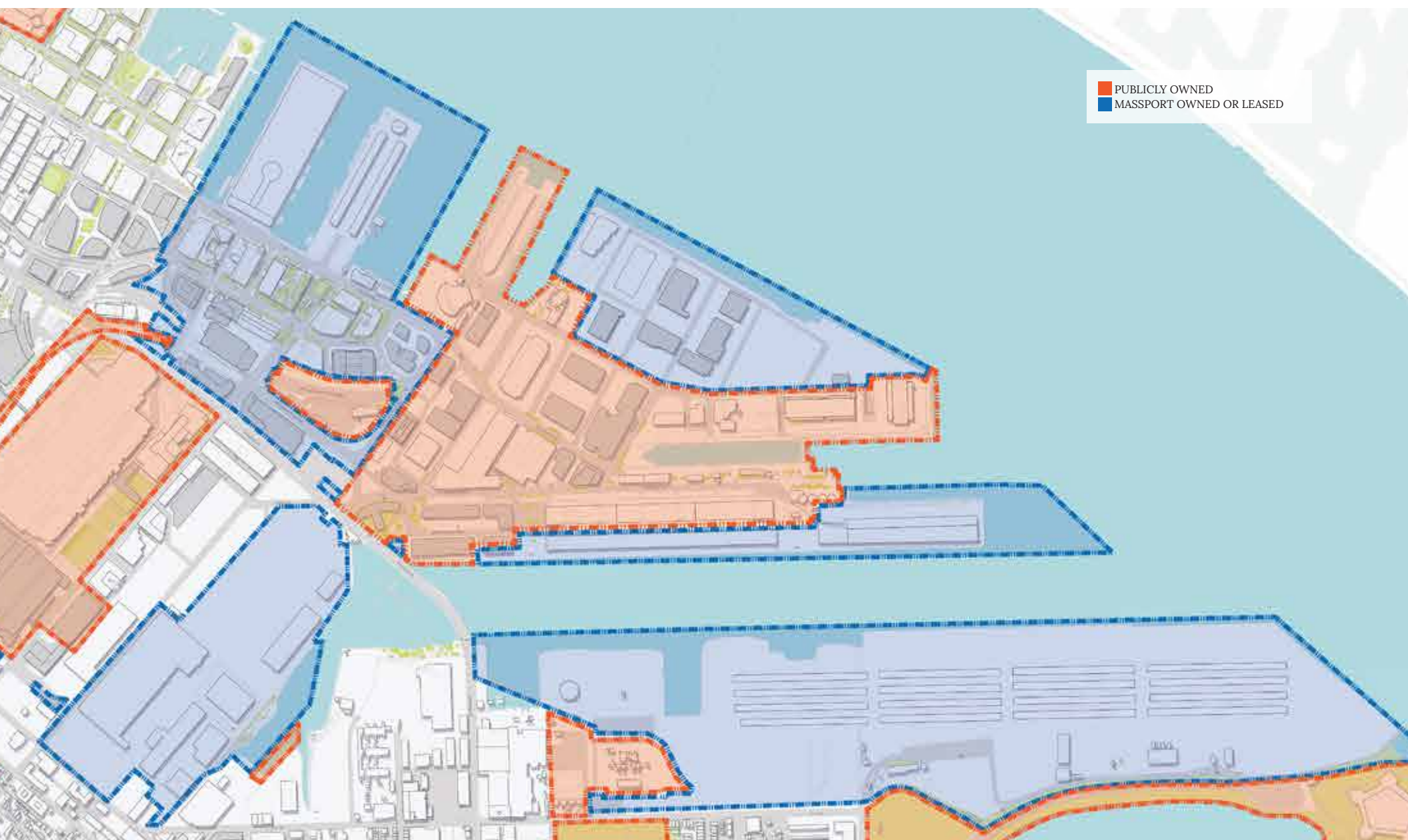
Flood protection within the South Boston Waterfront could be completed incrementally both in pieces or distinct “chunks” around the perimeter and vertically, adding height over time. For example, an initial mid-term solution could make use of existing space in the area of the Institute of Contemporary Art and then expand to add fill into the marina later in the century. It would not be possible to implement an incremental or near-term flood protection solution at the mouth of the marina, as a functional gate must be completed all at once and cannot be constructed incrementally.



SEAPORT BOULEVARD, RAYMOND L. FLYNN MARINE PARK, RESERVED CHANNEL



Seaport Boulevard, the Raymond L. Flynn Marine Park, and the Reserved Channel comprise a mix of maritime, commercial, and industrial uses. Massachusetts Port Authority (Massport) and the City of Boston are the largest long-term leaseholder and landowner. The area begins with the World Trade Center on Seaport Boulevard and wraps east to end with the Paul W. Conley Container Terminal (Conley Terminal) adjacent to Pleasure Bay. Photo Source: Boston Planning and Development Agency



SEAPORT BOULEVARD

The Seaport Boulevard study area begins at the World Trade Center and ends at Dry Dock 4, and is predominantly Massport property. Seaport Boulevard serves as a critical transportation corridor for the larger district.



Photos: South Boston Waterfront

RAYMOND L. FLYNN MARINE PARK

Boston's previously robust maritime industry declined after World War II with changes in freight transportation technologies. Investment by the Economic Development and Industrial Corporations, Massport, and others revitalized the port area around the Raymond L. Flynn Marine Park and the Reserved Channel, with the area experiencing increased maritime commercial uses, trucking, and container shipping over the last two decades. The Raymond L. Flynn Marine Park is a concentration of water dependent industries with heavy reliance on key primary and secondary transportation routes through the district. Much of the area is a Designated



Port Area, which prioritizes marine industrial uses. Significant planned development in the area presents an opportunity to build climate resilience over time.

The Raymond L. Flynn Marine Park, formerly known as the Boston Marine Industrial park, is owned by the City of Boston's Economic Development and Industrial Corporations. The park, formerly an Army and Naval base, extends 191 acres along the South Boston Waterfront. The area was nearly empty and abandoned until the land was granted to the Economic Development and Industrial Corporations between 1977 and 1983.

Since then, the area has become a prime location for consolidating, preserving, and growing Boston's ocean trade, maritime industries and industrial uses. Based on the master plan for the area, 67% of the park is reserved for maritime industrial purposes, 28% is used for industrial, and 5% is commercial. Tenants include breweries, research facilities, and seafood processing and wholesaling facilities.



Photos: Raymond L. Flynn Marine Park

RESERVED CHANNEL

Massport is the major landholder along the Reserved Channel with areas such as the Paul W. Conley Container Terminal (Conley Terminal). Key private landowners include Regate, the developers of the South Boston Edison Power Plant, FedEx, Boston Edison, Comcast, NES Rentals, and Robert N. Carp & Co.

The Reserved Channel is presently characterized by heavy industrial facilities along the entirety of its shores. Little to no natural bank edges remain. On the southern bank, the Conley Terminal and remnants of the former South Boston Edison Power Plant dominate the shoreline, accompanied by other industrial warehouses and commercial fishing facilities. On the northern side, the Flynn Cruiseport Boston at the Black Falcon Terminal spans over two-thirds of the shoreline.

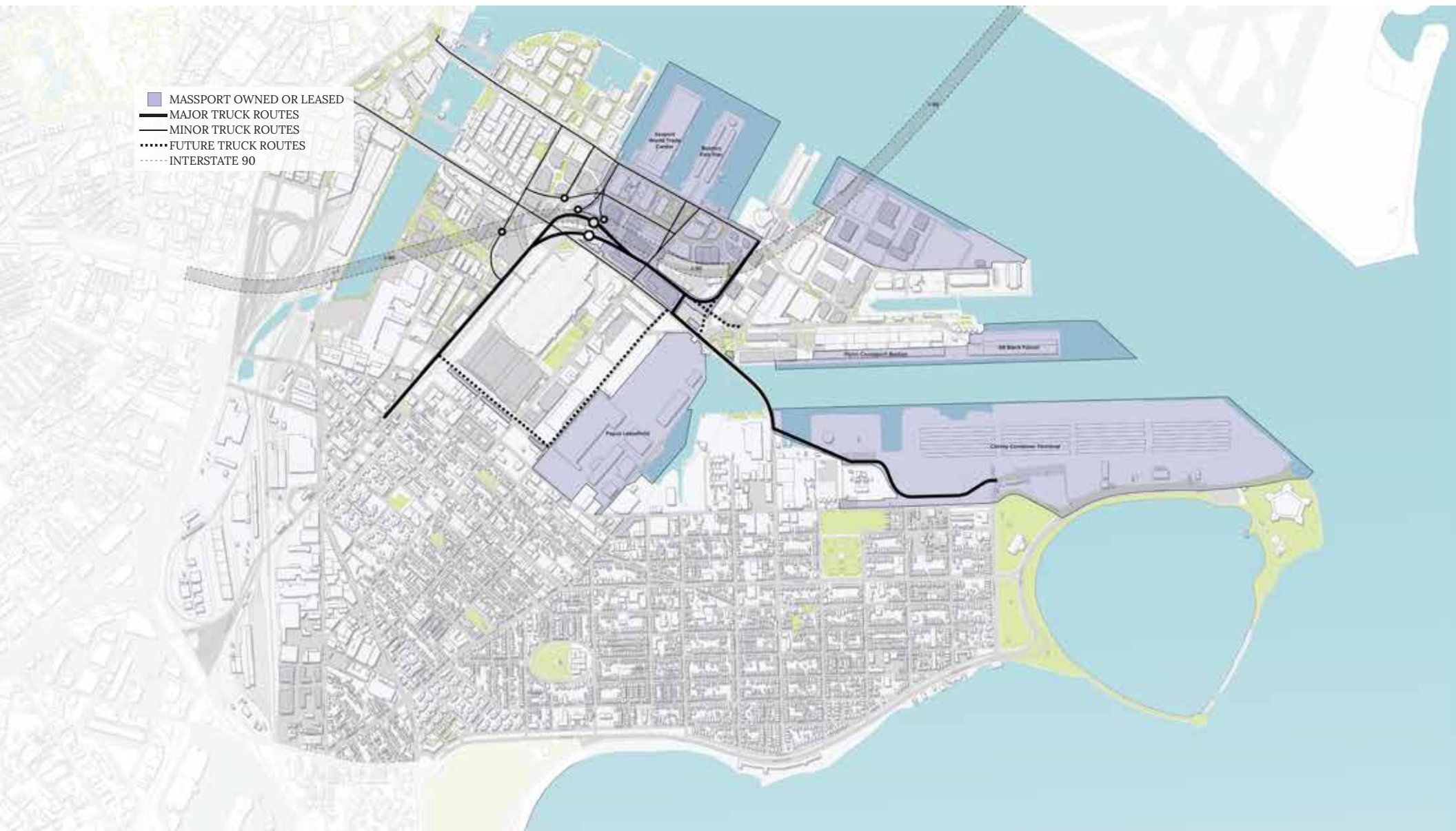
Cruiseport Boston, owned and operated by Massport, opened in 1986 and welcomed 13 cruise ships and a total of 11,723 passengers in its first season. In 2016, Cruiseport Boston welcomed 114 ships carrying 309,027 passengers. In 2017, this number jumped to 153 ships and 19 different cruise lines from late April through early November.

According to a 2013 report by the Cruise Lines International Association (CLIA):

- » *Massachusetts is one of the top ten states in the United States for economic impact from the cruise industry*
- » *Cruise industry spending generates over 8,000 jobs and \$479 million in income for Massachusetts workers*
- » *Cruise industry direct spending in Massachusetts exceeded \$493 million, with passengers and crew spending \$36 million in Boston alone in 2012*

- Flynn Cruiseport Boston Fact Sheet, Massport

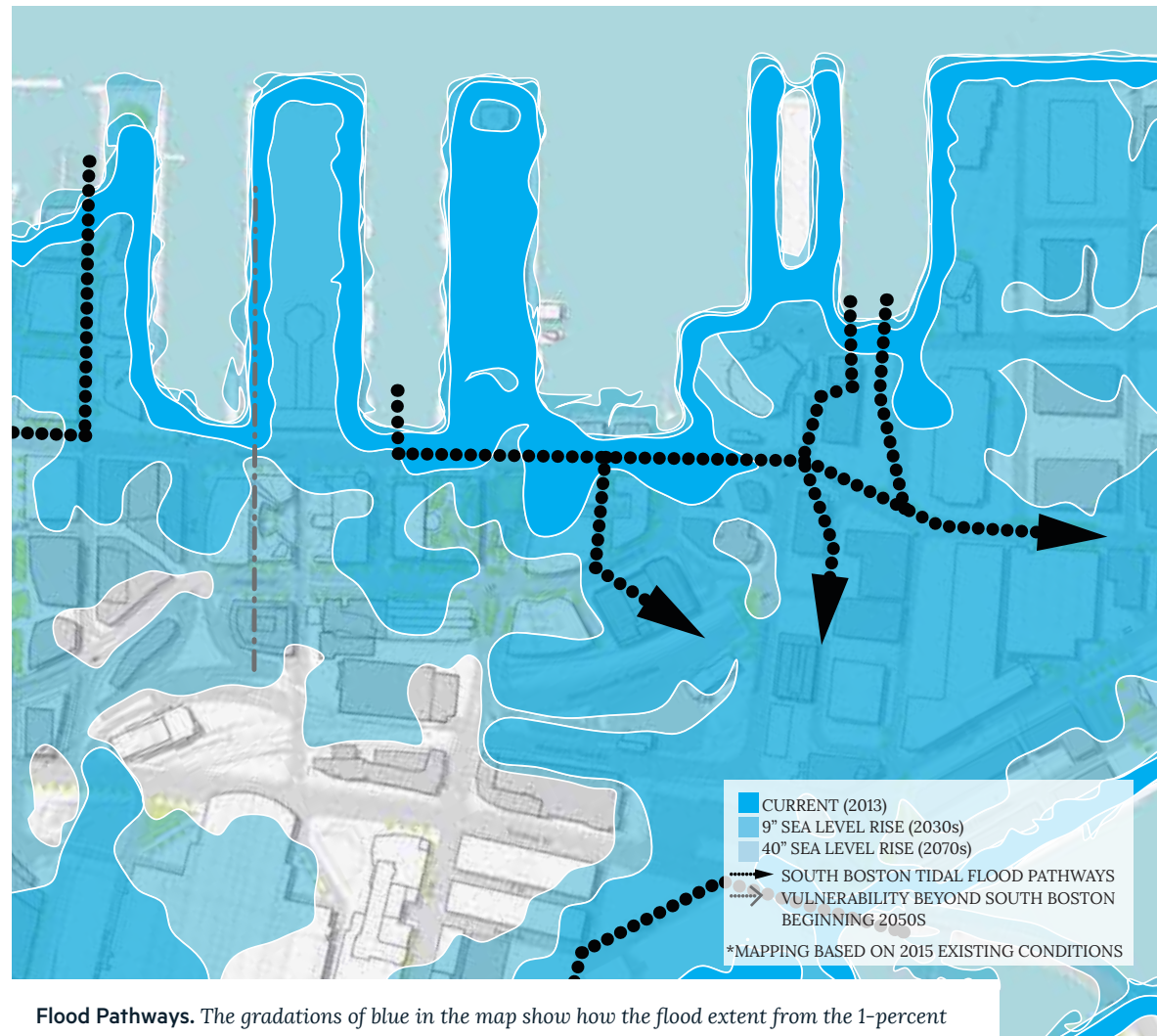




Land ownership in the Raymond L. Flynn Marine Park is predominantly Economic Development and Industrial Corporations-owned and Massport-leased.

FLOOD RISK

In the Raymond L. Flynn Marine Park area, present flood risk is mostly confined to the coastal fringe along the waterfront. Nevertheless, nearly the entire area is expected to flood with the 5-percent (1 in 20) annual chance flood level and widespread flooding could happen at least monthly with 40 inches of sea level rise. Several flood pathways, through topographical low points, will allow rising waters to penetrate inland into industrial areas along the Reserved Channel's western side. Areas along Northern Avenue near Liberty Wharf and the Blue Hills Bank Pavilion also serve as entrances for flood pathways. With 40 inches of sea level rise and no resilience action, the entirety of the Raymond L. Flynn Marine Park, and areas bordering the Reserved Channel would be inundated on at least an annual basis, with the majority subject to at least monthly flooding.

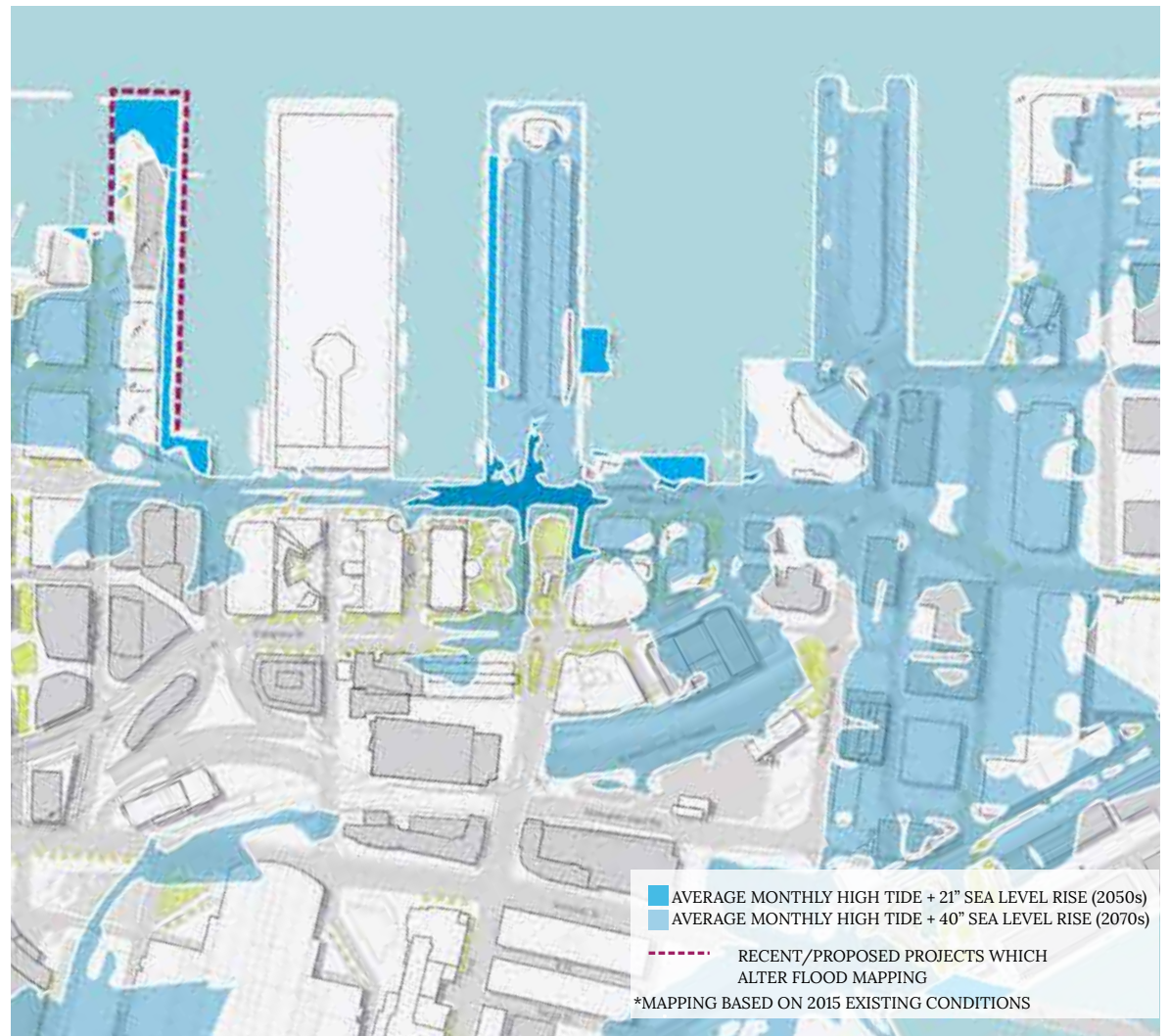


Flood Pathways. The gradations of blue in the map show how the flood extent from the 1-percent annual chance flood level changes from 2013 to 9 inches of sea level rise (2030s) and 40 inches of sea level rise (2070s). The colors do not indicate depth of flooding. Arrows indicate key flood pathways.

SEAPORT BOULEVARD FLOOD PATHWAYS

Low-lying land to the east of the Fish Pier is at current risk of coastal flooding. Two additional flood pathways enter to the east of the Pavilion. These flood pathways combine with others in the Raymond L. Flynn Marine Park and Reserved Channel to inundate both the Raymond L. Flynn Marine Park and Pappas Way to the edges of the South Boston neighborhood with low probability current flood elevations (0.5- to 0.2-percent annual chance flood level) and higher probability flooding with 9 inches of sea level rise (5-percent annual chance flood level (1 in 20)).

“Average monthly high tide” means the average of the highest tide experienced each month in 2015. Since tide ranges fluctuate seasonally, daily tides could rise above the average monthly high tide multiple times some months and not at all in other months.

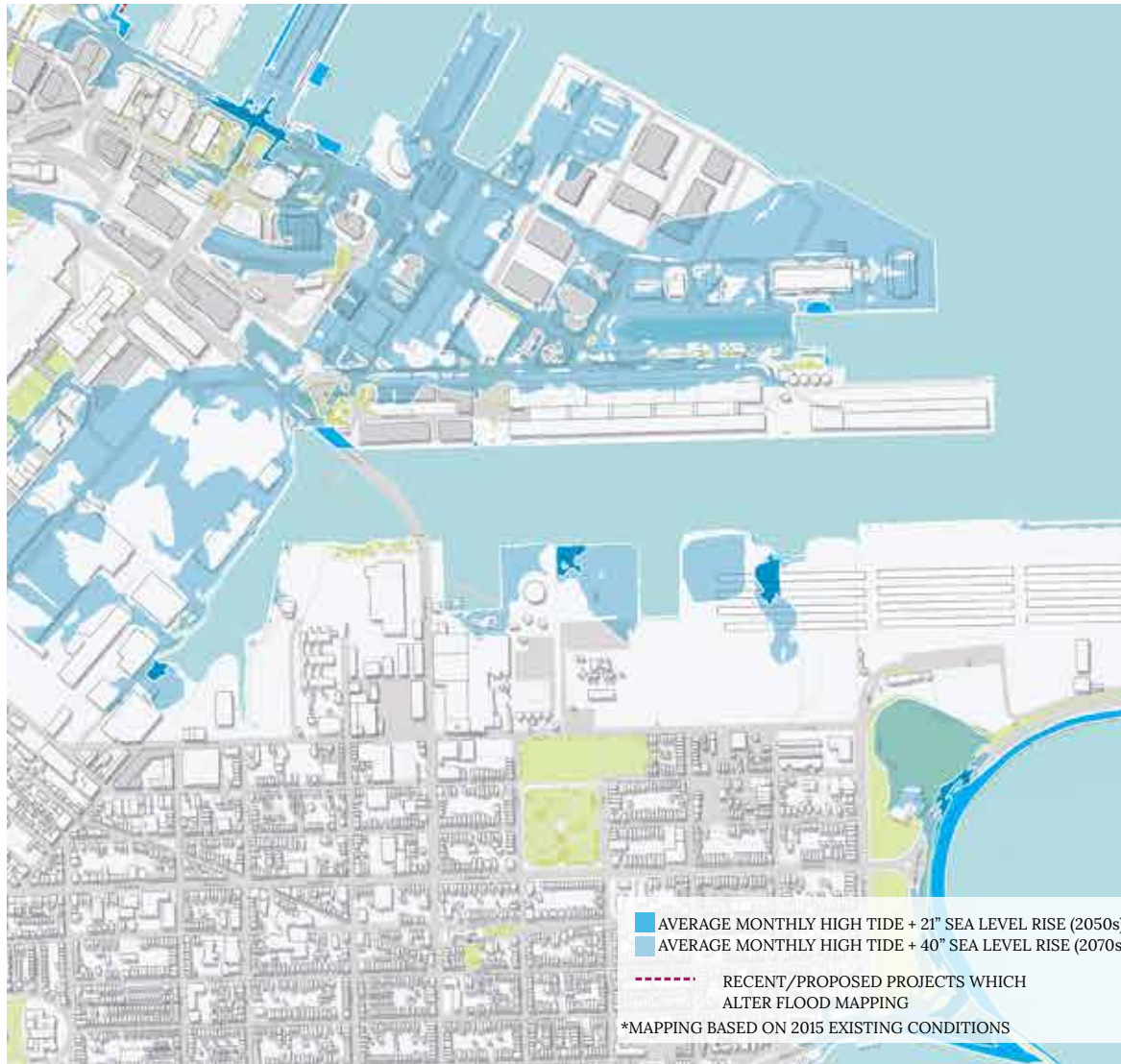


RAYMOND L. FLYNN MARINE PARK FLOOD PATHWAYS

The most prominent flood pathway enters at the northeastern edge of the Raymond L. Flynn Marine Park and combines with pathways from the Seaport Boulevard area to expose most of the Raymond L. Flynn Marine Park. Low probability flooding is anticipated now (0.5- to 0.2-percent annual chance flood elevation) and higher probability flooding is anticipated with nine inches of sea level rise (5-percent annual chance flood level (1 in 20)). A large portion of the Raymond L. Flynn Marine Park will be at risk to at least monthly flooding with 40 inches of sea level rise.



Probable future monthly storm flood extents (at the 1% Annual chance storm event).



Probable future monthly tidal flood extents (and areas of intervention).

RESERVED CHANNEL FLOOD PATHWAYS

Due to the low waterfront edges along the Reserved Channel, this area is exposed to coastal flooding from the 1-percent annual chance flood level in the first half of the century. The former Boston Edison power plant at the corner of Summer and First Streets will be exposed to flooding from high-probability storms in the mid- to late century. Four flood pathways exist along Pappas Way from Summer Street to the terminus of the channel.

As in other areas across South Boston, mitigated brownfields, coastal erosion, and increased groundwater levels may risk release of contaminants as sea levels rise and coastal flood events inundate capped sites.

With 9 inches of sea level rise (the projection for 2030), during a 1 percent chance annual event the flood pathways in the Reserved Channel could result in \$40,000 in direct physical and displacement damage to 5 structures and impact an estimated 16 people.

ENGAGEMENT FEEDBACK

Stakeholders along Seaport Boulevard, in the Raymond L. Flynn Marine Park, and along Reserved Channel emphasized continuity of operations, with special emphasis on maintaining ship to shore connections and existing truck routes.

A survey question asked participants “As a resident, what are your priorities for improvements to these areas?” The top three responses were:

Seaport Boulevard: Parks and Open Space (23%), Transportation (21%), and Parking (12%).

Raymond L. Flynn Marine Park and Reserved Channel: Parks and Open Space (23%), Transportation (18%), and Jobs (16%).

Stakeholders provided clear reactions:

- » The Cruiseport and other maritime, commercial, and industrial uses in the area are a great economic engine. Solutions cannot suppress current planned or existing economic activity and uses
- » Ferries and the Pavilion are great public amenities
- » Existing truck routes must be preserved
- » Existing and potential ship to shore connections must be considered for any resilience design
- » A Harborwalk is not appropriate in the area of the Raymond L. Flynn Marine Park and certain parts of the Reserved Channel for safety reasons
- » There is some opportunity for marshland restoration at the base of the Reserved Channel
- » There is a need for improved public transit serving the Raymond L. Flynn Marine Park / Reserved Channel area and South Boston as a whole
- » It is critical to maintain effective operation of the Port
- » The most important criterion is effectiveness

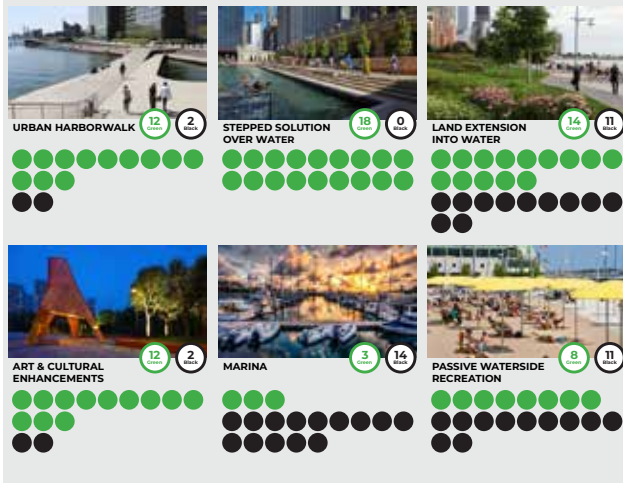
Over 150 people attended the second Climate Ready South Boston Open House on March 6, 2018 to learn more about the project and offer input on alternate flood protection strategies.



SEAPORT BOULEVARD

WHICH FLOOD PROTECTION ELEMENTS AND AMENITIES DO YOU PREFER?

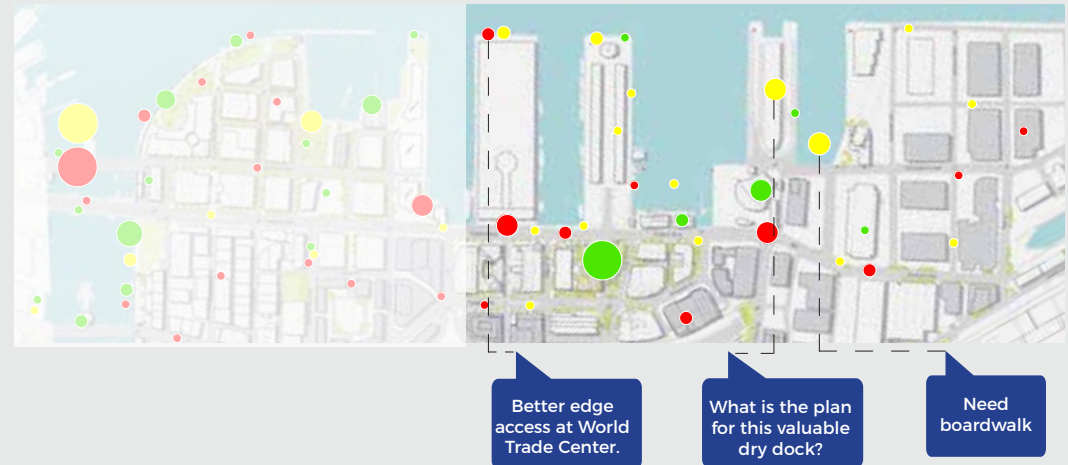
● = Want ● = Do Not Want



WHAT ARE YOUR WATERFRONT PUBLIC SPACE PREFERENCES?

● = something you love
● = something you want to change
● = something you want to add

*Larger circle size denotes clustering of public comments



Open House Summary for South Boston Waterfront and Seaport Boulevard, 12/11/17

COMMENTS

Planning for resiliency and flood-resistant construction

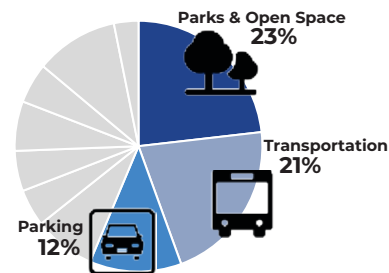
Elevate the Harborwalk to make a flood barrier/recreational "Dry Line."

Preservation of its historical integrity.

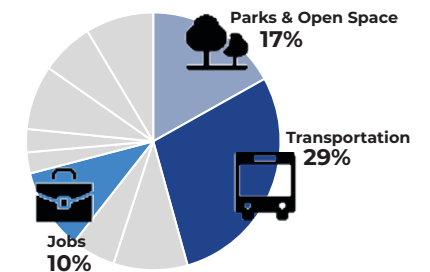
PRIORITIES

Respondents were asked to choose up to two top priorities for improvement. The following pie chart percentages indicate top categories selected for the Seaport Boulevard.

RESIDENT PRIORITIES



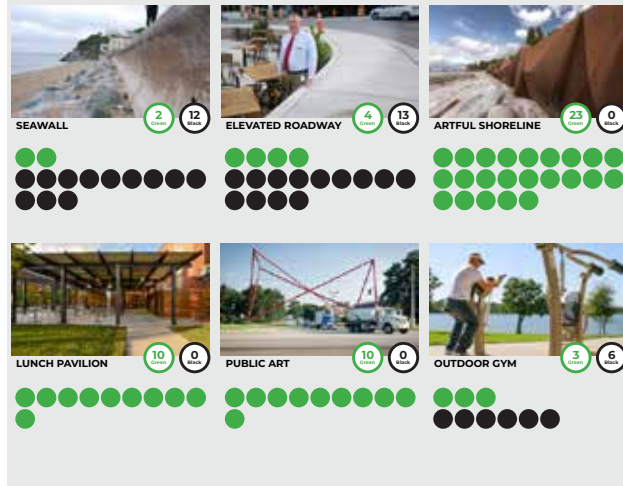
NON-RESIDENT PRIORITIES



RAYMOND L. FLYNN MARINE PARK

WHICH FLOOD PROTECTION ELEMENTS AND AMENITIES DO YOU PREFER?

● = Want ● = Do Not Want



WHAT ARE YOUR WATERFRONT PUBLIC SPACE PREFERENCES?

● = something you love
● = something you want to change
● = something you want to add

*Larger circle size denotes clustering of public comments



Open House Summary for Raymond L. Flynn Marine Park, 12/11/17

COMMENTS

Continued effective operation of the port

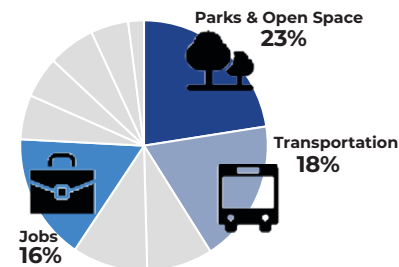
Updated definition of designated port areas to include flood-resilient marine education and tech.

The Marine Channel area and South Boston as a whole needs to improve how people get to and from South Boston with better public transit.

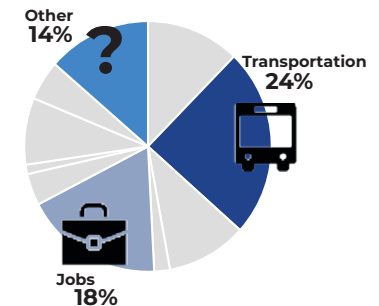
PRIORITIES

Respondents were asked to choose up to two top priorities for improvement. The following pie chart percentages indicate top categories selected for the Raymond L. Flynn Marine Park.

RESIDENT PRIORITIES



NON-RESIDENT PRIORITIES

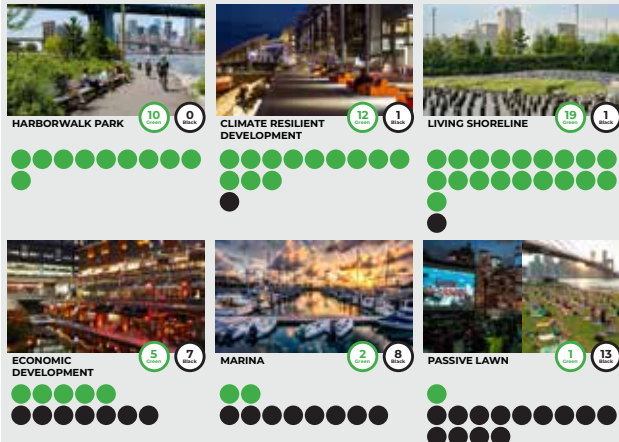


Online Survey Results for Raymond L. Flynn Marine Park, 9/28/17 - 12/31/17

RESERVED CHANNEL

WHICH FLOOD PROTECTION ELEMENTS AND AMENITIES DO YOU PREFER?

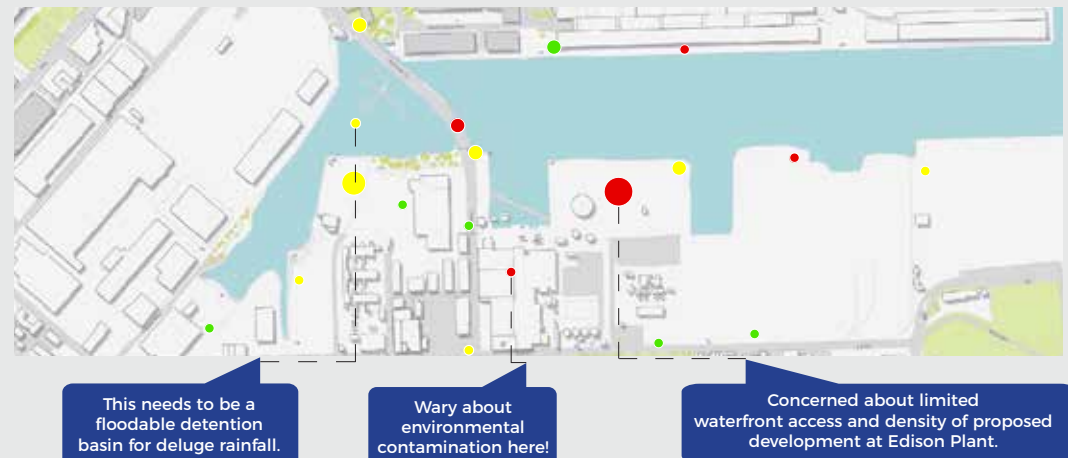
● = Want ● = Do Not Want



WHAT ARE YOUR WATERFRONT PUBLIC SPACE PREFERENCES?

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● = something you want to change
● = something you want to add

*Larger circle size denotes clustering of public comments



Open House Summary for Reserved Channel, 12/11/17

COMMENTS

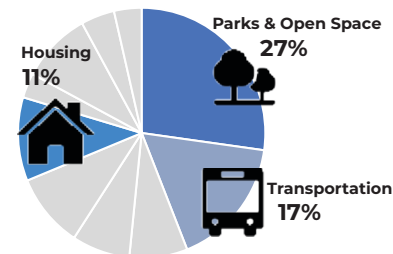
Black Falcon and Design Center are great amenities. A green space and better access would improve the area

Continue the Harborwalk so that it makes a circuit around the channel

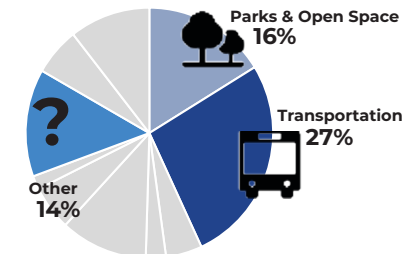
PRIORITIES

Respondents were asked to choose up to two top priorities for improvement. The following pie chart percentages indicate top categories selected for the Reserved Channel

RESIDENT PRIORITIES



NON-RESIDENT PRIORITIES



Online Survey Results for Reserved Channel, 9/28/17 - 12/31/17

Estimated Costs for Alignment Options A and B

OPTION A

ESTIMATED COST	\$36 - \$42 million
ESTIMATED MAINTENANCE COST	\$550,000 - \$650,000* per year

*Maintenance costs are expected to be 1.5 percent of the implementation costs.

OPTION B

ESTIMATED COST	\$140 - \$161 million
ESTIMATED MAINTENANCE COST	\$2.1 - \$2.4 million* per year

*Maintenance costs are expected to be 1.5 percent of the implementation costs.

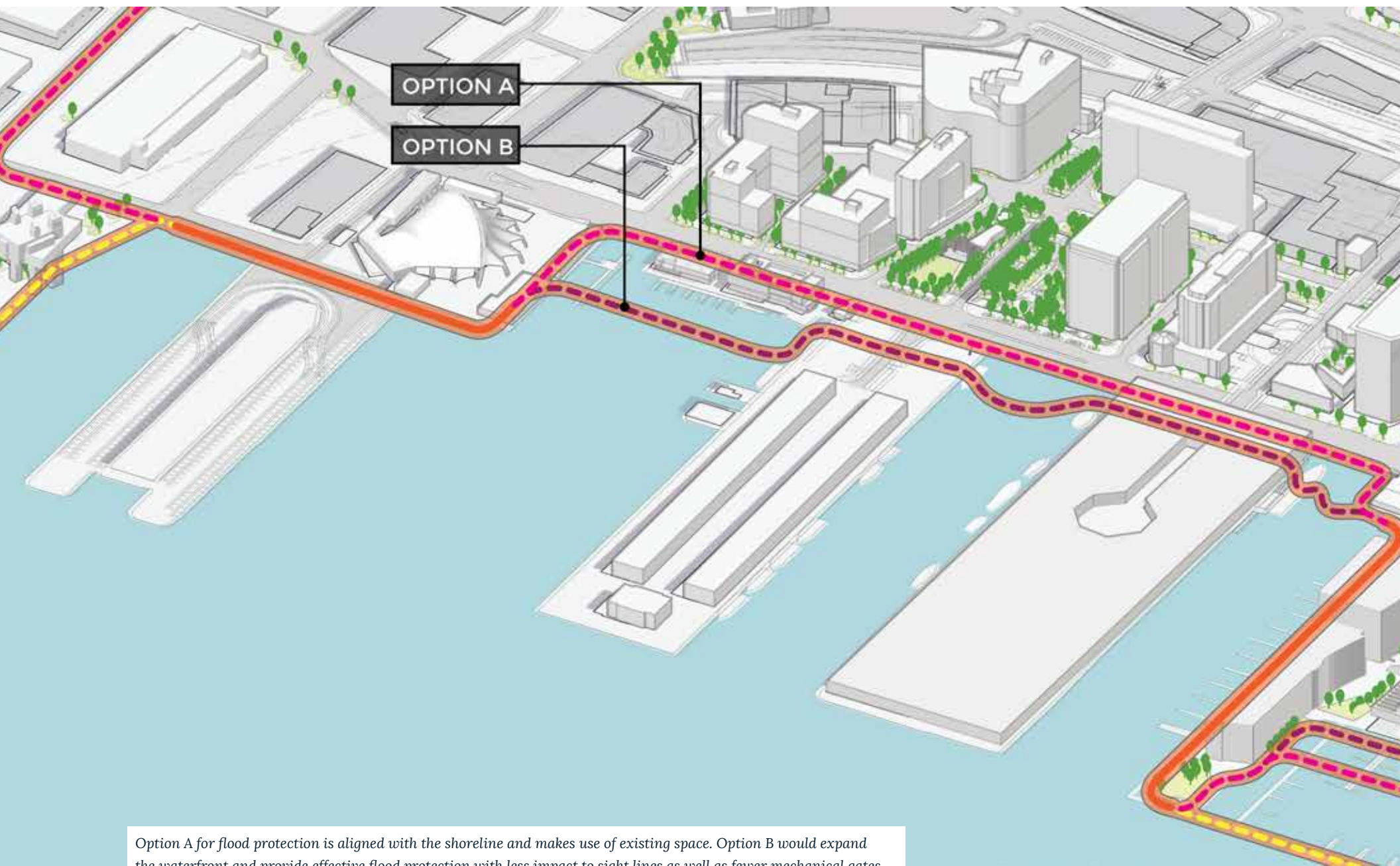
SEAPORT BOULEVARD: MID-TERM COASTAL RESILIENCE SOLUTIONS

The Seaport Boulevard Area is significantly space-constrained between the existing waterfront and the roadway. We examined two alignment alternatives for Seaport Boulevard area:

Option A. Flood protection along the existing shoreline

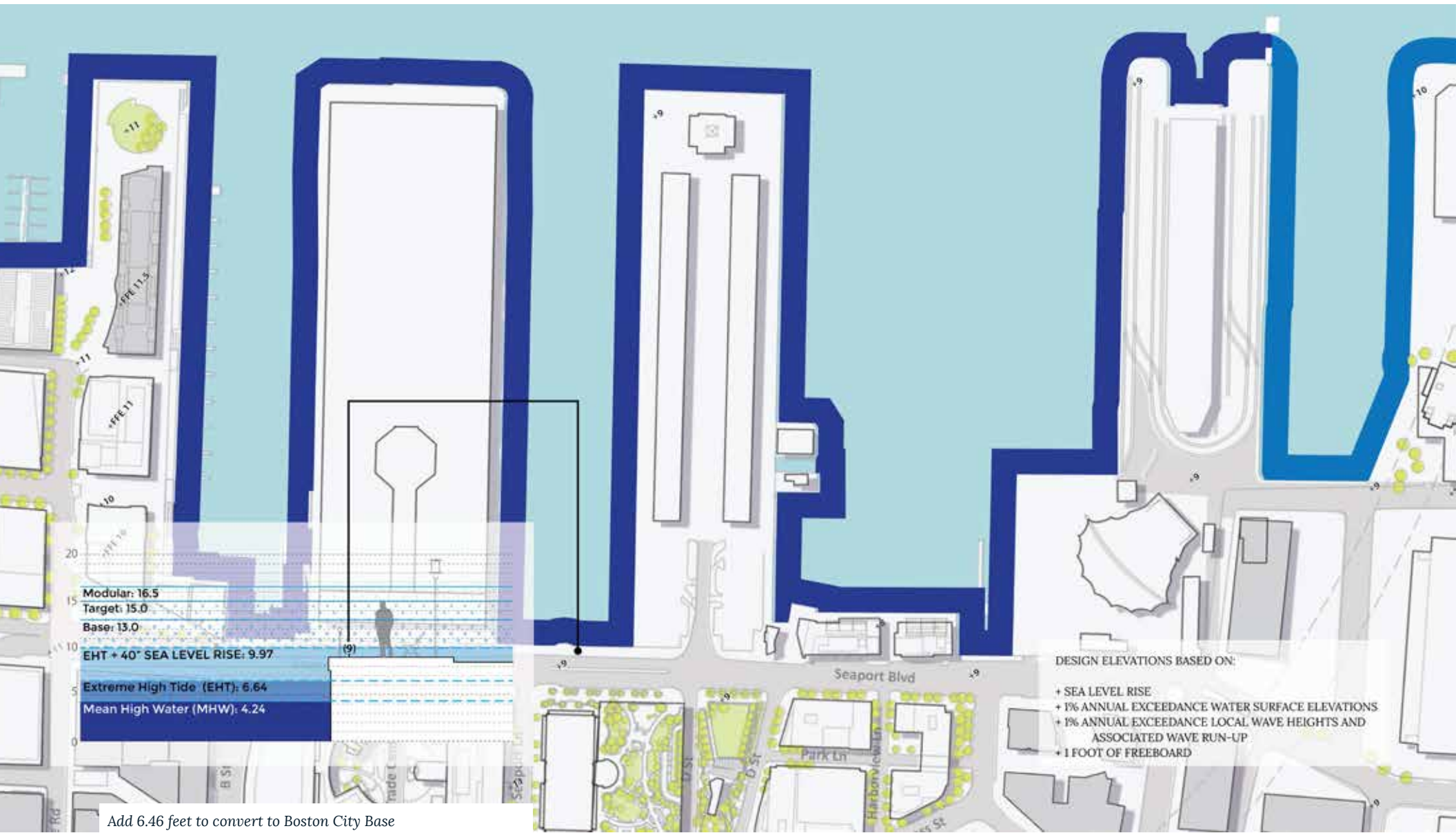
Option B: Flood protection built out into the water

For each option, there are minor variations possible for the alignments, and for each alignment, there are multiple technical approach options, and a variety of possible design concepts.



Option A for flood protection is aligned with the shoreline and makes use of existing space. Option B would expand the waterfront and provide effective flood protection with less impact to sight lines as well as fewer mechanical gates. These options are not mutually exclusive.

Both alternatives propose a minimum of 15 feet NAVD88 as the design elevation and could be adapted to higher design elevations. This will require an average of about 6 feet above grade in the mid-term.



EFFECTIVENESS

The effectiveness of both options is limited in the long term by flood pathways generated from other parts of the district; flood pathways originating in the Raymond L. Flynn Marine Park could connect with Seaport Boulevard flood pathways. With flooding to the 5-percent annual chance flood level elevation with 9 inches of sea level rise, Seaport Boulevard flood pathways potentially merge with those from the South Boston Waterfront, the Raymond L. Flynn Marine Park, and the Reserved Channel.

Still, flood protection along Seaport Boulevard could independently mitigate over \$30 million in losses in the form of direct physical damage to buildings, as well as their contents and inventory, and displacement and relocation costs from the 10-percent annual chance flood elevation with 9 inches of sea level rise (2030s).

Reduced Exposure and Losses as a Result of Alignment Options A and B

The options could equally reduce exposure and expected impacts to the 1-percent annual chance flood elevations with 0 sea level rise. At the 1-percent annual chance elevation with no sea level rise, coastal resilience design strategies in this area could mitigate risk to close to 175 people and close to \$30 million in expected direct physical damages and relocation / displacement costs. The Seaport Boulevard coastal resilience strategy must be combined with coastal resilience measures in other areas in order to remain effective with sea level rise. True effectiveness will depend on design and long term maintenance. These figures do not include exposure or expected losses avoided for any structures outside of the alignment that must be independently floodproofed.

With 9 inches of sea level rise, Seaport Boulevard coastal resilience design strategies must be combined with measures in Raymond L. Flynn Marine Park, Reserved Channel, and South Boston Waterfront to be effective. With 21 inches and 40 inches of sea level rise, Seaport Boulevard coastal resilience measures must be combined with coastal resilience measures in Fort Point Channel, Raymond L. Flynn Marine Park, Reserved Channel, and South Boston Waterfront to be effective against flooding in the area.

ALIGNMENT OPTION A. FLOOD PROTECTION OPTIONS AT THE EXISTING SHORELINE OF SEAPORT BOULEVARD

Option A makes use of existing available space on the shoreline along Seaport Boulevard. Potential solutions include proposed seawall with floodgates at access points to the piers, individual building protection for those built out onto the water, and a proposed public park where there is space available adjacent to the Blue Hills Pavilion.

Floodproofing of buildings represents an additional cost of \$113 to \$131 million due to the large footprints of the World Trade Center, Fish Pier, and Liberty Wharf buildings. Principal causes of cost variation include:

- » Whether the flood protection alignment occurs on existing land or within the water
- » Whether the structure is a wall, elevated roadway, or earthen feature
- » The number of penetrations of the protection feature (for example, requiring flap gates or surface openings with closeable flood gates)

Current unknowns include:

- » The number, type, and condition of existing outfalls along shoreline

EVALUATION CRITERIA PERFORMANCE

EFFECTIVENESS



ENVIRONMENTAL IMPACT



DESIGN LIFE AND ADAPTABILITY



FEASIBILITY



EQUITY



SOCIAL IMPACT



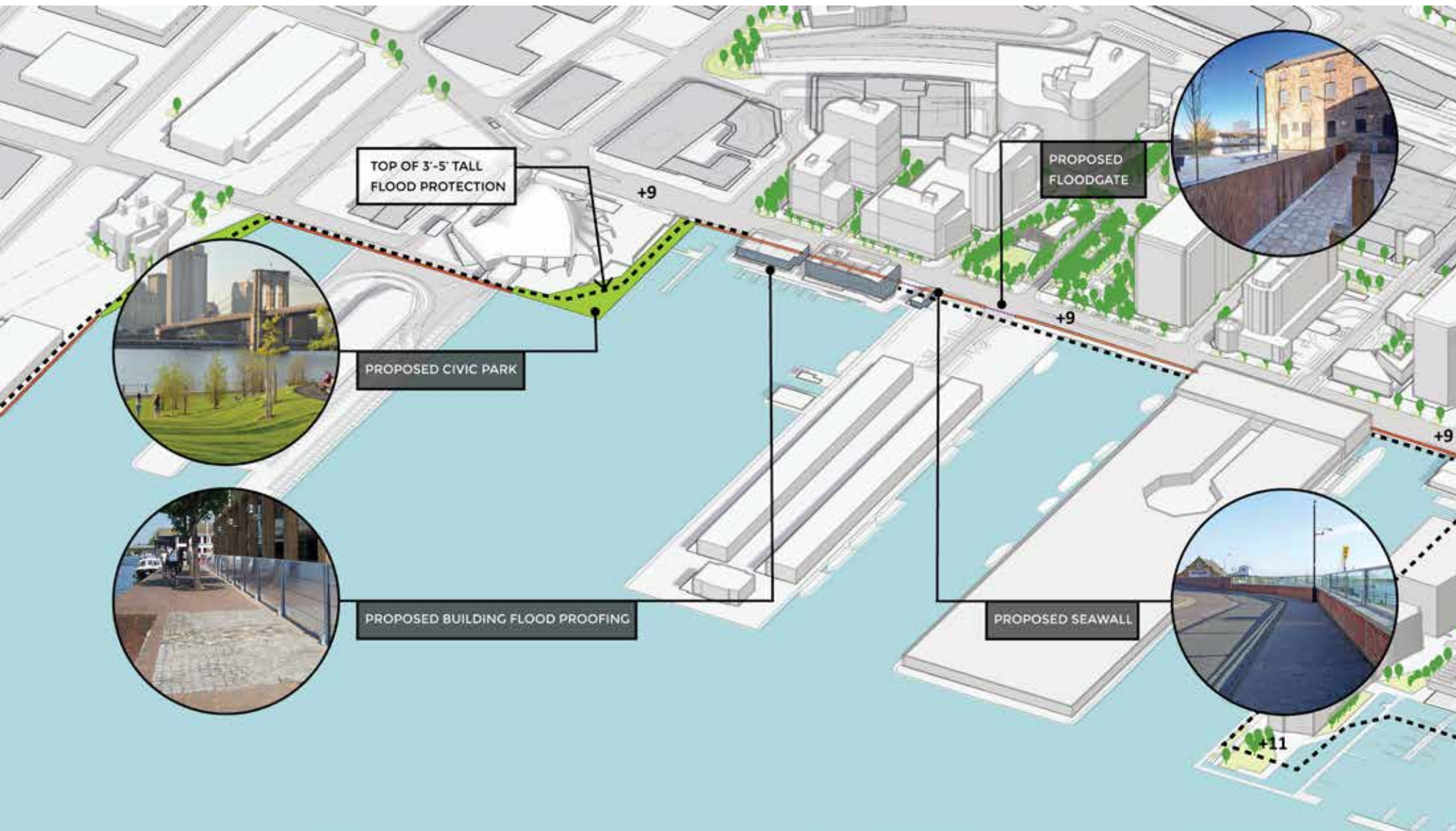
VALUE CREATION



- » The number, type, and condition of buried subsurface utilities (electric, gas, stormwater, wastewater, fiber, etc.)
- » Subsurface soil permeability conditions and the necessity for seepage cutoff measures such as sheeting, grout walls, or other treatments
- » Ability to permit in-water construction and the presence of contaminated soils
- » Availability of materials and labor and material costs

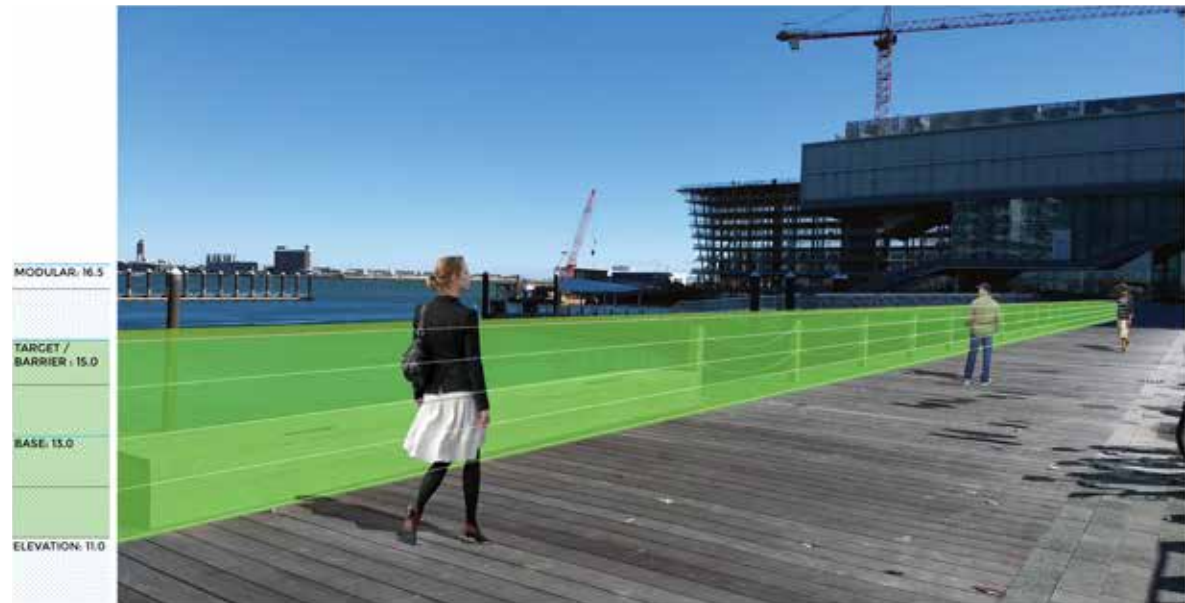
KEY CONSIDERATIONS:

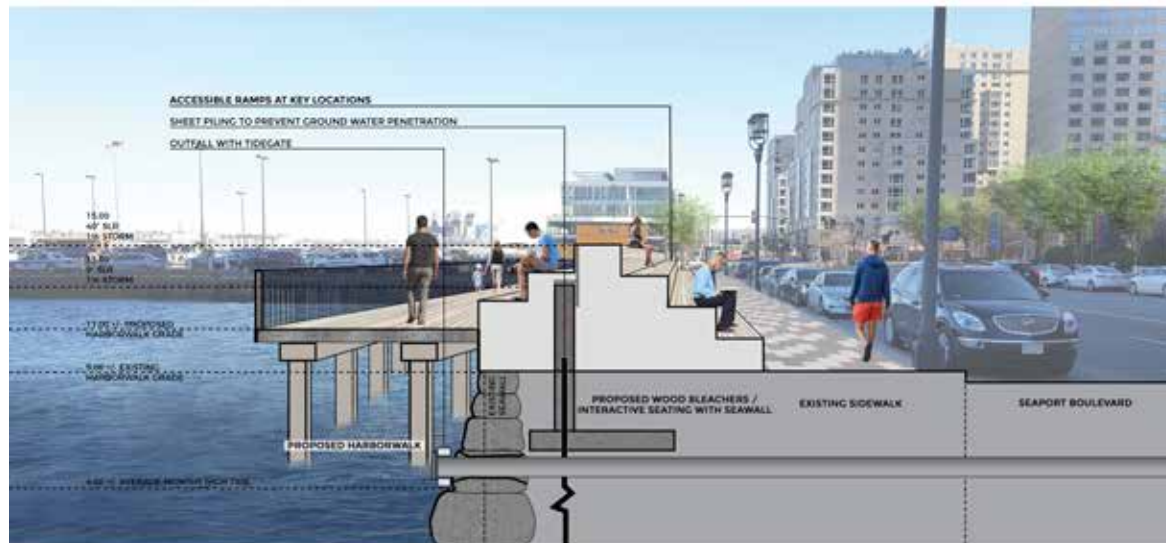
- » Multiple mechanical gates represent potential points of failure
- » Can be designed to address 40 inches of sea level rise now, and may be adapted to address higher flooding later
- » The target elevation could alter the existing relationship with the waterfront, even with additional design features
- » Once sea level rise has surpassed a threshold of roughly 20 inches, flooding as frequently as monthly is expected. This should impact design considerations related to operable flood gates



Design concept prototypes for flood protection alignment option along the shoreline of Seaport Boulevard. Option A makes use of existing space.

The following four images demonstrate the relationship of the different possible design elevations to the existing grade at varying points along the waterfront, and the effect they could have on sight lines to the water. The final image demonstrates ways that higher elevation designs can be adapted to enhance waterfront access.





ALIGNMENT OPTION B. FLOOD PROTECTION OPTIONS BUILT OUT INTO WATER THROUGH THE USE OF FILL

Option B is similar to Option A, but would build out into the water to expand public park space.

Floodproofing of buildings represents an additional cost of \$113 to \$131 million due to the large footprints of the World Trade Center, Fish Pier, and Liberty Wharf buildings.

EVALUATION CRITERIA PERFORMANCE

EFFECTIVENESS



ENVIRONMENTAL IMPACT



DESIGN LIFE AND ADAPTABILITY



FEASIBILITY



EQUITY



SOCIAL IMPACT

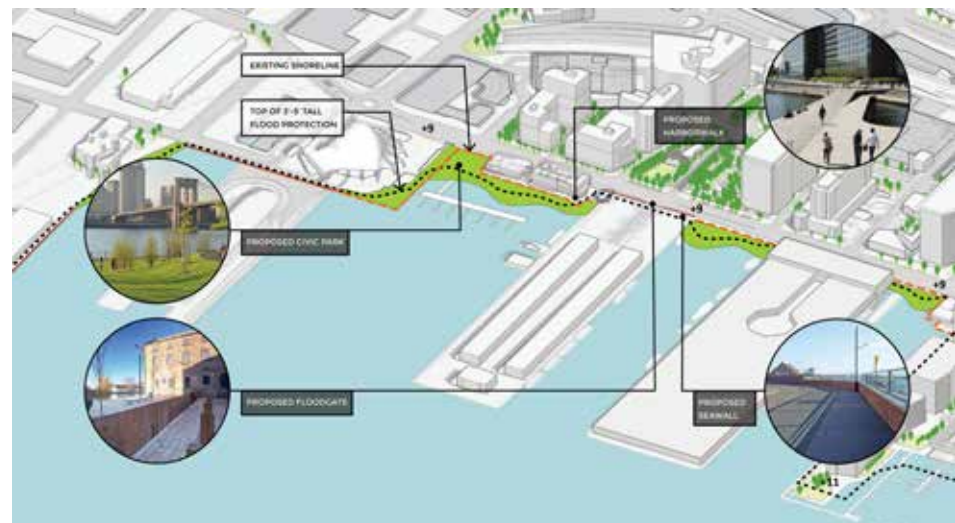


VALUE CREATION



KEY CONSIDERATIONS:

- » Long-term opportunity to significantly improve public park space
- » Requires only one mechanical gate (on Fish Pier)
- » Making land presents permitting challenges under existing regulations
- » Can be designed to address 40 inches of sea level rise now, and may be adapted to address higher flooding later



Design concept prototypes for flood protection alignment option expanded into the waterfront along Seaport Boulevard. Option B expands flood protection to add park space.

Alignment Option Comparison Across Evaluation Criteria

CRITERION	COMPARISON	CRITERION	COMPARISON
EFFECTIVENESS	Options A and B could be designed to equal flood elevations and adapted to higher elevations over time. Impacts to sight lines could lower the designed flood protection elevation with Option A , whereas this is not expected to be an issue with Option B . In addition, Option B requires fewer mechanical gates, which present potential points of failure. Option A would leave Liberty Wharf outside of the alignment and require that it be independently floodproofed.	ENVIRONMENTAL BENEFITS	Option A may have lesser environmental impact than filling the water (Option B); however, stirring up potentially contaminated soils during excavation (Option A) would be of concern. Option B is anticipated to be more constrained in terms of permitting.
FEASIBILITY	Both flood protection options are common. Option A can be implemented incrementally, but the majority of action must knit together seamlessly to provide a complete line of defense. The existing regulatory context may present barriers to implementation of Option B in the near-term.	SOCIAL IMPACT	The possible recreational, cultural, and aesthetic benefits that could be provided through Option B range from an expanded harborwalk and green space to new seating, educational opportunities, and more. While Option A can be designed to provide social benefits, the options are more limited as the area is more space constrained.
DESIGN LIFE AND ADAPTABILITY	Both options are largely passive solutions with similar maintenance frequencies that can be adapted to higher sea levels. Option A could be effective sooner, as it is possible to implement it incrementally.	EQUITY	Option B would provide new and enhanced access to the waterfront, and may be combined with educational opportunities and community partnerships. Nevertheless, design would have to take into consideration existing operations and would require careful consideration to avoid negative impacts to industry in the area. Option A could be designed to enhance access to the waterfront.
		VALUE CREATION	Depending on the design configuration of Option B , a flood protection system at this location could create a new spot to recreate and provide additional benefit to the surrounding businesses. Option A is unlikely to affect the value of the area.

SEAPORT BOULEVARD: RECOMMENDED NEAR-TERM COASTAL RESILIENCE SOLUTIONS

Flood protection along Seaport Boulevard in this area could be completed incrementally both in pieces or distinct “chunks” around the perimeter and vertically, adding height over time. There is no “high ground” available in this area to tie into. Nevertheless, through coordinated design, the flood protection solution may be completed incrementally, tying flood protection solutions on one property to those adjacent to it.

The cost to complete the flood barrier elements of the project will be between \$19 and \$22 million. Floodproofing the Fish Pier would add an additional \$29 to \$33 million. Near-term earthen berm or flood wall features could be designed and constructed in such a manner that they could be raised in the long term as sea level rises.

These near-term improvements could prevent tens of millions of dollars in direct physical damage and displacement costs during a large flood event.

EVALUATION CRITERIA PERFORMANCE

EFFECTIVENESS



ENVIRONMENTAL IMPACT



DESIGN LIFE AND ADAPTABILITY



FEASIBILITY



EQUITY



SOCIAL IMPACT

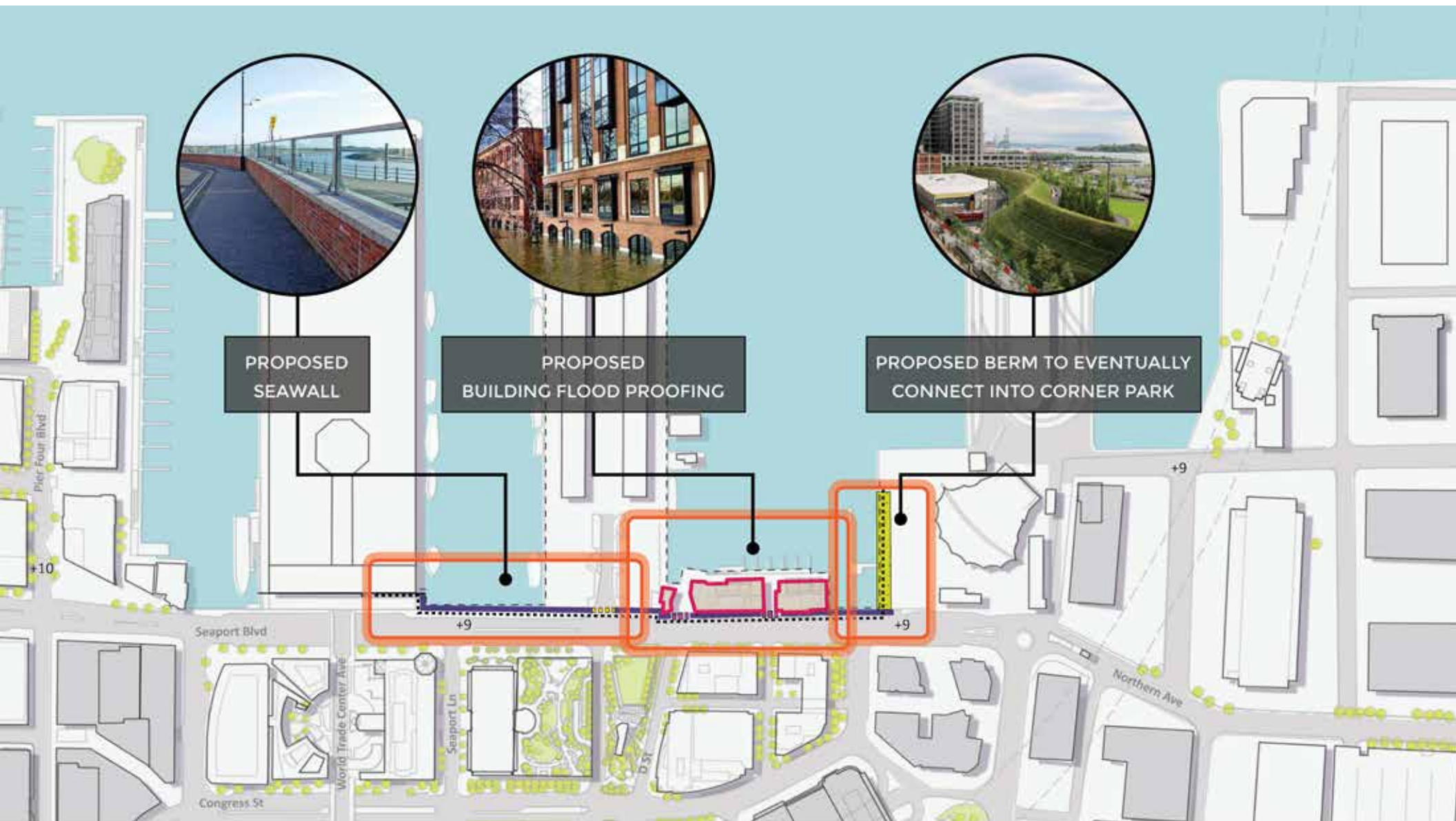


VALUE CREATION

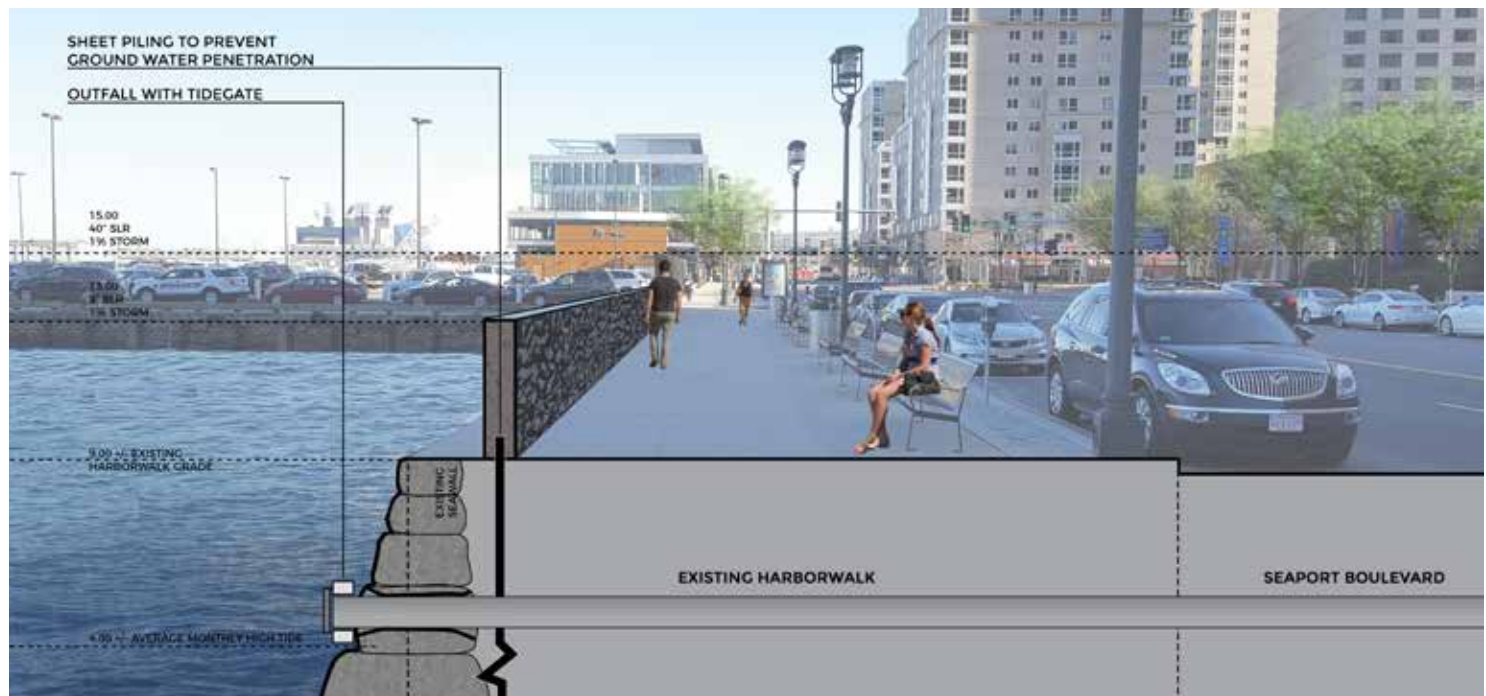


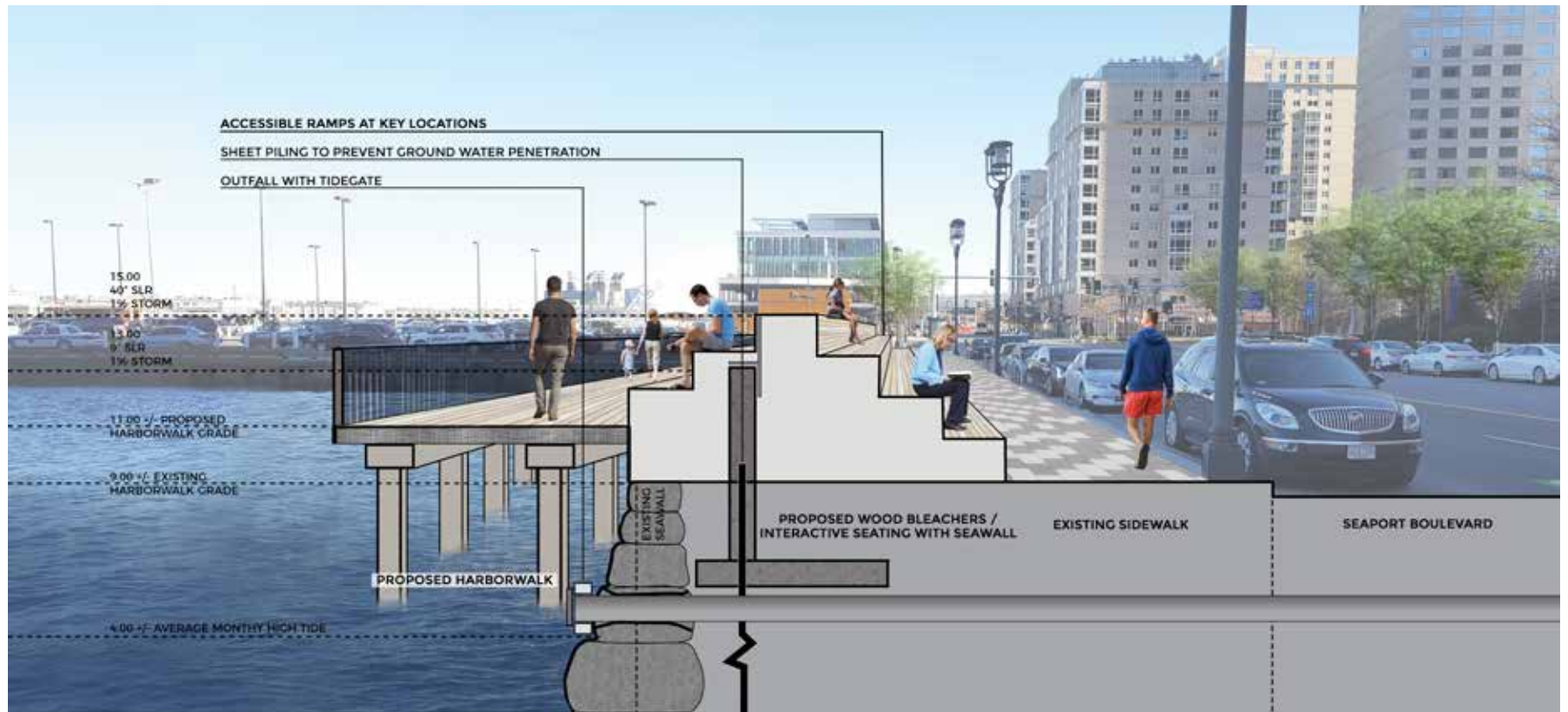
KEY CONSIDERATIONS:

- » Limited open space for installation of flood protection features
- » Multiple mechanical gates represent potential points of failure
- » Can be designed to address 9 inches of sea level rise now, and may be adapted to address higher flooding later
- » Installation of features to heights required for long term flood protection could interrupt existing pedestrian and ground floor sightlines of water views



Near-term coastal flood protection can be completed in steps correlating to the most urgent areas for action along Seaport Boulevard.





The progression of images demonstrates how the harborwalk along Seaport Boulevard could be adapted in the near term to be flood resilient. A floodwall adjacent to the existing Harborwalk may not disrupt existing sight lines if it is built to the base design elevation of 13 feet NAVD88, which is the 1-percent annual chance flood level with 9 inches of sea level rise and one foot of freeboard. Higher elevations could be adapted with creative additions and expansions of the harborwalk. The target elevation, the 1-percent annual chance flood level with 40 inches of sea level rise and 1 foot of freeboard, for example, is 2 feet higher and would require design alternatives to avoid significantly disrupting the existing relationship with the waterfront in this area.

Estimated Costs for Alignment Options A and B

OPTION A

ESTIMATED COST	\$197 - \$228 million
ESTIMATED MAINTENANCE COST	\$3.0 - \$3.4 million* per year

*Maintenance costs are expected to be 1.5 percent of the implementation costs.

OPTION B

ESTIMATED COST	\$132 - \$193 million
ESTIMATED MAINTENANCE COST	\$2.0 - \$2.9 million per year*

*Maintenance costs are expected to be 1.5 percent of the total cost to implement the solution and excludes floodproofing operations and maintenance (O&M).

RAYMOND L. FLYNN MARINE PARK: MID-TERM AND LONG-TERM COASTAL RESILIENCE SOLUTIONS

We examined two alignment alternatives for the Raymond L. Flynn Marine Park and Reserved Channel:

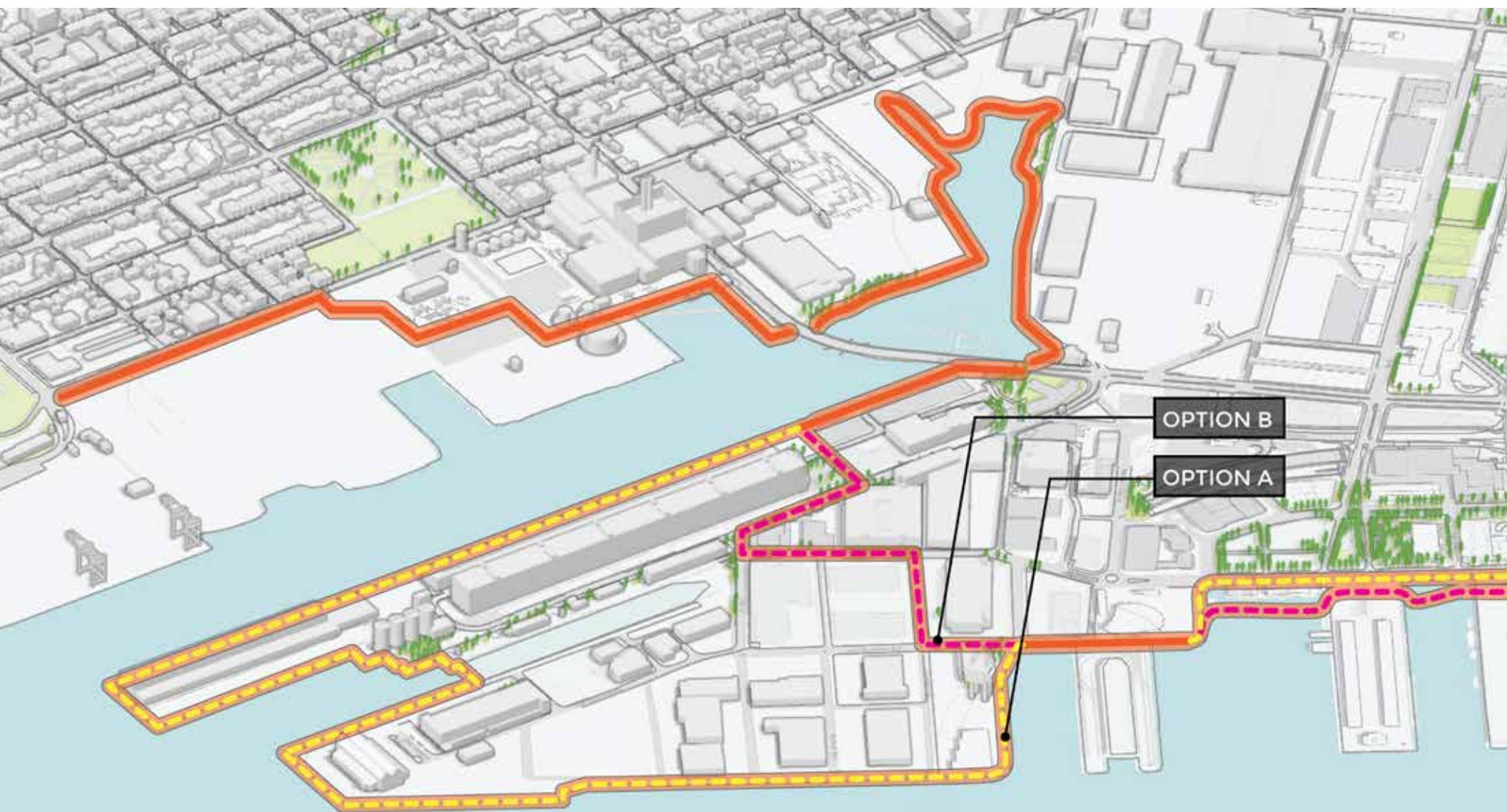
Option A. Flood protection along the perimeter of the Raymond L. Flynn Marine Park and Reserved Channel

Option B. Flood protection interior to the Marine Park

For each option, there are minor variations possible for the alignments, and for each alignment, there are multiple technical approach options and a variety of possible design concepts.

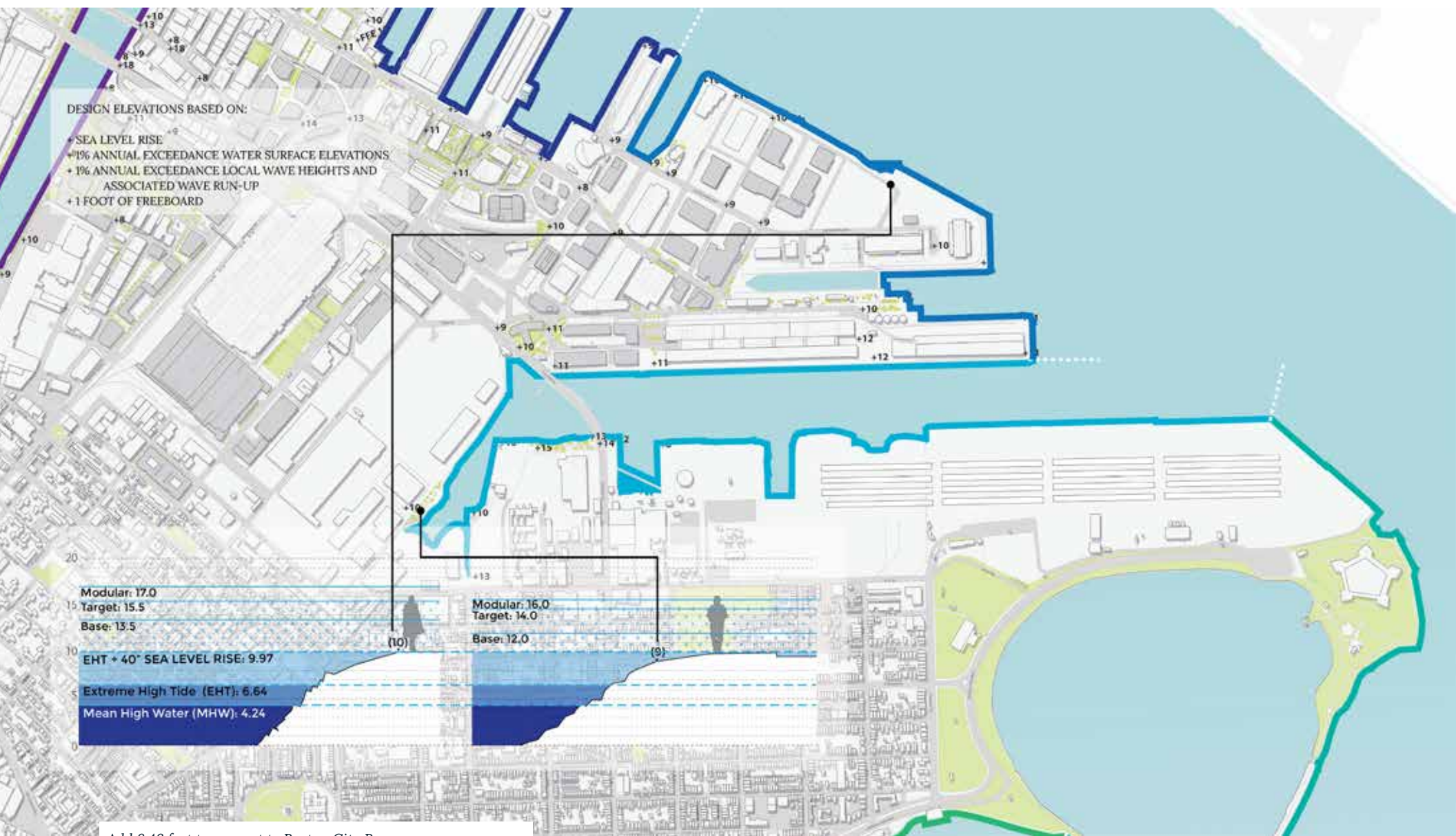
EFFECTIVENESS

The effectiveness of both options is limited in the long-term by flood pathways generated from other parts of the district; flood pathways originating in the Seaport Boulevard area could connect with Raymond L. Flynn Marine Park and Reserved Channel flood pathways with 9 inches of sea level rise, or a low probability flood event now. The effectiveness of Option B largely depends on individual building floodproofing on the water side of the solution. Option A may be the most effective for the large portion of the Raymond L. Flynn Marine Park that would otherwise be at risk to at least monthly flooding with 40 inches of sea level rise.



Option A provides flood protection along the perimeter of the Raymond L. Flynn Marine Park and Option B aligns flood protection along interior roadways to cut off the flood pathway. Option B would require floodproofing and additional adaptive action seaward of the solution.

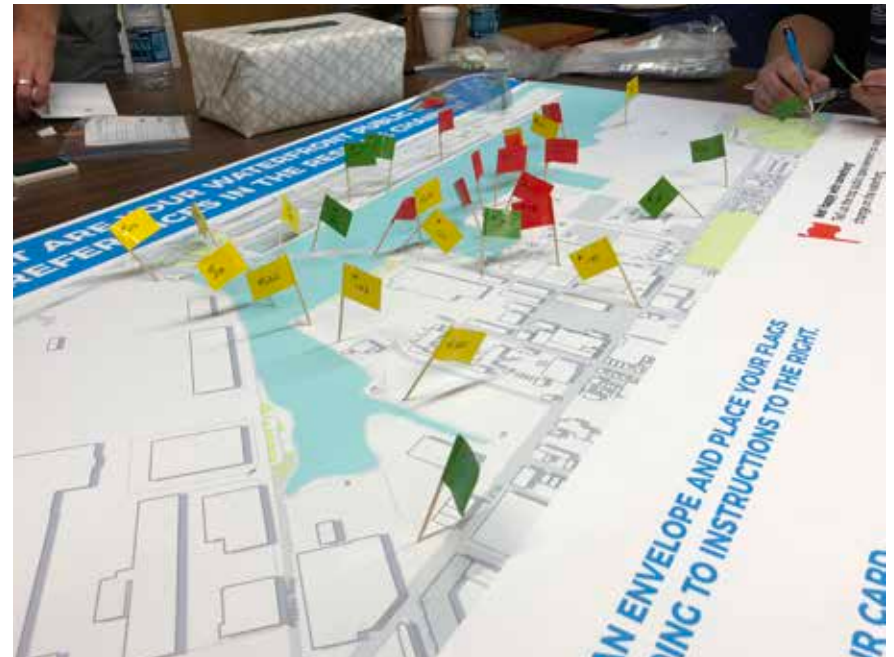
Both options propose a minimum of 14 to 15.5 feet NAVD88, which is the target elevation. This would require actions three to 6 feet above grade, depending on the area.



Add 6.46 feet to convert to Boston City Base

Reduced Exposure and Losses as a Result of Alignment Options A and B

Both options in the Raymond L. Flynn Marine Park and Reserved Channel must be combined with coastal resilience design strategies in other areas to be effective to the 1-percent annual chance flood elevation with 9 inches of sea level rise and beyond. No structure exposure is detected without sea level rise. Due to the low-lying land in the area, coastal resilience design strategies can be flanked by flood pathways originating in other parts of South Boston, including Seaport Boulevard first, then South Boston Waterfront. With 21 inches of sea level rise, coastal resilience design strategies in this area must also be combined with actions in Fort Point Channel in order to maintain effectiveness inland. More analysis is required to determine exactly how water is expected to flow overland and how much independent protection could be provided within the Marine Industrial Park and Reserved Channel areas.



Attendees at the December Open House offered feedback via interactive input stations, which allowed them to write comments about what they like, dislike, and want to see in the public realm.

ALIGNMENT OPTION A. FLOOD PROTECTION OPTIONS AT THE SHORELINE OF THE MARINE PARK

Option A includes a perimeter water’s edge solution (e.g., flood wall, sea wall, stepped access) to prevent flooding within the Raymond L. Flynn Marine Park.




































Principal causes of future design cost variation could include:

- » Whether the flood protection alignment occurs on existing land or within the water
- » Whether the structure is a wall or earthen feature
- » Ship to shore connections
- » The number of penetrations of the protection feature (for example, requiring flap gates or surface openings with closeable flood gates)

Current unknowns include:

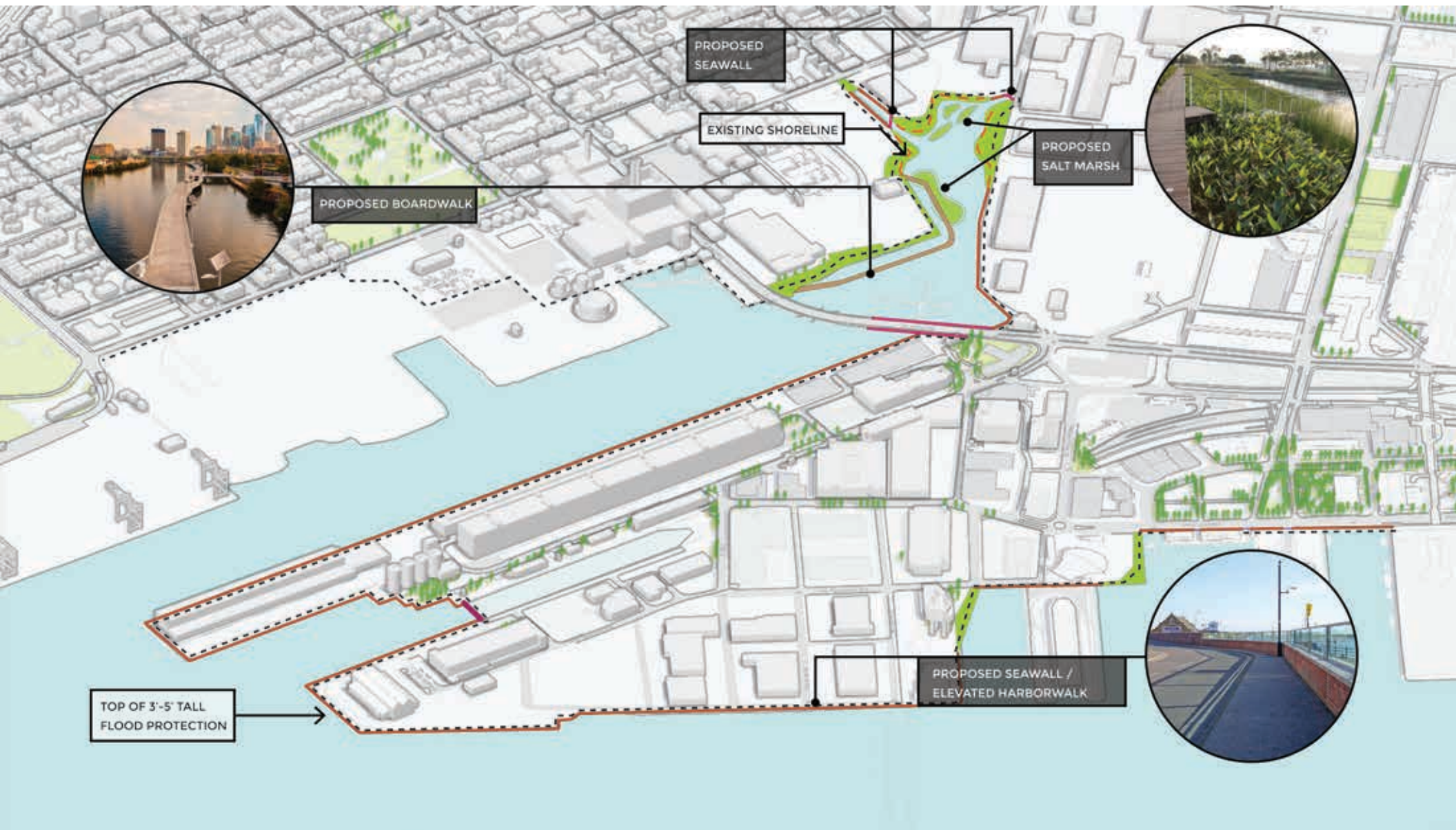
- » The number, type, and condition of existing outfalls along shoreline
- » The number, type, and condition of buried subsurface utilities (electric, gas, stormwater, wastewater, fiber, etc.)
- » Subsurface soil permeability conditions and the necessity for seepage cutoff measures such as sheeting, grout walls, or other treatments

EVALUATION CRITERIA PERFORMANCE

EFFECTIVENESS					
ENVIRONMENTAL IMPACT					
DESIGN LIFE AND ADAPTABILITY					
FEASIBILITY					
EQUITY					
SOCIAL IMPACT					
VALUE CREATION					

KEY CONSIDERATIONS:

- » Careful design is required to avoid disruption of current and planned waterfront uses
- » Potential operational disruption during construction of the flood protection solutions
- » Can be designed to address 40 inches of sea level rise now and may be adapted to address higher flooding later



Design concept prototypes for flood protection alignment option along the shoreline of the Marine Park.

ALIGNMENT OPTION B. FLOOD PROTECTION OPTIONS INTERIOR TO THE MARINE PARK

Option B involves installing a flood protection solution along the interior roadway to prevent flood pathways to the rest of the district. This solution requires individual protection of the properties on the water side of the solution. This solution could be accomplished in two different ways, presented as sub-option B1 and sub-option B2.

B1: Interior floodwall along sidewalk or roadway with self-closing or manual gates at intersections.

B2: Elevated roadway, sidewalk or both, with sloped elevation change of roadway intersections.

This area poses the highest potential floodproofing costs across all subareas of the study. Should floodproofing of existing buildings be considered, it would add an additional \$291 to \$335 million to individually floodproof over 20 buildings in the Raymond L. Flynn Marine Park area. Additional operations and maintenance costs would range from \$4.3– \$5.1 million per year.

Principal causes of cost variation include:

- » Sub-option choice
- » Inclusion of floodproofing cost to project

EVALUATION CRITERIA PERFORMANCE

EFFECTIVENESS



ENVIRONMENTAL IMPACT



DESIGN LIFE AND ADAPTABILITY



FEASIBILITY



EQUITY



SOCIAL IMPACT



VALUE CREATION

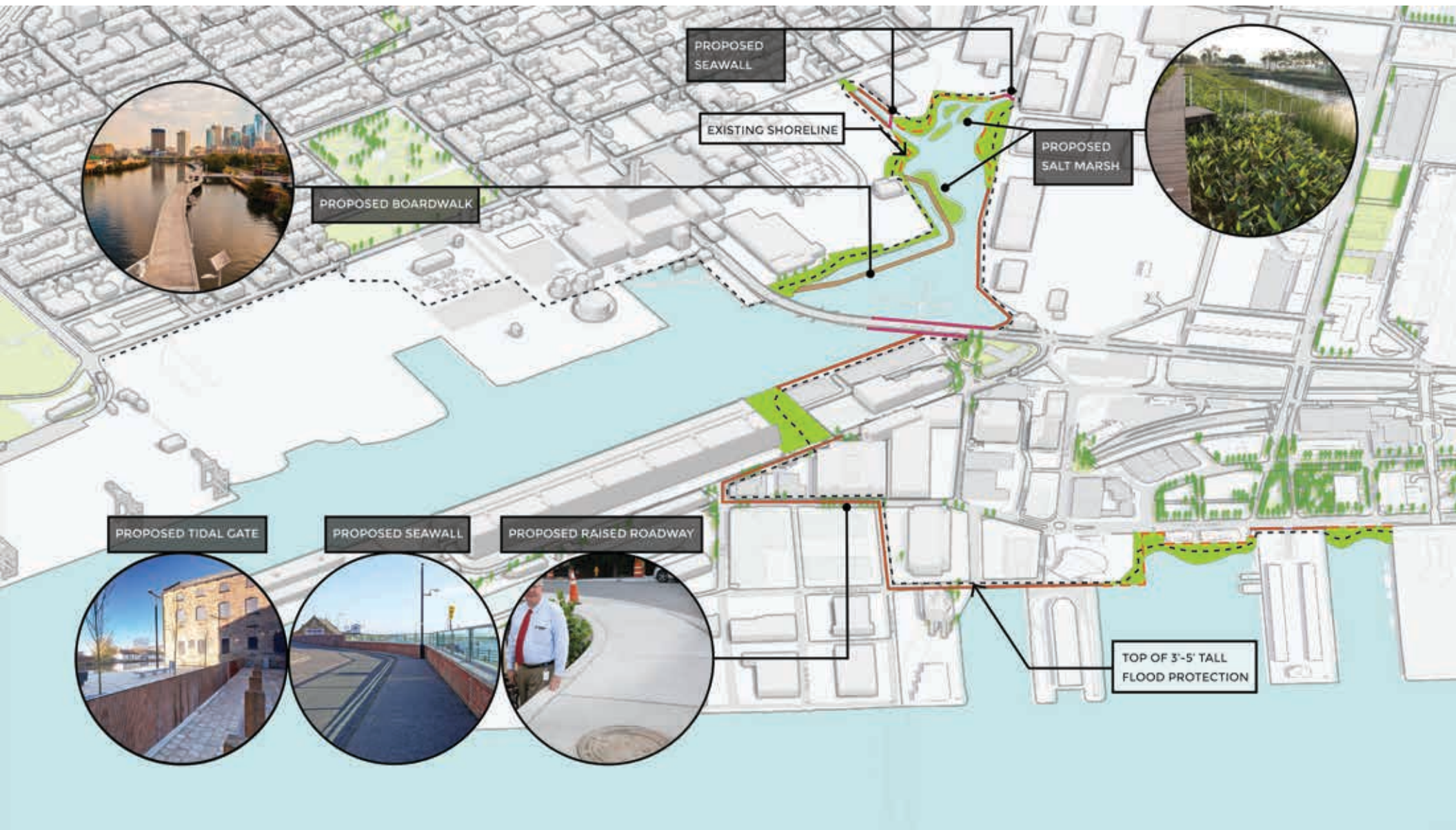


KEY CONSIDERATIONS:

- » Potential points of failure if gates used to accommodate exit from area
- » Potential for significant operational disruption to the area during construction and/or additional accommodations on nearby properties likely to be required
- » Alternate actions would be needed to protect land uses on water side of the solution

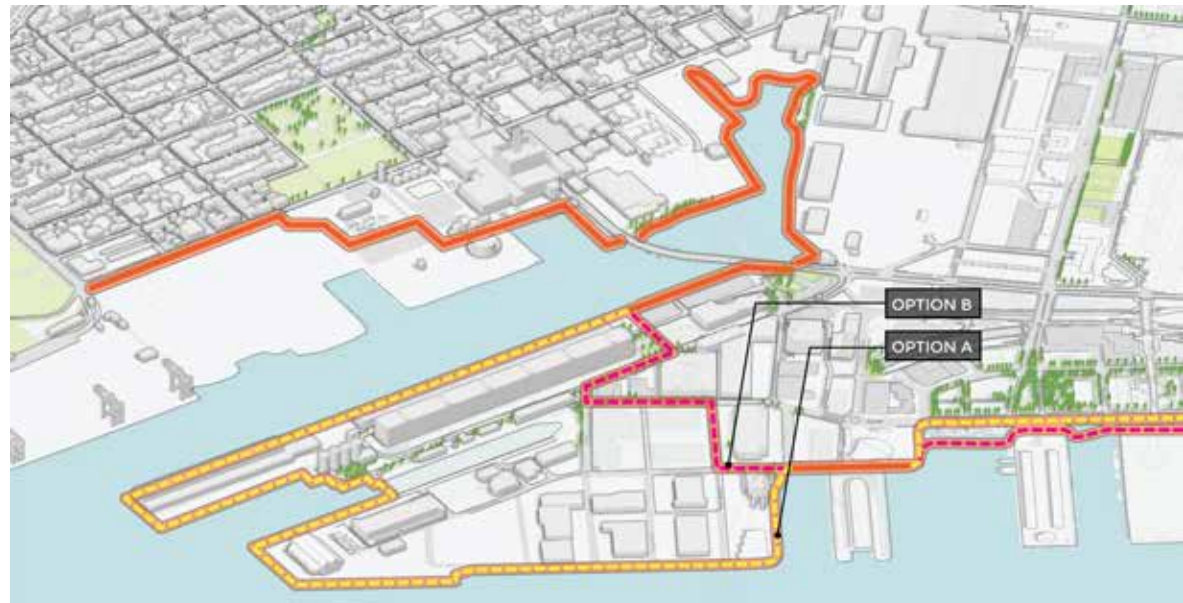
Principal factors that contribute to cost uncertainty include:

- » The number, type, and condition of existing outfalls along shoreline
- » The number, type, and condition of buried subsurface utilities (electric, gas, stormwater, wastewater, fiber, etc.)
- » Subsurface soil permeability conditions and the necessity for seepage cutoff measures such as sheeting, grout walls, or other treatments
- » Ability to permit in-water construction and the presence of contaminated soils
- » Availability of materials and labor and material costs



Design concept prototypes for flood protection alignment option along the shoreline of the Marine Park.

COMPARING ALIGNMENT OPTIONS



OPTION A

Option A provides flood protection along the *perimeter* of the Raymond L. Flynn Marine Park and Reserved Channel.

OPTION B

Option B aligns flood protection along roadways *interior to* the Marine Park to cut off the flood pathway. Option B would require floodproofing and additional adaptive action seaward of the solution.

Alignment Option Comparison Across Evaluation Criteria

CRITERION	COMPARISON	CRITERION	COMPARISON
EFFECTIVENESS	Option B requires elevated roadways or mechanical gates, and floodproofing of buildings (both existing and future) to be effective. Option A can be designed to be passive and effective for all properties in this area, which would require significantly more utility relocation to provide for elevated roadways.	ENVIRONMENTAL BENEFITS	Both options will face similar regulatory constraints. Given the industrial nature of the area, environmental impact during construction (potentially contaminated soils, etc.) will be a large consideration.
FEASIBILITY	Both flood protection options are common. Option B would require more specialized engineering and significant coordination with utilities/infrastructure operations and maintenance teams. The up-front investment required for Option B may be a challenge. Option B also leaves properties in front of the implemented solution to floodproof individually.	SOCIAL IMPACT	Option A will provide optional aesthetic benefits, whereas this is unlikely to be integrated into Option B's design. Additionally, Option B could potentially complicate existing uses in the area.
DESIGN LIFE AND ADAPTABILITY	Option A could be effective sooner, as it is possible to implement it incrementally, and will remain effective for longer without significant investment to adapt to higher sea levels. Option B cannot be designed for higher sea levels, as closure of gates for regular tidal inundation will shut down areas of the Marine Park too frequently to be feasible.	EQUITY	Option B will adversely affect operations during construction and will leave buildings seaward of the alignment, leading to less equitable distribution of benefits within the project area.
		VALUE CREATION	Neither option is expected to add or decrease the value of the area, though design could be integrated into Option A that could increase value.

SOUTH BOSTON NEIGHBORHOOD

“The relative safety of these older landmarks reflects the history of our city: transformed through centuries of landfill, the original islands and peninsula of the city remain higher and more protected than areas built on filled tidelands. Comparison of Boston’s original landforms to the 1-percent annual chance floodplain late in the century shows a close parallel; large portions of the original landforms in ... South Boston remain out of the coastal floodplain even late in the century while areas that were filled over time are at higher risk of flooding from coastal storms.”

– Climate Ready Boston



Photo Credit: Sswonk via Wikimedia Commons



Photo Credit: Compass Real Estate



Photo Credit: Robert Linsdell via Wikimedia Commons



Photo Credit: Arnold Reinhold via Wikimedia Commons

Due to its elevated topography, the interior of the South Boston neighborhood is not at significant risk from storm or tidal flooding events this century.

The areas of greatest risk lie along the waterfront adjacent to Day Boulevard and Pleasure Bay, though they do not contain a major flood pathway that threatens inland areas.

The majority of the land along the waterfront of the South Boston neighborhood is owned by governmental entities, most notably the

Massachusetts Department of Conservation and Recreation (DCR). DCR is the primary landowner and operator of the waterfront park and public spaces in Pleasure Bay and along Day Boulevard, the areas at risk to coastal flooding by the 2040s. Coastal resilience measures in these areas will mitigate risk to homes along the waterfront.



Pleasure Bay and Castle Island are important assets to South Boston. Pleasure Bay, immediately adjacent to the 60 acres of container storage at Massport's Conley Terminal, connects with popular beaches and a Harborwalk along Day Boulevard, which end at Moakley Park.

The South Boston Neighborhood, itself, is predominantly residential, and has seen development pressure as a result of the growth along the waterfront in recent years.



Photo Credit: Doc Searls via Wikimedia Commons



The South Boston neighborhood was settled on high ground in the 18th century. For this reason, the residential neighborhood is at a much lower flood risk than the rest of South Boston.

FLOOD RISK

Due to the sharp rise in topography, most areas along Day Boulevard will not suffer significantly different flooding extents from high tides between the present day and 2070. A small number of areas are expected to have a 1-percent annual chance of flooding with 9 inches of sea level rise. With 40 inches of sea level rise, all of the South Boston neighborhood waterfront areas would be flooded from the 1-percent annual chance flood elevation, including Castle Island State Park, the Marine Park adjacent to Pleasure Bay, and Day Boulevard and Columbia Road. This flooding may affect the first rows of houses along the waterfront, but will not spread further inland.

Despite the limited pathways in the South Boston neighborhood, over 600 people and close to 200 buildings are located in the area that could be inundated by the 1-percent annual chance flood elevation with 40 inches of sea level rise (2070s). Without action, the South Boston Neighborhood risks \$75 million in direct physical damage to structures and relocation costs from the same flood elevation. These costs do not include the long term costs associated with the risk to important community assets such as Pleasure Bay and the Day Boulevard beaches.

The South Boston historic residential neighborhood has the only high ground in the area and can expect increased development pressure over time with sea level rise.

A flood pathway opens up between Conley Terminal and Marine Park late in the century. Because there is very little flood risk from this area to adjacent residential properties, we did not evaluate flood risk nor flood protection options for this area

By the 2040s, the South Boston neighborhood faces risk to public amenities at Pleasure Bay, and the beaches along Day Boulevard. In the long term, without action, this flood risk will begin to affect the properties nearest the shore.





“Castle Island is awesome and is part of what makes Boston a world-class city.”

- South Boston resident

“Love the Harborwalk. Make sure it is our “dryline” as sea level rises.”

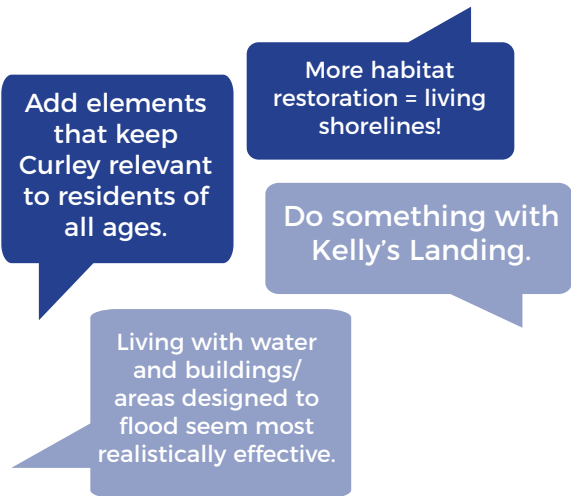
- South Boston resident

ENGAGEMENT FEEDBACK

Residents in the South Boston neighborhood were supportive of public waterfront adaptations that would allow for strong, continued connection to the water. Much of the public space in the neighborhood is along the waterfront. Stakeholders understand that changes in sea level could change waterfront connectivity.

Residents preferred natural features, such as beaches, to hardened features, such as seawalls. Nonetheless, they are open to integration of public amenities and overlooks into hardened features. One example could be an elevated harbor walk, whose base also serves as a seawall.

Many residents expressed concerns about flood risk to affordable housing, parks and open space, and transportation. An equally frequent theme was the concern about potential accelerated displacement. 128 survey respondents reported living in the South Boston neighborhood.



Feedback for South Boston Neighborhood

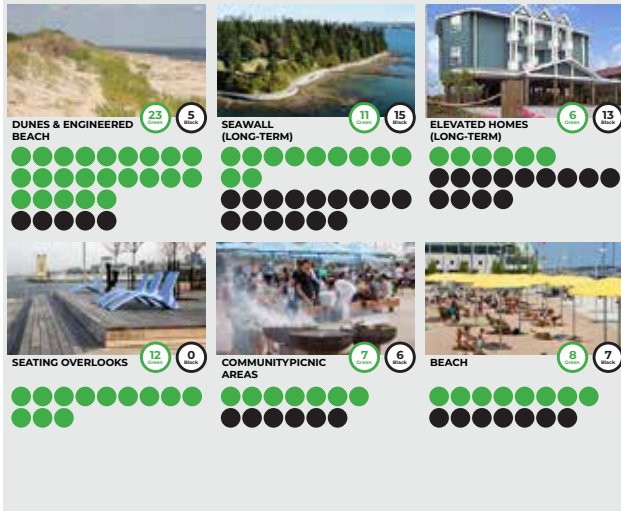
A survey question asked “As a resident, what are your priorities for improvements to these areas?” The top three priorities for the South Boston neighborhood: 1) Transportation 2) Parking 3) Parks & Open Space.

SOUTH BOSTON NEIGHBORHOOD

WHICH FLOOD PROTECTION ELEMENTS AND AMENITIES DO YOU PREFER?

● = Want

● = Do Not Want



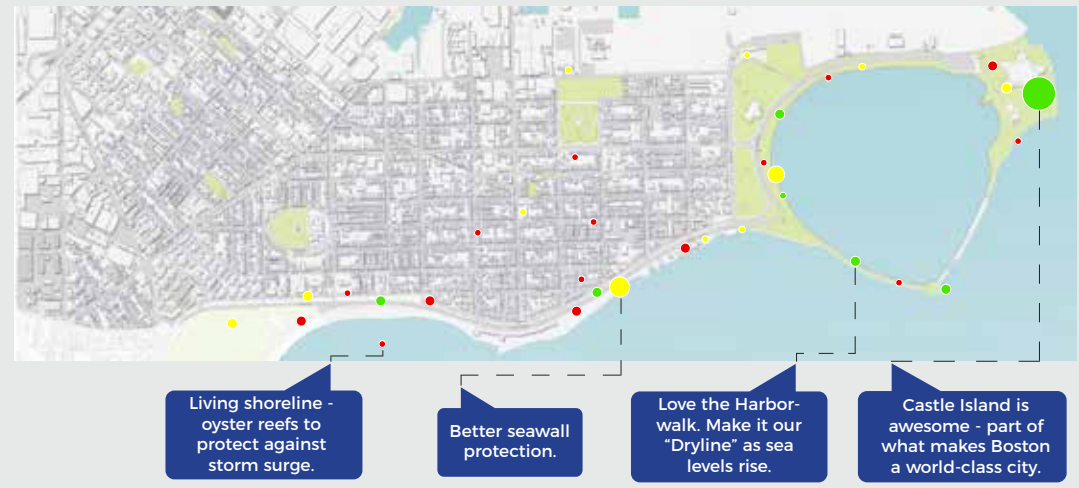
WHAT ARE YOUR WATERFRONT PUBLIC SPACE PREFERENCES?

● = something you love

● = something you want to change

● = something you want to add

*Larger circle size denotes clustering of public comments



Open house summary for South Boston Neighborhood 12/11/17

COMMENTS

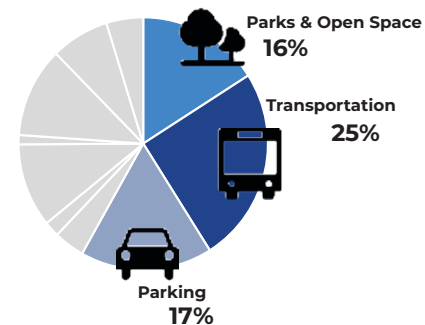
Open Pleasure Bay for boats/ferries to Rose Wharf, Logan, Winthrop, UMass Boston, and Marina Bay.

Connect Carson Beach to Moakley Park, recreate dune ecosystem and awesome park that protects inland.

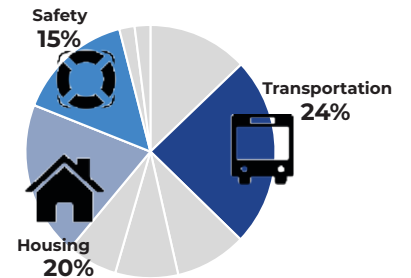
PRIORITIES

Respondents were asked to choose up to two top priorities for improvement. The following pie chart percentages indicate top categories selected for the South Boston Neighborhood.

RESIDENT PRIORITIES



NON-RESIDENT PRIORITIES



Online Survey Results for South Boston Neighborhood, 9/28/17 - 12/31/17

Estimated Costs for Alignment Option A and B

OPTION A

ESTIMATED COST	\$210 million - \$243 million
ESTIMATED MAINTENANCE COST	\$3.2 million - \$3.6 million per year*

* Maintenance costs are expected to be 1.5 percent of the total cost to implement the solution.

OPTION B

ESTIMATED COST	\$260 million - 299 million
ESTIMATED MAINTENANCE COST	\$3.9 million - \$4.5 million per year*

* Maintenance costs are expected to be 1.5 percent of the total cost to implement the solution.

MID-TERM COASTAL RESILIENCE SOLUTIONS

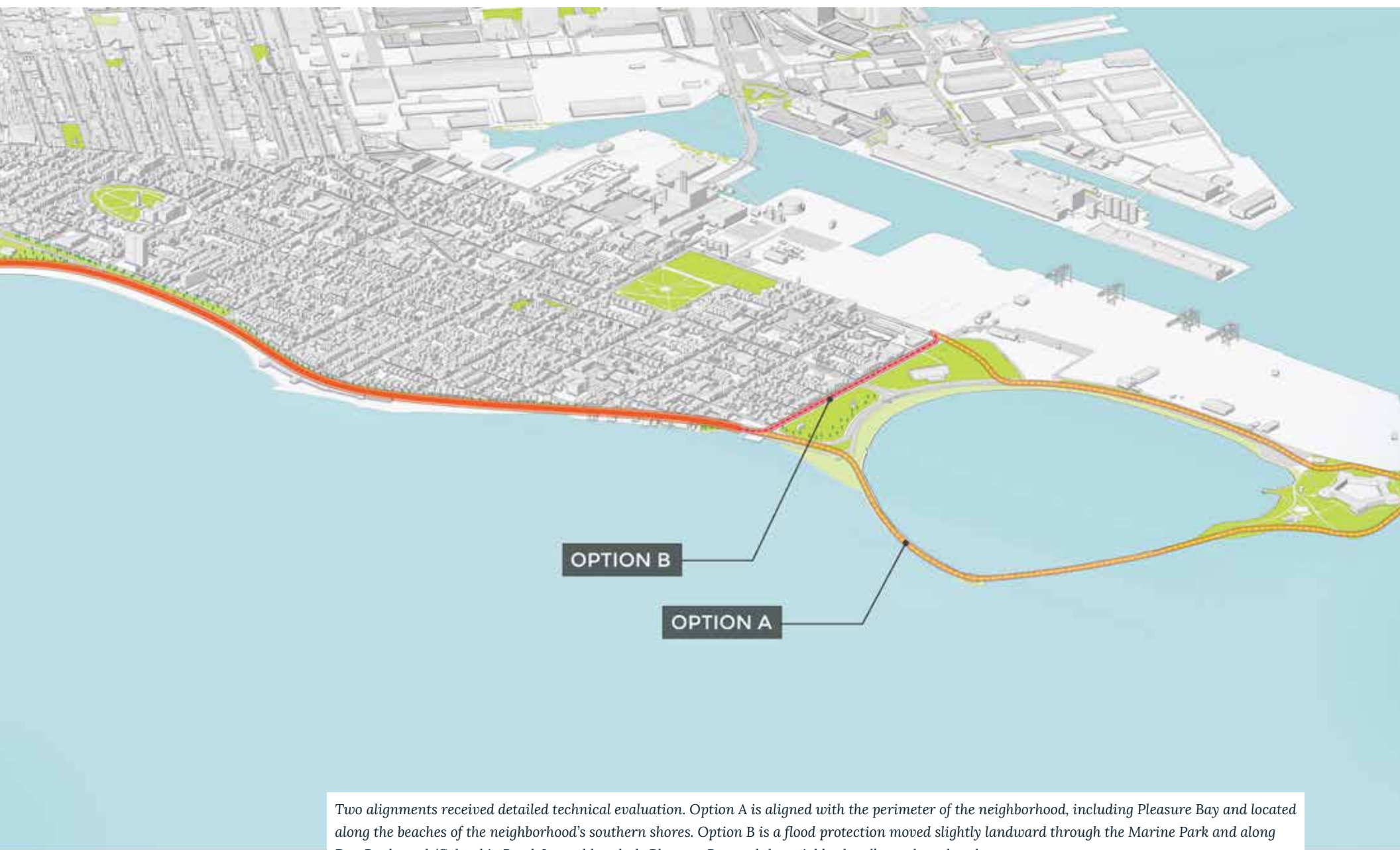
As noted in the Coastal Resilience Solutions section of the Context and Approach chapter, technical elements were combined to form coastal flood protection alternatives for the near-, mid-, and long-term. We examined two practical alignment alternatives for the South Boston neighborhood. For each option, there are minor variations possible for the alignments, and for each alignment, there are multiple technical approach options and a variety of design concepts.

Option A is characterized by coastal hardening, and involves perimeter protection at Pleasure Bay and a floodwall / raised Harborwalk at Day Boulevard.

By the 2040s, resilient coastal design in the South Boston neighborhood focuses on retention of beaches and park space in Pleasure Bay. In the long term, actions taken to protect beaches and the Harborwalk along Day Boulevard could form a layer of protection for properties just north of the beaches. Action may be necessary to harden individual structures mid- to late-century as a second line of defense.

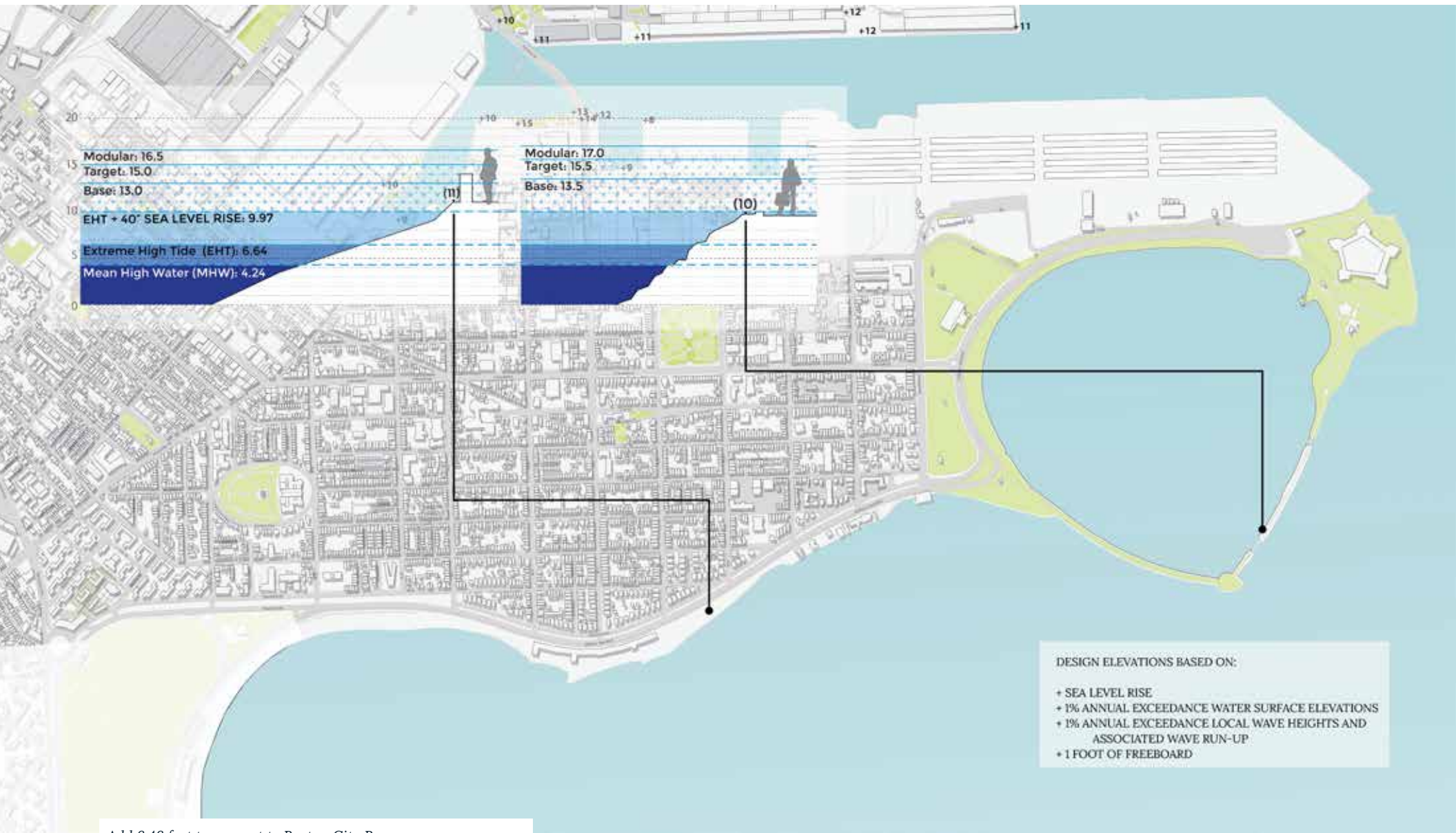
Option B is characterized by coastal restoration and inland flood protection, and involves beach nourishment and Farragut Road park elevation.

Options for Pleasure Bay and Day Boulevard have been combined for simplicity and due to similarities in the options. It is feasible for Option A for Pleasure Bay to be combined with Option B for Day Boulevard and vice versa.



Two alignments received detailed technical evaluation. Option A is aligned with the perimeter of the neighborhood, including Pleasure Bay and located along the beaches of the neighborhood's southern shores. Option B is a flood protection moved slightly landward through the Marine Park and along Day Boulevard/Columbia Road. It would exclude Pleasure Bay and the neighborhood's southern beaches.

Both options propose 15 to 15.5 feet NAVD88 design elevations, which require varying heights above grade.



EFFECTIVENESS

This neighborhood sees relatively lower risk than other areas and has no flood pathways threatening inland areas. The two options are equally effective in reducing risk of displacement and direct physical damage to structures, as well as disruption of transportation. Both alignment alternatives could independently mitigate flooding at or exceeding the 0.1-percent annual chance flood with 40 inches of sea level rise (2070s).

Option A provides increased flood protection of recreational amenities at Pleasure Bay over Option B, while Option B provides increased flood protection of recreational amenities along Day Boulevard over Option A.

Reduced Exposure and Losses as a Result of Alignment Options A and B

The options could equally reduce exposure and expected impacts to the 1-percent annual chance flood elevations with 0, 9, 21, and 40 inches of sea level rise. True effectiveness will depend on design and long term maintenance. With no sea level rise, risk to recreational amenities is the focus of mitigation, as less than \$0.5 million in direct physical damages to structures and their contents and relocation / displacement costs are expected at the 1-percent annual chance elevation. As sea level rise progresses, however, mitigation of risk to people and structures increases. For example, with 40 inches of sea level rise, coastal resilience design strategies in South Boston neighborhood could mitigate risk to 625 people currently living in the area, 130 buildings, and \$75 million in direct physical damage and relocation / displacement costs due to flooding of structures and their contents at the 1-percent annual chance flood elevation. Loss of recreational and cultural amenities in the area have not been quantified.




































ALIGNMENT OPTION A. COASTAL HARDENING: PERIMETER PROTECTION AT PLEASURE BAY AND FLOODWALL / RAISED HARBORWALK AT DAY BOULEVARD

Shoreline strategies include elevated harborwalk floodwall, earthen berms, and open park space whenever possible. The existing Harborwalk includes areas around Pleasure Bay and along Day Boulevard in close proximity to buildings such as Fort Independence, the Marine Park ice rink, the South Boston and Columbia Yacht clubs, as well as the Curley Community Center. Placing protection features in close proximity to these structures will require close coordination with stakeholders and the community.

Principal causes of cost variation include:

- » Whether the flood protection alignment occurs on existing land or within the water
- » Whether the structure is a wall or earthen feature
- » The number of penetrations of the protection feature (for example, outfalls requiring flap gates or surface openings with closeable flood gates)

EVALUATION CRITERIA PERFORMANCE

EFFECTIVENESS					
ENVIRONMENTAL IMPACT					
DESIGN LIFE AND ADAPTABILITY					
FEASIBILITY					
EQUITY					
SOCIAL IMPACT					
VALUE CREATION					

The difference between the existing elevation and the target elevation could affect the final cost. Principal factors that contribute to cost uncertainty at this stage of conceptual design include:

- » The number, type, and condition of existing outfalls along the alignment
- » The number, type, and condition of buried subsurface utilities (electric, gas, stormwater, wastewater, fiber, etc.)

KEY CONSIDERATIONS:

- » Potential water quality concerns in Pleasure Bay that could be mitigated through design
- » Potential loss of beach over time without additional adaptation measures
- » Expanded Harborwalk around Pleasure Bay
- » Reconfiguration of Columbia Road and Day Boulevard to enable construction of flood protection features.

- » Subsurface soil permeability conditions and the necessity for seepage cutoff measures such as sheeting, grout walls, or other treatments
- » Ability to permit in-water construction and the presence of contaminated soils
- » Availability of materials and labor and material costs



Option A includes perimeter protection of South Boston along Pleasure Bay and the seashore along Day Boulevard. Coastal adaptations would include elevating the Harborwalk along its current path or routing the line of protection down the right-of-way of Day boulevard/Columbia Road. It also would include converting the concrete wall along the southern edge of the Conley Terminal to a flood wall.




































ALIGNMENT OPTION B. COASTAL RESTORATION AND INLAND FLOOD PROTECTION: BEACH NOURISHMENT AND FARRAGUT ROAD PARK ELEVATION

Shoreline strategies are varied and include replenished beaches with engineered dunes, earthen berms, open park space, seawalls, and elevated roadway, floodproofed buildings, and reinforced flood walls in isolated areas. In some areas, the strategy would install the line of protection further inland, such as along Farragut Road. In other cases, the strategy would construct the flood protection seaward of the existing beach, such as along Day Boulevard. The existing Harborwalk includes areas along Day Boulevard in close proximity to buildings such as the South Boston and Columbia Yacht clubs, as well as the Curley Community Center. Strategies to situate protection features in close proximity to these structures will require close coordination with stakeholders and the community. This alignment would travel through and reconfigure the Marine Park and would require floodproofing of the ice rink within the park.

Principal causes of cost variation include:

- » Whether the flood protection alignment occurs on existing land or within the water
- » Beach-quality sediment availability in proximity to the site

EVALUATION CRITERIA PERFORMANCE

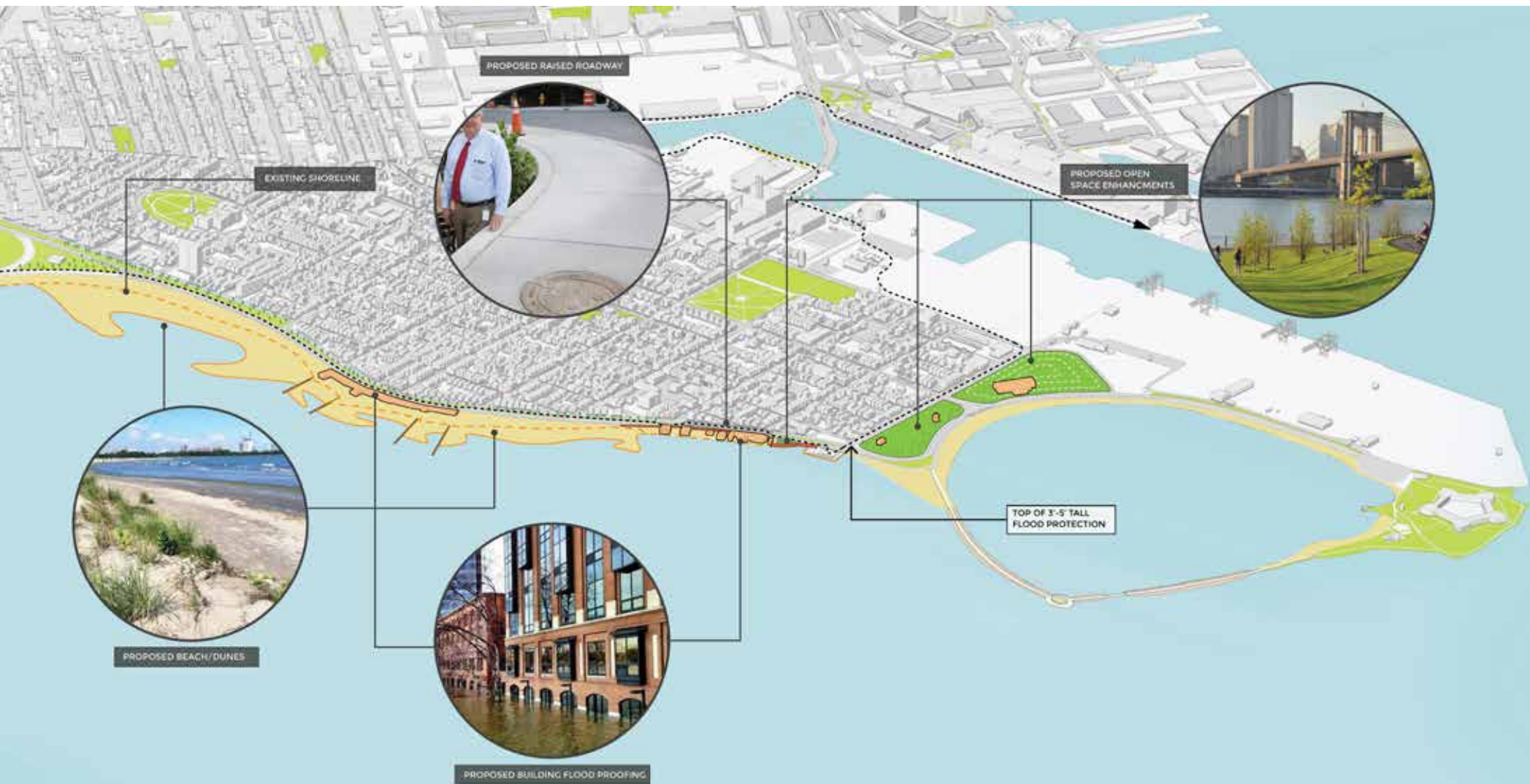
EFFECTIVENESS					
ENVIRONMENTAL IMPACT					
DESIGN LIFE AND ADAPTABILITY					
FEASIBILITY					
EQUITY					
SOCIAL IMPACT					
VALUE CREATION					

- » Whether the structure is a wall or earthen feature
 - » The number of penetrations of the protection feature (for example, outfalls requiring flap gates or surface openings with closeable flood gates)
- The difference between the existing elevation and the target elevation could affect the final cost. Principal factors that contribute to cost uncertainty at this stage of conceptual design include:
- » The number, type, and condition of existing outfalls along the alignment

KEY CONSIDERATIONS:

- » Increased maintenance costs over time for beach replenishment
- » Alignment bypassing of Pleasure Bay
- » Complexity associated with permitting beach nourishment
- » Converting the beach to an engineered beach would increase federal funding eligibility for restoration post-disaster

- » The number, type, and condition of buried subsurface utilities (electric, gas, stormwater, wastewater, fiber, etc.)
- » Subsurface soil permeability conditions and the necessity for seepage cutoff measures such as sheeting, grout walls, or other treatments
- » Ability to permit in-water construction and the presence of contaminated soils
- » Availability of materials and labor and material costs



Option B includes berm adaptations in the Marine Park along Farragut Road rather than perimeter protection around Pleasure Bay. Along Day Boulevard, Option B would move the line of protection seaward to incorporate restored beach and dune features instead of elevating the Harborwalk.

FEMA provides funding for post-disaster restoration of engineered and regularly nourished and maintained, but not natural beaches. It would be useful for the Commonwealth to conduct a beach nourishment evaluation and develop a master plan for the beaches at Pleasure Bay and along Day Boulevard. Resilient design can be integrated with the engineering of the beach, and could provide the following benefits:

- » *Protect the beach amenities in the case of a storm event*
- » *Support eligibility for federal funding in the case of a presidential disaster declaration.*

Resilient design of the beaches is expected to help mitigate risk to residential property north of Day Boulevard.

POSSIBLE COMBINATION OF LONG-TERM ALIGNMENT ALTERNATIVES

Stakeholders in this area have many options to evaluate and mix and match compared to other areas of the South Boston waterfront. South Boston's southern shores along Day Boulevard are a prime example: there is significant public right-of-way between Columbia Drive and the beach which could be adapted to sea level rise through elevated roadways, Harborwalk, beach renourishment, flood walls, and more. Different combinations of options have not been explored in detail.

Alignment Option Comparison Across Evaluation Criteria

CRITERION	COMPARISON	CRITERION	COMPARISON
EFFECTIVENESS	Option A would protect the shores of Pleasure Bay in addition to all property protected by Option B . Option B would provide protection to the beaches along Day Boulevard, whereas Option A would not. Neither option would rely heavily on mechanical activation of moving features, and the number of structures expected to benefit from the solution is the same.	ENVIRONMENTAL BENEFITS	Both options have regulatory hurdles: Option A would require measures designed such that the health (water quality) of Pleasure Bay be preserved. This could limit the number of times or duration of time Pleasure Bay could be closed off from surrounding waters. Option B would require significant permitting to locate, excavate, and place acceptable sediments to replenish beaches along Day Boulevard.
FEASIBILITY	All features proposed in Options A and B are common, although location, excavation, and placement of beach renourishment sand in Option B could pose significant feasibility risks. Likewise, any reconfiguration of Day Boulevard and Columbia Drive would require significant planning coordination among transportation stakeholders.	SOCIAL IMPACT	The possible recreational, cultural, and aesthetic benefits that could be provided through Option A range from an expanded green space to new seating and educational opportunities not just along the Harborwalk, but along Pleasure Bay. Option B would provide other opportunities such as a revitalized or reimagined community center in the Marine Park, as well as renourished beaches along Day Boulevard.
DESIGN LIFE AND ADAPTABILITY	Both Options would be expected to become effective and remain effective along similar timelines, although Option B would require future beach renourishment activities, limiting effectiveness over time as compared to adaptation features constructed on land.	EQUITY	Both options would provide new and enhanced waterfront access. Neither is anticipated to limited public connectivity, educational opportunities, or community partnerships.
		VALUE CREATION	Both options provide similar enhancements to public waterfront connectivity and recreation while protecting the same area of urban commercial and residential infrastructure.

04 REGULATORY RESILIENCE STRATEGIES



REGULATORY RESILIENCE STRATEGIES

Coastal resilience design strategies have to follow city, state, and federal regulations and policies. Environmental regulations implemented decades ago protect important resources and do not always consider flood protection, or the consequences of warming oceans, sea level rise, or pollution caused by flooding. As our understanding of sea level rise evolves, there is an opportunity to update regulations to include resilience at all scales of development, from individual buildings to neighborhoods, to the whole City, while maintaining the original mission of these regulations (e.g., to protect the environment). Flood protection and environmental protection / restoration are not mutually exclusive. In fact, thoughtful updates to existing regulations could clarify and streamline the permitting processes for proposed resiliency strategies.

Ensuring that federal, state, and city regulations both allow for creative approaches to coastal resilience and establish minimum standards will require action by and coordination among all levels of government. Furthermore, as the City advances specific design solutions, we may discover more flexibility in existing regulations than was initially apparent. The City will continue to collaborate with state and federal jurisdictions on needed regulatory reforms.

Updates to federal, state, and city regulatory mechanisms and planning policies would allow more efficient implementation of the South Boston flood protection strategies. An integrated solution that includes all three layers of coastal resilience design and regulatory solutions will allow South Boston to guide future development and investment that promotes long-term risk reduction and climate change adaptation, while continuing to protect environmental resources and foster economic development.

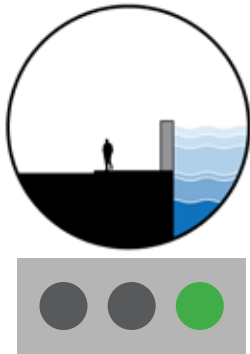
Coastal resilience design strategies in South Boston will require local Conservation Commission approval, state level waterways and water quality approvals, federal permits from the U.S. Army Corps of Engineers (USACE) under the Clean Water Act, and in some cases, Boston Landmarks Commission and Massachusetts Historical Commission approvals.

Constructed ground (placing fill material in the water) and navigational solutions (flood control projects in navigable waters) are the technical approaches with the most significant permitting and regulatory challenges.

PERMITTING COASTAL RESILIENCE DESIGN STRATEGIES

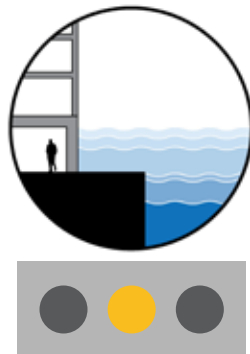
This section summarizes existing permitting requirements and potential challenges in permit approvals for coastal resilience design strategies in South Boston. Following this overview, each permitting pathway is described in greater detail with opportunities to adapt the existing permitting process and allow more effective implementation of climate resilience projects. While this section provides some guidance and suggestions for regulatory challenges to implementing our proposed resilient design strategies, we look forward to working with the Commonwealth on a coordinated approach as many of our proposed actions may be beneficial at a regional level. The Commonwealth's integrated State Hazard Mitigation and Climate Adaptation Plan will include analysis of adaptation strategies and a framework for implementation including needed regulatory or policy revisions. The Commonwealth has already initiated stakeholder discussions on climate change preparedness, including possible regulation reforms. These discussions include developing revisions to Land Subject to Coastal Storm Flowage regulations and associated Chapter 91 regulations.

Expected Regulatory Feasibility. Red, yellow, and green lights indicate whether a technical approach is likely to experience significant, moderate, or little to no difficulty when proceeding through the existing regulatory framework.



1. VERTICAL SEAWALL OPTION: Green light.

Permitting requirements for seawalls vary based on location and the extent to which the proposed solution will increase the height of an existing wall feature, extend the length or width of existing features, or construct a new seawall. A USACE permit, Massachusetts Department of Environmental Protection (MassDEP) waterways license, and a wetlands Order of Conditions are required for construction of new seawalls and for some alterations to existing seawalls. Seawalls must be maintained over time and may require designs that allow for future alterations that increase the height of the seawall. Some of South Boston's seawalls are designated historic landmarks and are within the jurisdiction of the Massachusetts Historical Commission (MassHistoric) and the Boston Landmarks Commission. Replacement of historic seawalls along Fort Point Channel is allowable provided that new seawalls are capped with reclaimed granite.



2. WATERTIGHT BUILDINGS/STRUCTURES: Yellow light.

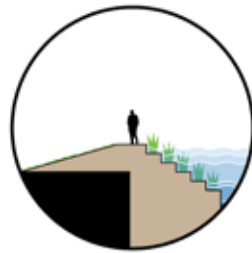
While the Massachusetts Building Code and Boston's Flood Hazard Districts Zoning Code (Article 25) establish a standard for freeboard above base flood elevations, these standards are based on the historic FEMA special flood hazard area designations and fail to account for sea level rise and expected increases in stormwater flow. These codes also allow for wet-floodproofed and dry-floodproofed buildings and non-inhabitable uses on lower floors, but local height restrictions and dimensional requirements unintentionally disincentivize these structural mitigation measures because they would reduce the usable space within the building. As property owners try to maximize use of the property and floor area ratios, structures could be subject to height limitations or additional fire/safety code requirements for taller buildings. Reliance on watertight buildings would likely require incentives to design beyond the requirements of the existing building code. The Board of Building Regulation and Standards (BBRS) and the Boston Planning and Development Agency (BPDA) should be flexible to minimize disincentives for using higher design elevations. MassDEP is developing an approach to grant relief to height restrictions when increases in height are necessary to adopt climate resiliency measures.

Structural floodproofing is encouraged in addition to shoreline solutions to provide multiple layers of flood protection. Flood levels may exceed shoreline solutions. Buildings with floodproofing measures are provided additional flood protection benefits in case shoreline solutions fail or if stormwater flooding presents a threat.



3. RAISED HARBORWALK/PARK SPACE OVER EXISTING LAND: Green light.

Raising the existing harborwalk, creating park space, and incorporating berms or flood storage are permissible activities under existing regulations if those measures are constructed over existing land or fill.



4. CONSTRUCTED GROUND (NEW FILL IN THE WATER): Red light.

While flood protection is a water-dependent use under Chapter 91 regulations, large fill-based flood protection solutions that extend into the Boston Harbor or Fort Point Channel are more challenging to permit. Chapter 91 categorical restrictions require minimizing the amount of fill below the high water mark, and the USACE must determine that the solution is the “least environmentally damaging practicable alternative.” Existing USACE criteria discourages the proposed constructed ground solutions and point to landward solutions as less environmentally damaging. Fill projects will also require a variance under the wetlands regulations and mitigation for the filled wetlands resources. It is not clear if an Order of Conditions could be achieved for the large-scale projects proposed, and if approved, the mitigation requirements could be cost-prohibitive.

During the construction of the Central Artery / Tunnel Project large quantities of soil excavated for the tunnel were placed in Fort Point Channel and around Spectacle Island. These fill projects obtained the necessary Chapter 91, USACE, and wetlands permits and approvals.



5. TRANSPORTATION/NAVIGATION: Yellow light.

Existing regulations allow for non-fill based construction projects over the water, as well as navigational tide gates, but require considerable time-intensive review including sediment transport impacts, HarborMasters regulations, water circulation, and fish and boat navigation.

Opportunities to increase resilience. The following table summarizes the challenges and opportunities present in specific regulations and permits needed to implement coastal resilience design strategies. The sections following the table present the challenges and potential solutions in greater detail.

Agency and Regulation	Challenge	Applicable Coastal Toolkit Option	Regulatory Solution Options
Massachusetts Department of Environmental Protection (MassDEP) - Waterways	Categorical restrictions on fill and certain engineering and construction standards could limit options in space-constrained areas of South Boston	Constructed Ground	<ul style="list-style-type: none"> » Update categorical restrictions on fill to define extent and type of flood control fill projects that can gain approval » Define the types of flood control projects that qualify as water dependent uses to include constructed ground (fill) that provides public access to the water » Use maintenance of fill as a permit requirement and tool to address future overtopping and erosion
MassDEP - Wetlands	<ul style="list-style-type: none"> » Impacts to wetlands resources and mitigation requirements present permitting challenges for large-scale fill projects » Wetlands regulations rely on historic FEMA maps to identify land subject to coastal flooding and do not consider changes to flood levels as sea level rise progresses 	Modification of policy/regulatory framework recommended to implement project	<ul style="list-style-type: none"> » Update state wetlands regulations to address coastal fill-based flood resilience projects when the flood protection, erosion or pollution prevention benefits outweigh the impact on wetlands resources » Develop guidelines and specific review and approval criteria for coastal fill-based flood mitigation projects. Criteria may include: <ul style="list-style-type: none"> » Conversion of land under water to new marshes or living shorelines » Creation of new wetlands or flood storage areas on new filled land » Long-term viability of living shorelines » Remediation of contaminated sediment, or response to loss of marshes or coastal banks as sea level rises by replication in new locations » Provide incentives through reduction of fill mitigation requirements for projects that provide multiple public benefits, including environmental benefits

Agency and Regulation	Challenge	Applicable Coastal Toolkit Option	Regulatory Solution Options
MassDEP – Wetlands and U.S. Army Corps of Engineers (USACE)	Large scale fill projects and construction in water are difficult to justify through permitting when there are feasible options that use existing land	Constructed Ground Transportation / Navigation	<ul style="list-style-type: none"> » Develop coordinated guidelines that designate new wetlands, habitat creation, stormwater retention, pollution prevention measures on the constructed land to be fill mitigation measures acceptable to Conservation Commission, MassDEP, and USACE » Include public access and adaptability to sea level rise as evaluation criteria in future “least environmentally damaging practicable alternative” determinations
MA Board of Building Regulations and Standards (BBRS)	Building Code relies on historic FEMA maps to address changing flood risk	Watertight buildings/ structures	<ul style="list-style-type: none"> » Update the State Building Code with references to Climate Ready flood maps and design requirements that address changing flood risk » Revise State Building Code standards for elevated first floors in updated flood zones » Require wet floodproofing and dry floodproofing of space below the base flood elevation using 40 inches of sea level rise » Update standards to address extreme heat, cold, and wind conditions » Develop guidelines for meeting accessibility standards at structures elevated above 40-inch base flood elevation
Boston Planning and Development Agency (BPDA)	Flood Overlay Zoning requirements rely on historic FEMA maps and building code requirements	Constructed Ground Watertight buildings/ structures	<ul style="list-style-type: none"> » Develop Climate Ready zoning that establishes use and dimensional requirements and design guidelines based on anticipated flood levels » Use overlays to promote district wide zoning solutions
Boston Planning and Development Agency (BPDA)	<ul style="list-style-type: none"> » Changes to federal and state regulations to incorporate climate resilience will be needed for South Boston flood risk urgency » As changes are made to federal and state regulations, update local ordinances for consistency. 	Constructed Ground Transportation/ Navigational Watertight buildings/ structures	<ul style="list-style-type: none"> » Use conditional permits or flexible design incentives (e.g., Art. 80) in the City Zoning Code to elevate buildings, floodproof structures, provide greater on-site stormwater retention, and protect against flooding, extreme storms, heat and wind » Establish flood resiliency as an overriding public interest in City ordinances and zoning code to facilitate flexibility in Chapter 91 and Wetlands Regulations » Develop or revise the Municipal Harbor Plans to address flood protection projects

REGULATORY RESILIENCE STRATEGIES

South Boston regulatory resilience strategies will:

- » Establish consistent guidelines and standards for development of district scale flood protection projects. Formal guidance and standards will expedite project design and simplify permitting
- » Incorporate the best available information on future conditions as it is introduced
- » Consider the fundamental interest of local, state and federal agencies in protecting health, safety, and welfare through flood protection
- » Balance potential externalities of fill-based flood protection projects with value added by the proposed solutions. Value added may include, for example:
 - Creation of new or enhanced habitat or open space and other public amenities
 - Reduced stormwater runoff
 - Prevention of storm damage
 - Reduced shoreline erosion
 - Prevention of environmental contamination

STATE REGULATORY RESILIENCE STRATEGIES

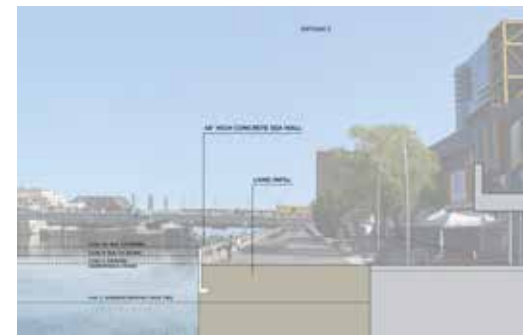
CHAPTER 91: MASSACHUSETTS PUBLIC WATERFRONT ACT

Current Regulations and Challenges

Chapter 91 protects the public's right of access and use of the Commonwealth's tidelands and waterways. The Public Waterfront Act was the driving force to develop the Boston Harborwalk. Chapter 91 and the regulations present in 310 CMR 9.00 identify the state as the regulating body for construction, dredging, and filling of coastal and inland waterways. These activities in waterways require a license from MassDEP, and in some cases, review under the Massachusetts Environmental Policy Act. Projects that do not meet the standards for approval under the regulations can seek a variance under 310 CMR 9.21; however, the variance process can be lengthy and unpredictable. Instead, changes could be made to the regulations to facilitate future flood protection projects. The key challenges and potential changes include:

- » Authorization of Emergency Actions (310 CMR 9.20). 310 CMR 9.20 allows an expedited review and approval process for Chapter 91 in emergency situations where swift and immediate action is essential to avoid a serious

Projects along the Fort Point Channel may be the most complicated to pursue under Chapter 91 and the Wetlands Protection Act.



Federal and state regulations that provide opportunities to reduce regulatory obstacles and encourage multi-faceted coastal flood protection are Chapter 91/ Waterways Regulations, Wetlands Regulations, Massachusetts Building Code, and Chapter 21E. Local improvements to regulatory resilience include developing Climate-Ready Zoning and coordinating with Boston Conservation Commission on criteria for review and approval of fill projects and mitigation strategies which provide flood protection and resilience. The matrix below identifies the South Boston coastal resilience design strategies that would benefit from federal, state, and local regulatory revisions. These coastal resilience design strategies could be applied elsewhere in the City and region.

	FEDERAL AND STATE CHANGES			LOCAL OPPORTUNITIES			
	Chapter 91/ Waterways Regulations	Wetlands Regulations (Federal, State, and Army Corps Permits)	Building Code	Development Incentives	Retrofit Program	Climate-Ready Zoning	Coordinated Infrastructure Planning
Fort Point Alignment A3 and A4: Fill in the Harbor	X	X					
Fort Point Alignment B: Gate at Fort Point Channel Mouth	X	X					
Waterfront Option A: Shoreline Options	X						
Waterfront Option B: Middle of Marina	X	X					
Waterfront Option C: Mouth of Marina	X	X					
Waterfront Option D: Seaport Boulevard			X	X	X	X	X
Marine Park Option A: Perimeter Flood Protection	X	X					
Marine Park Option B: Interior Flood Protection			X	X	X	X	X
South Boston Neighborhood Alignment Option A: Perimeter flood protection with floodwalls and raised harborwalk	X	X					
South Boston Neighborhood Alignment Option B: Beach Nourishment and Road Elevation	X	X					

and immediate threat to health, safety, or the environment. Emergency actions are subject to review by MassDEP, and likely do not consider urgent, anticipated flood risk.

Potential Course of Action

Clearly define urgent projects and include climate risk as a criterion to allow for expedited permitting of flood protection projects. It is important to implement the coastal resilience design strategies before flood events to prevent the need for emergency action to repair damage after the flood event. Fort Point Channel and Seaport Boulevard near-term resilience projects are urgent and may need regulatory changes. Nevertheless, mid-term flood protection alignments in the Reserve Channel and Marine Park may benefit from swift implementation due to this change.

- » Categorical Fill Restrictions (310 CMR 9.32). Except for certain limited projects, large-scale fill projects for flood protection are generally not eligible under the existing regulations. To meet the requirements for approval under this section, flood protection projects must take reasonable measures to minimize the amount of fill, for example substitute fill with pile-supported or floating structures. These requirements could preclude technical approaches that rely on fill for flood protection and stormwater retention,

particularly in space constrained areas. These same fill projects can also advance the aims of Chapter 91 and benefit the public by providing open space and continued access to water.

Potential Course of Action

Revise the categorical fill restrictions to allow more expansive filling for flood protection projects. The allowance must maintain public access and provide specific criteria to confirm the project is for flood protection. Several South Boston coastal resilience design strategy options involve fill, particularly those that incorporate the creation of open space or wetland areas. Creation of open space or natural resources for floodplain management and flood protection purposes would be more easily permitted with this update.

- » Engineering and Construction Standards (310 CMR 9.37). Shoreline engineering projects must be located landward of the existing high water mark unless required for structural integrity. This limits the ability to extend the shoreline seaward for resilience and public use purposes.

Potential Course of Action

Consider expanding Engineering and Construction Standards to allow development of multi-use flood protection projects seaward of the high water mark. Updates to the Engineering and Construction Standards and the Categorical Fill Restrictions to allow fill-based flood

protection projects should go hand-in-hand to be effective for fill-based or over-water coastal protection projects in South Boston.

- » 310 CMR 9.37 requires projects to incorporate sea level rise expectations over the design life of buildings; these projections reference historical rates of increase in New England coastal areas as the minimum threshold.

Potential Course of Action

Incorporate projected sea level rise into the design life of buildings, seawalls, bulkheads and all projects subject to Chapter 91 review based on regional climate change and sea level rise projections. Revising 310 CMR 9.00 to integrate future sea level rise conditions in project design will align Waterways regulations with potential resilience upgrades to the Building Code, Climate-Ready Zoning and other resilience measures presented in this section.

Implications

The suggested revisions to 310 CMR 9.00 and Chapter 91 more clearly support implementation of the South Boston coastal resilience design strategies and similar solutions throughout the City. These projects would produce co-benefits such as flood protection and public amenities. Nevertheless, Chapter 91 is a long-standing and well-established statute with associated regulations. Revisions to the Wetlands Protection Act and Massachusetts Building Code may

also be necessary for consistency across regulations. Revisions to 310 CMR 9.00 may allow infrastructure and other flood protection projects to move forward, but those projects may also require new licenses or revisions to existing licenses, potentially raising financial and legal implications for waterfront property owners. The significant amount of shoreline involved in the South Boston perimeter flood protection strategies means that the City and other project proponents must take special consideration of existing Chapter 91 licenses when working with stakeholders and property owners through implementation process.

Optional Approach: Consolidated Review for Chapter 91 Licenses

A Chapter 91 License will be required for the flood protection projects developed in tidelands or filled tideland areas. MassDEP could conduct a consolidated review to facilitate the Chapter 91 licensing for multiple projects along the shoreline. Although this consolidated review process would not eliminate the need for individual Chapter 91 licenses, MassDEP could issue a consolidated written determination with special conditions for the full range of projects to simplify the project licensing.

KEY CONSIDERATIONS

- » Written determination would guide the review process for the individual projects and the applicable pre-defined, special conditions would be incorporated into the final licenses.
- » Since most projects will be developed on private property, the property owners will be required to obtain the Chapter 91 licenses or amend the existing licenses to include the flood protection projects and applicable special conditions.
- » A consolidated written determination, obtained by the City, could streamline this process and reduce the burden on the property owners.
- » Projects within the Raymond L. Flynn Marine Park, would have a different approval process because there is a Chapter 91 Master License for the Designated Port Areas (DPA). If the proposed flood protection projects vary from the requirements of the existing DPA Master License, the City can seek an amendment to the Master License for those projects.

WETLANDS PROTECTION ACT

Current Regulations and Challenges

The Wetlands Protection Act governs inland and coastal wetlands to protect wetlands resources, water quality, flood control interests, and wildlife habitats and fisheries, and provide storm damage prevention and pollution prevention. Proponents of projects within wetlands resource areas must submit a Notice of Intent (NOI) to the Boston Conservation Commission and obtain an Order of Conditions from the Commission prior to beginning work. The City does not have its own wetlands ordinance and currently relies on the state Wetlands Protection Act regulations (310 CMR 10.00). Because Wetlands regulations oversee construction and fill in the floodplain, nearly all of the South Boston coastal design strategies will require an Order of Conditions. The following suggestions to update the Wetlands Protection Act may expedite review and approval of the South Boston coastal resilience design strategies.

- » Land subject to coastal storm flowage (LSCSF) boundaries and regulations (310 CMR 10.04): LSCSF means land subject to inundation caused by coastal storms up to and including the 1-percent annual chance flood event, surge of record, or storm of record, whichever is greater. Massachusetts uses the 1-percent annual chance flood zone noted on FEMA's Flood Insurance Rate Maps to define LSCSF resource

areas, which are based on historic, rather than predictive, flooding. The boundaries of LSCSF will expand over time with sea level rise, but projects permitted today are not required to consider those future flood conditions. Even if future conditions were taken into consideration, the regulations provide limited performance standards for stormwater management and road construction, and do not include general standards for other construction within LSCSF.

Potential Course of Action

Define the LSCSF to reference the 1-percent annual chance event with 40 inches of sea level rise and establish specific performance standards for developed and undeveloped LSCSF resource areas. For example, projects in the developed LSCSF resource area may have less stringent fill restrictions than in undeveloped resource areas. Another performance standard for the current LSCSF areas may require projects in the 40-inch sea level rise flood zone to be designed with adaptive flexibility over time to prevent exacerbation of current and future flood conditions. These LSCSF flood zone performance standards may be linked to similar standards set forth in the Massachusetts Building Code, or Climate Ready Zoning Overlay.

- » Minimize Adverse Effects Requirements (limitations on filling wetlands resources): The Boston Conservation Commission can impose special conditions if a project may adversely impact a resource area. The Order of Conditions would issue a requirement to minimize or mitigate those impacts, such as limit excavation and fill. Such conditions may require Harborwalk to be constructed over the water or limit the linear expansion of seawalls. Proposed resiliency measures may require larger areas of fill resulting in significant impacts to coastal wetland resource areas. The projected volumes of fill will present challenges to meeting the existing wetland regulatory requirements and compliance with the interests of the Wetlands Protection Act

Potential Course of Action

Revise state wetlands regulations to balance potential adverse impacts with value added by the project. Value added can include creation of open space and other public amenities, reduced stormwater runoff, storm damage prevention, reduced shoreline erosion, remediation of existing environmental contamination and prevention of new releases of contaminants. Wetlands regulatory agencies may consider reducing wetland mitigation requirements for such "self-mitigating" projects.

Implications

Climate change and sea level rise will likely cause significant changes to wetlands resources, expanding some inland wetlands and inundating coastal land. Existing regulations could prohibit implementation of fill projects meant to address more frequent tidal flooding and prevent degradation of the shoreline.

Options to increase resilience and project implementation effectiveness through the Wetlands Protection Act would require changes at the state level and adoption of a local wetlands ordinance or policy guidelines. Fill mitigation requirements are open to interpretation, but consistent standards can be developed through a local ordinance allowing constructed land if it is considered partially “self-mitigating.” The self-mitigating definition may apply to fill that incorporates new wetland areas, rain gardens, or natural retention areas. Alternative definitions of the LSCSF is more complicated due to the breadth of impact and would require state-level revisions to the regulation.

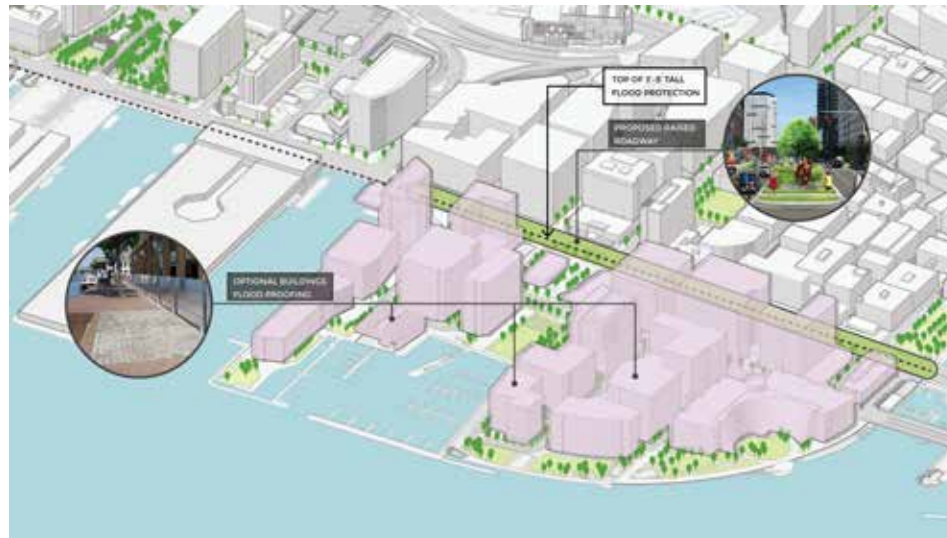
MASSACHUSETTS BUILDING CODE

Current Regulations and Challenges

The Massachusetts Building Code, administered by BBRS and enforced locally through Boston Inspectional Services, provides minimum standards for flood-resistant buildings within FEMA's flood zones. The 9th edition of the Building Code came into effect on January 1, 2018, which includes provisions of ASCE 24-14, Flood Resistant Design and Construction. While the 9th edition of the Building Code does increase the minimum design elevation for occupied structures, it does not consider other standards such as cumulative substantial improvement, additional freeboard requirements, and more stringent substantial improvement requirements for repetitive

loss structures. Similar to Chapter 91 and the Wetlands Protection Act, the Building Code also does not consider the dynamic nature of flood zones and flood elevations based on sea level rise expectations.

Revisions to the Building Code are not required for implementation and construction of the South Boston coastal flood protection options, but will supplement inland alternatives such as raising Seaport Boulevard in the South Boston Waterfront or providing interior flood protection in the Marine Park. More stringent building codes will provide that over time, structures not protected by the South Boston alignments will incorporate resilience measures such as elevated first floors and wet floodproofing strategies.



Individual cities and towns may request more restrictive building code standards to address special local conditions per M.G.L c. 143 §98. Nevertheless, the Board of Building Regulations and Standards has generally not approved proposed local changes for more restrictive Building Code provisions. The State did adopt a base energy code that applies to all structures within municipalities that decide to adopt the initiative, referred to as the Stretch Code. The Stretch Code has more stringent energy efficiency standards for new residential construction and renovations or additions, and the opportunity may exist to develop a Stretch Code for flood resilience. Considering these factors, the following actions would support the increased resilience of buildings that are not integrated into a district-wide flood protection system:

Potential Course of Action

- » Consider dynamic inundated areas and rising base flood elevations. Advocate for changes to the Building Code to incorporate protections against flood damage for sea level rise projections over the useful life of a project. Assuming that buildings constructed today will remain in place for at least 60 years, adopt the 1-percent chance event with 40 inches of sea level rise as the standard design flood elevation.

- » Pursue higher code standards, such as additional freeboard requirements, assigning V-Zone regulations to coastal A-zone construction, cumulative substantial improvement calculations (clear procedures and tools for tracking this would also be required), or requiring more stringent substantial improvement determinations for repetitive loss structures. The Board of Building Regulations and Standards should also consider updating wet proofing standards, guidance for extreme weather conditions, and align new design standards for elevated ground floors in flood zones with existing handicap access requirements.

Implications

The Board of Building Regulations and Standards wishes to maintain consistent building regulations across the state. Therefore, implementation of regulatory changes at the state level will be a long-term endeavor that requires strategic partnerships. Higher standards for construction may lead to increased costs of construction, although the long-term benefits of reduced flood damage would outweigh the increased costs of construction. Applying higher standards in future flood zones may require outreach and stakeholder engagement, including to home builders, developers, and property appraisers.

MASSACHUSETTS HISTORICAL COMMISSION

Current Regulations and Challenges

MassHistoric reviews new construction and renovations that require funding, licenses, or permits from state or federal governmental agencies for impacts to historic and archaeological properties. It is the nature of the federal or state agency involvement that triggers review, not listing in the National or State Registers of Historic Places. Any replacement, retrofits, or rehabilitation of historic structures will be subject to project review and conditions set by MassHistoric and the Boston Landmarks Commission.

Potential Course of Action

Identify near-term retrofitting opportunities for historic buildings and infrastructure that will expedite MassHistoric review of coastal resilience design strategies. A few of South Boston's seawalls are designated historic landmarks or located in designated historic districts and are within the jurisdiction of MassHistoric and the Boston Landmarks Commission. Precedence has been set for the replacement of historic seawalls along Fort Point Channel; replacement is allowable provided that new seawalls are capped with reclaimed granite. Likewise, historic buildings, such as the Necco buildings, may be retrofitted and floodproofed if historical materials or materials with the same or similar aesthetics are utilized on the exterior of the building.

Implications

In the near term, structures can be retrofitted or built utilizing reclaimed or similar materials, though this can have significant cost implications. In the long term, as climate change affects more historic structures in the area, the City can advocate for specific review and conditional approvals for material types and equipment location based on the changing climate and protection needs or predicted losses for individual historic structures.

CITY REGULATORY RESILIENCE STRATEGIES

DEVELOPMENT INCENTIVES

Current Regulations and Challenges

All major and certain smaller building projects are subject to Article 80 of the Boston Zoning Code and must consider present and future climate conditions in design. Recently, the Boston Planning and Development Agency updated the Article 37 Climate Resiliency Checklist (Checklist), required as part of Article 80 review, to include the area expected to flood at the 1-percent annual chance flood elevation with 40 inches of sea level rise. Projects within this area must consider flood protection as part of their development plans. The Checklist recommends, but does not require, the design elevation for new critical facilities and buildings with ground floor residential units incorporate 40 inches of sea level rise plus two feet. It suggests that all other projects add 40 inches of sea level rise plus one foot.

Potential Course of Action

- » Design Recognition. A city recognition program can provide examples and highlights of best practices for flood-risk reduction measures and protection against extreme rain, snow, wind and heat. Developers in the region agree that flood and other climate resilience measures are becoming a commodity, and a recognition

program may increase local design competition and yield more innovative flood-resilient buildings in the Boston area. The City can also assist in lowering the cost of flood-risk reduction measures by providing examples and guidance documents exemplifying cost effective solutions that can be adapted to projects across the City.

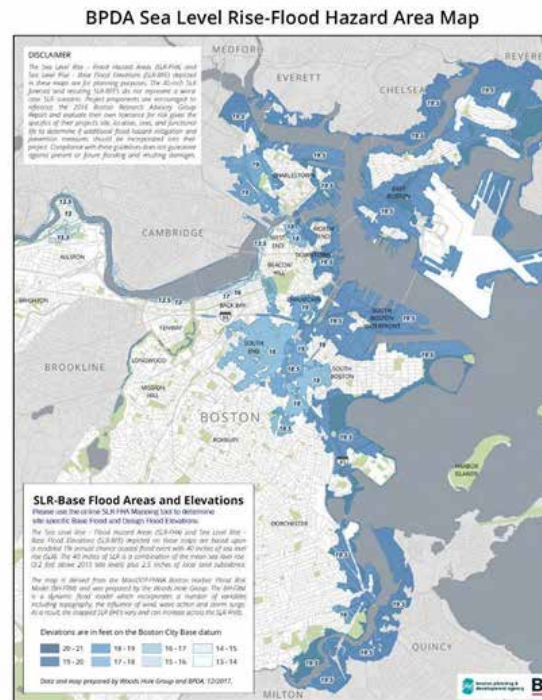
City regulatory resilience strategies can provide near- and mid-term mechanisms to protect new development and substantially improved projects in the long term. Financial incentives for retrofitting existing buildings assist property owners in protecting existing structures. City-driven solutions can build momentum for incorporating long-term resilience goals into state and federal regulations.

CLIMATE READY ZONING OVERLAY DISTRICT

Current Regulations and Challenges

Article 25: Flood Hazard Districts of the City's zoning code embodies the National Flood Insurance Program flood damage prevention standards. Article 25 applies to all areas that correspond to FEMA's Special Flood Hazard Areas delineated on Suffolk County's Flood Insurance Rate Maps. The Special Flood Hazard Areas are identified using historic flood information and modeling, and do not consider predicted climate changes such as sea level rise and more frequent and intense storm events. The Flood Resistant Design and Construction provisions of the Massachusetts Building Code also reference FEMA's Special Flood Hazard Areas.

Until higher standards and dynamic flood risk are incorporated into the Massachusetts Building Code, Boston can enforce more stringent floodplain management regulations through the land use and dimensional requirements in the zoning code, through conditional uses for development in the floodplain, and through the Article 80 development review process. BPDA recently updated the Article 37 Checklist to require project proponents to address how their building and site design will manage a 1-percent annual chance flood elevation with 40 inches of sea level rise. Examples of additional changes to the Boston Zoning Code for floodplain management include defining the ground floor in relation to the base flood elevation, changing the



definition of building height to exclude uninhabited space used for flood protection, and increasing the requirements for permeable surfaces or stormwater retention.

The Community Rating System is a FEMA program through which flood insurance policy premiums can be reduced directly through flood risk resilience actions taken by the City.

Similar to the Building Code revisions, the new Climate Ready Zoning Overlay can be applied to inland areas within South Boston as a support framework for areas that do not benefit from the proposed alignments or are not yet protected during the time period when perimeter protections are designed and constructed. An optional approach to roll-out the overlay district and corresponding incentives and requirements has three phases:

- » Phase 1: Required Adaptation to 1 percent annual chance flood elevation with 40 inches of sea level rise. As a near-term measure, within the future flood inundation zone, the Climate Ready Zoning Overlay District may require that new construction and substantial improvement projects currently subject to Article 25 incorporate flood protection measures and require adaptation of existing structures to the 1-percent annual chance flood elevation with 40 inches of sea level rise. In areas of shared flood risk, property owners could also be required to address the impact of their own development, including any new fill or construction, on flooding at the surrounding properties and coordinate with neighboring property owners on potential publicly or privately funded district-wide solutions. This may require property owners to engage consultants with specialized knowledge of flood protection. To reduce the burden on property owners, the

City could issue guidance documents and case studies of prototypes highlighting measures that can reduce the cost and effort involved in compliance. This process would give property owners within the overlay district greater flexibility in design, rather than mandating specific measures, such as elevated ground levels or flood gates. It would also encourage property owners to incorporate construction standards that are more protective than currently required under the Massachusetts Building Code.

- » Phase 2: Expanded Applicability of Phase 1.
Phase 2 of the overlay district expands the Phase 1 square footage threshold to include smaller structures and impose a lower threshold for substantial improvement determinations: 30-percent substantial improvement determination threshold rather than 50-percent, for example. Broader district-wide solutions could require consideration of flood prevention solutions beyond the individual property boundaries to address flood pathways and migration within areas of shared flood risk and allow off-site mitigation, where such mitigation would be more effective. The zoning code could also require offsetting flood storage or other mitigation for new construction or expansion of impervious surfaces in areas expected to flood, for example, three or more times each year.

Harborpark and Waterfront Manufacturing Districts

The City's existing zoning codes applicable to South Boston can be revised to implement actions similar to those proposed under Phase 1 of the Climate-Ready Zoning Overlay District. While more stringent zoning requirements may not be required for efficient implementation of the perimeter solutions, they can build inland resilience in the long term. Prior to potential revisions to federal and state regulations, the City would need to ensure that existing zoning does not conflict with regulations of other governing authorities. The City's Harborpark Districts (Article 42A, Article 42E), Waterfront Manufacturing District (Article 42D), and the South Boston Neighborhood District (Article 68) can serve as platforms to develop and issue performance standards and design guidelines, flood protection review requirements, and Chapter 91 special project qualifications without conflicting with other regulatory standards.

- » Performance Standards and Design Guidelines may require new projects or substantial improvements to mitigate flood risk by compensating for increased impervious surfaces, elevating or floodproofing the structure, or accommodating water on site to protect neighboring properties. Coordination of infrastructure design standards may also be included in this effort.
- » Flood Protection Review Requirements include the review of flood impacts and mitigation measures as part of the City's required development review process. The review requirements may also include review of district-wide plans to ensure that projects will not preclude implementation of multi-parcel flood protection strategies.
- » Chapter 91 Requirements referenced in the Boston Zoning Code can be revised to add to the list of proper public purposes, "the protection of public health, safety, and general welfare as it may be affected by any projects in tidelands and in floodplains." This additional language could be used to justify a variance for the technical solutions as an overriding municipal interest.

- » Phase 3: Re-Evaluate Future Flood Inundation Zone. To account for the dynamic nature of sea level rise and increasing flood inundation areas, overlay boundaries should be reevaluated at set intervals. The re-evaluation would examine actual rates of sea level rise and adopt new projections of future conditions, as appropriate. Any resulting change to the zoning overlay district boundaries would require an amendment to the zoning ordinance

Implications

Creating a Climate Ready Overlay District may cause confusion with the existing Article 25 Flood Hazard Districts overlay, which would still be the regulatory tool for administering NFIP requirements. Nevertheless, as the City prepares for application and entrance into the Community Rating System (CRS), adopting the Climate Ready Overlay District in addition to Article 25 would allow the City to administer the NFIP floodplain management program within future flood zones and obtain CRS credits for instituting higher standards. This approach requires that justification of the sea level rise projections and future flood inundation areas as the best available flood data. It is important to note that flood insurance requirements would still be based on the FEMA Special Flood Hazard Area to prevent property owners from overpaying premiums for future flood risk.



Some homes in the South Boston residential neighborhood along Day Boulevard may be appropriate for elevation in the long term, such as this example of an elevation in progress from Provincetown, Massachusetts.

Lower substantial improvement thresholds could be paired with a City, state, or federally funded retrofit program to support residents and businesses in bringing their structures into compliance with new policy. Such a program could reduce cost burden on members of the community, and could support buy-in of higher standards.

Retrofit programs can pave the way for widespread regulatory change. Such programs should be developed through a well-executed public engagement effort that fosters a trusting and transparent relationship between a municipality and the public.

PRIVATE PROPERTY AND INFRASTRUCTURE RESILIENCE STRATEGIES

South Boston needs a multi-layered approach that also increases the resilience of inland systems and property. Increasing the resilience of private property and infrastructure systems, at various scales, decreases the likelihood of damage in the case of a flood event.

RETROFIT PROGRAM FOR EXISTING BUILDINGS

Retrofit programs promote improvements to existing buildings on a neighborhood or district-level scale. Recent examples include energy efficiency programs such as Renew Boston and Mass Save.

Potential Course of Action

Pilot a South Boston retrofit program. FEMA administers two grant programs on an annual basis that fund site-specific flood mitigation projects such as structure elevation, parcel acquisition and structure demolition, wet floodproofing, and dry floodproofing activities. This includes the Flood Mitigation Assistance and Pre-Disaster Mitigation grant programs. Local municipalities are eligible applicants for the programs and must sponsor property owner mitigation proposals to FEMA. Both programs target mitigation of properties with

FEMA's Hazard Mitigation Assistance (HMA) programs fund site-specific flood mitigation projects, including structure elevation as noted in the photograph from Provincetown, MA. One option to increase property-based resilience is to pursue funding under the HMA programs to retrofit buildings in South Boston, particularly those at risk of recurrent flooding. The U.S. Department of Housing and Urban Development (HUD) Community Development Block Grant funds have also been used for such projects in the past.

Considering Boston's abundance of historic assets, FEMA's guidelines for floodproofing historic buildings and infrastructure is a good resource for any retrofit program. The NFIP Floodplain Management Bulletin for Historic Structures (May 2008) lists the following mitigation measures that have minimal impact on historically significant features:

- » *Elevating electrical and mechanical systems and utilities*
- » *Relocating contents*
- » *Creating positive drainage*
- » *Using flood-damage resistant materials*
- » *Filling or wet floodproofing basements*
- » *Installing floodwalls to protect openings*
- » *Temporary measures*

repetitive losses from natural hazards, but will consider projects with expected increased risk due to changing conditions such as sea level rise.

INFRASTRUCTURE COORDINATION

South Boston contains significant stormwater, transportation, and power infrastructure systems with unique interdependencies maintained by various public utilities, private companies, and local, state, and federal agencies. For example, the Massachusetts Turnpike Authority's Central Artery and Tunnel project (CA/T) constructed the Ted Williams Tunnel and I-90 Tunnel entrances to connect South Boston to Downtown and East Boston, and in the process relocated gas, electric, telephone, sewer, and water lines maintained by 31 separate companies.

Some infrastructure agencies already factor climate change and sea level rise-related risk into asset management and capital improvement programs. Nevertheless, South Boston needs more coordination between infrastructure agencies and their design standards, implementation strategies, and financing mechanisms to achieve long term flood risk resilience. Because many assets and systems in South Boston are co-located or interdependent, infrastructure agencies will need to work together to increase resilience across systems. As described in Climate Ready Boston, important steps include:

- » Set common infrastructure design standards for

resilience, including identifying a design level of protection based on the anticipated life of the project and expected climate change conditions.

- » Mainstream resilience measures into ongoing capital programs.
- » Coordinate capital improvements plans for maximum infrastructure protection. For example, agencies may meet annually to discuss upcoming projects and identify opportunities for collaboration in critical areas, such as planning multiple infrastructure improvements to occur at the same time within the same utility corridor in the 40-inch sea level rise scenario flood zone.
- » Infrastructure agencies can work with other state and city agencies to streamline permitting regulations and coordinate internal procedures and policies to facilitate partnership.
- » Co-fund projects with capital improvements budgets, publicly demonstrating collaboration between parties and value added to the community.
- » Establish an Infrastructure Coordination Committee with the authority to increase cooperation among infrastructure agencies, including setting resilience standards, implementing multiple lines of defense, and leveraging capital improvement plans and budgets.

A coordinated effort to develop and have shovel-ready resilience projects planned and designed may increase the chances for the City receiving funding under one or more post-disaster programs.



Image from Climate Ready Boston



9 INCHES SEA LEVEL RISE



21 INCHES SEA LEVEL RISE



36 INCHES SEA LEVEL RISE

LEGEND

-  Average morning High Tide
-  25 Annual Chertem Storm
-  15 Annual Chertem Storm
-  Palm
-  Ripple
-  Heavy Rain
-  Light Rain
-  Innocent Rain
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Coordination is required to ensure critical infrastructure, such as the assets outlined above in this image from Climate Ready Boston, are resilient against climate change related hazards. The 36 inches sea level rise scenario in the image above from the Climate Ready Boston Report is equivalent to the 40 inches sea level rise scenario contemplated in this report.

Existing Infrastructure Coordination Efforts

» **Boston Water and Sewer Commision (BWSC) backflow preventers.**

The City is coordinating with BWSC in its effort to install backflow preventers and develop an asset management and maintenance program for these assets moving forward. The City will continue to coordinate with the agency on flooding vulnerabilities in the municipal stormwater drainage system, including other South Boston outfalls owned by Massachusetts Department of Transportation (MassDOT), Economic Development Industrial Corporations, private landowners, and Massport. The City has engaged many of these entities throughout the Climate Ready Boston engagement process and will continue to work on shared flood protection interests, including stormwater outfall backflow preventers.

» **Smart Utilities.**

The Smart Utilities Policy for Article 80 Development Review—adopted by the BPDA Board on June 14, 2018—calls for five of the ten Smart Utility Technologies (SUTs) studied throughout the SUV project to be incorporated into new Article 80 developments: district energy microgrid, green infrastructure, adaptive signal technology, smart street lights, and telecom utilidor. This proposed new policy will be launched as a two year pilot and will include informational education sessions with developers, engineers, architects, and City staff. Two of the selected SUTs for the pilot are particularly relevant to resilience strategies for the South Boston neighborhood: District Energy Microgrids and Green Infrastructure. Recent City initiatives, including Climate Ready Boston, Imagine 2030, and Resilient Boston identify District Energy Microgrids as one means to increase climate resiliency during grid power outages and improve equity by decreasing energy costs, and utilizing green infrastructure as a tool to increase resilience to flooding and as a source of new jobs.



05 IMPLEMENTATION ROADMAP



IMPLEMENTATION ROADMAP

The implementation roadmap will guide coastal resilience actions in South Boston. The roadmap includes cost estimates, high-level phasing plans, and benefit-cost analyses. The actions needest soonest to reduce vulnerability are described in more detail and include recommendations on design, policies, partnerships, and funding. Regulatory resilience actions needed to implement longer-term solutions, are described in Section 04.



South Boston residents provide feedback at the open houses held at the project open houses.



Near-, mid- and long-term coastal resilience solutions in the South Boston study area.

Capital and Maintenance Costs for South Boston Coastal Resilience

Study Area	Implementation Cost	Annual Maintenance Cost
Fort Point Channel	\$108M* to \$197M*	\$1.6M* to \$3.0M*
South Boston Waterfront	\$25M to \$150M^	\$0.4M to \$2.3M^
Seaport Boulevard	\$37M to \$161M^^	\$0.6M to \$2.4M^^
Raymond L. Flynn Marine Park and Reserved Channel**	\$132M to \$228M^^^	\$2.0M to \$3.4M^^^
South Boston Neighborhood	\$210M to \$299M	\$3.2M to \$4.5M
Total	\$521M to \$1.0B	\$7.8M to \$15.2M

*Only includes costs for the east side and base of the Fort Point Channel. Does not include costs for the west side of the Fort Point Channel.

** Does not include Conley Terminal. Massport is conducting a separate resilience planning effort for this area.

^Option D within the South Boston Waterfront would require floodproofing of at least 15 structures that would be left outside of the alignment. This would add \$137 to \$158 million to capital costs and \$2.1 to \$2.4 million in annual maintenance costs.

^^Floodproofing of the Fish Piers and World Trade Center are not included in these costs. Floodproofing of these assets would add \$113 to \$131 million to capital costs and \$1.7 to 2.0 million in annual maintenance to the project costs. Converting the dry dock into a 7 acre park could add \$75 to \$87 million.

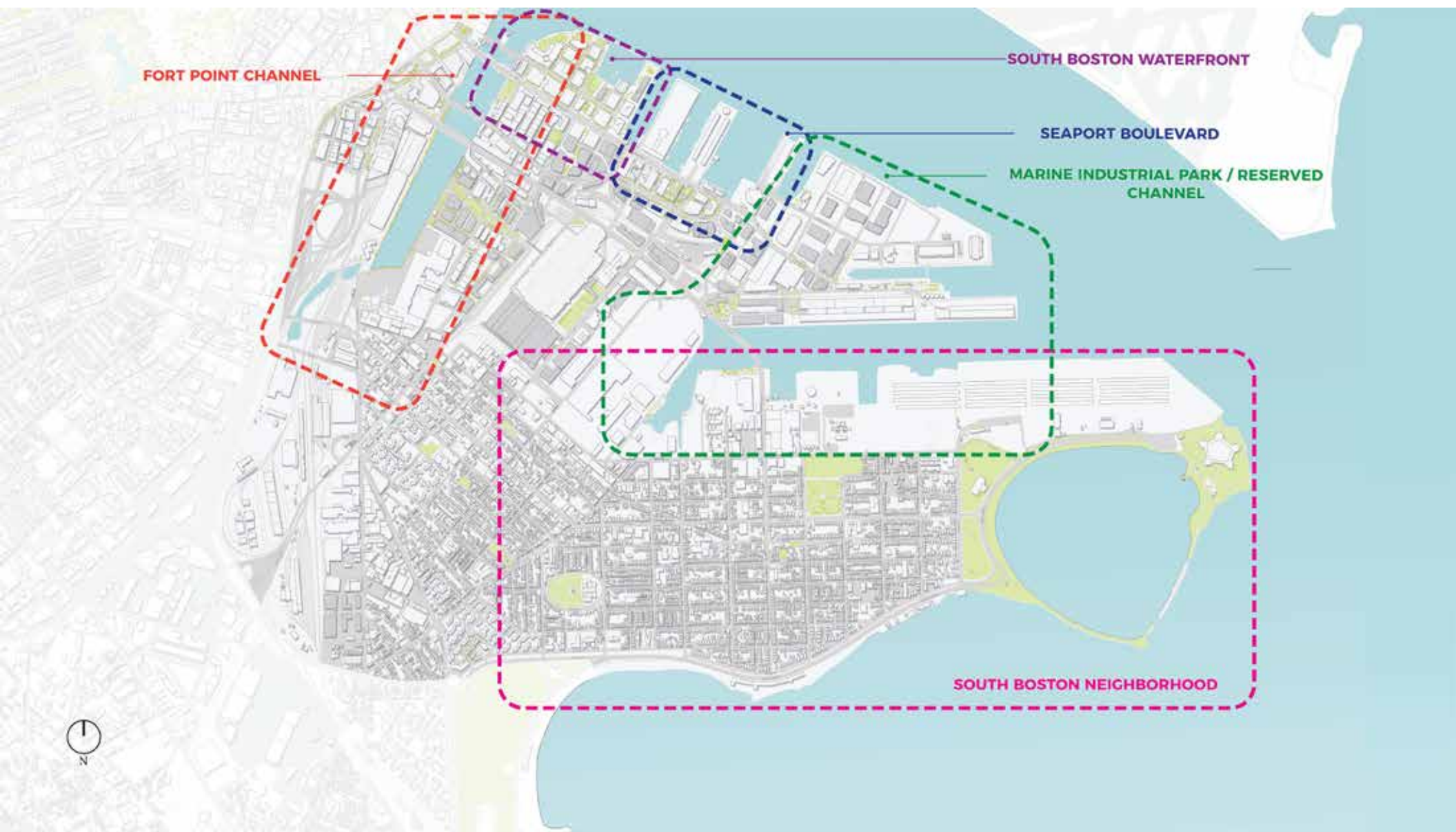
^^^Option B within the Raymond L. Flynn Marine Park would require floodproofing of at least 20 structures that would be left outside of the alignment. This would add \$291 to \$335 million to capital costs and \$4.4 to 5.0 million in annual maintenance costs.

COASTAL RESILIENCE COST ESTIMATES

Coastal resilience actions in South Boston are expected to cost between \$513 million and \$1 billion between now and the 2060s, not including floodproofing of the piers along Seaport Boulevard or actions along the west side of the Fort Point Channel. Together, these actions could protect 40,000 people, over 5,100 structures, and \$8 billion in direct physical damage, displacement costs, mental stress and anxiety, and lost productivity associated with the 1-percent annual chance flood elevation with 40 inches of sea level rise (2070s).¹

Preliminary cost estimates for the various feature components, such as waterfront parks, berms, and shoreline protection features required to achieve flood protection are based on readily available data. They do not reflect design-level considerations for the area, such as as-built surveys of existing underground utilities or geotechnical information.

¹ Exposed population and structures are based on 2016 population and structure data developed through Climate Ready Boston, except for new structures developed in the South Boston Waterfront since that time through May of 2018. Those structures have been added to the dataset. No projected growth is considered.



COASTAL RESILIENCE STRATEGY PHASING

Flood risk in South Boston accelerates rapidly. The National Flood Insurance Program (NFIP) requires that all new development and redevelopment be protected to at least the 1-percent (1 in 100) annual chance of flooding, known as the base flood elevation. Without action, most of the district's waterfront will be below the current base flood elevation with nine inches of sea level rise (2030s). A significant portion of the waterfront will have a 5 percent (1 in 20) or greater annual chance of flooding with 9 inches of sea level rise (2030s).

To reduce this risk, this report recommends near-term resilience actions that should be completed by 2025. Mid-term actions are those that should be completed over the next 25 years. Long-term actions are those that can be completed in the 2050s and beyond. Potential sea level rise later in the century is less certain. The timeframe for long-term actions should be re-evaluated periodically. These include actions on the west side of the Fort Point Channel and the northern edge of the Reserved Channel / southern edge of the Raymond L. Flynn Marine Park, as well as potential expansions or modifications to near- and mid-term actions in Fort Point Channel, South Boston Waterfront, and Seaport Boulevard.

The majority of coastal resilience solutions in South Boston, including the east side of the Fort Point Channel, the South Boston Waterfront, Seaport Boulevard, most of the Raymond L. Flynn Marine Park, Reserved Channel, Pleasure Bay, and Day Boulevard should be in place before 2040 in order to avoid potential significant flood risk consequences.

Coastal resilience design strategy phasing plans reflect our current understanding of how flood risks will evolve, foreseeable cycles of development and redevelopment, and the time necessary to complete different actions.

Priority is based on size and frequency of expected flood impacts. Actual timing will be affected by:

- » *Funding availability*
- » *Partnerships*
- » *Other infrastructure improvements*
- » *Social, environmental, economic, and recreational needs*

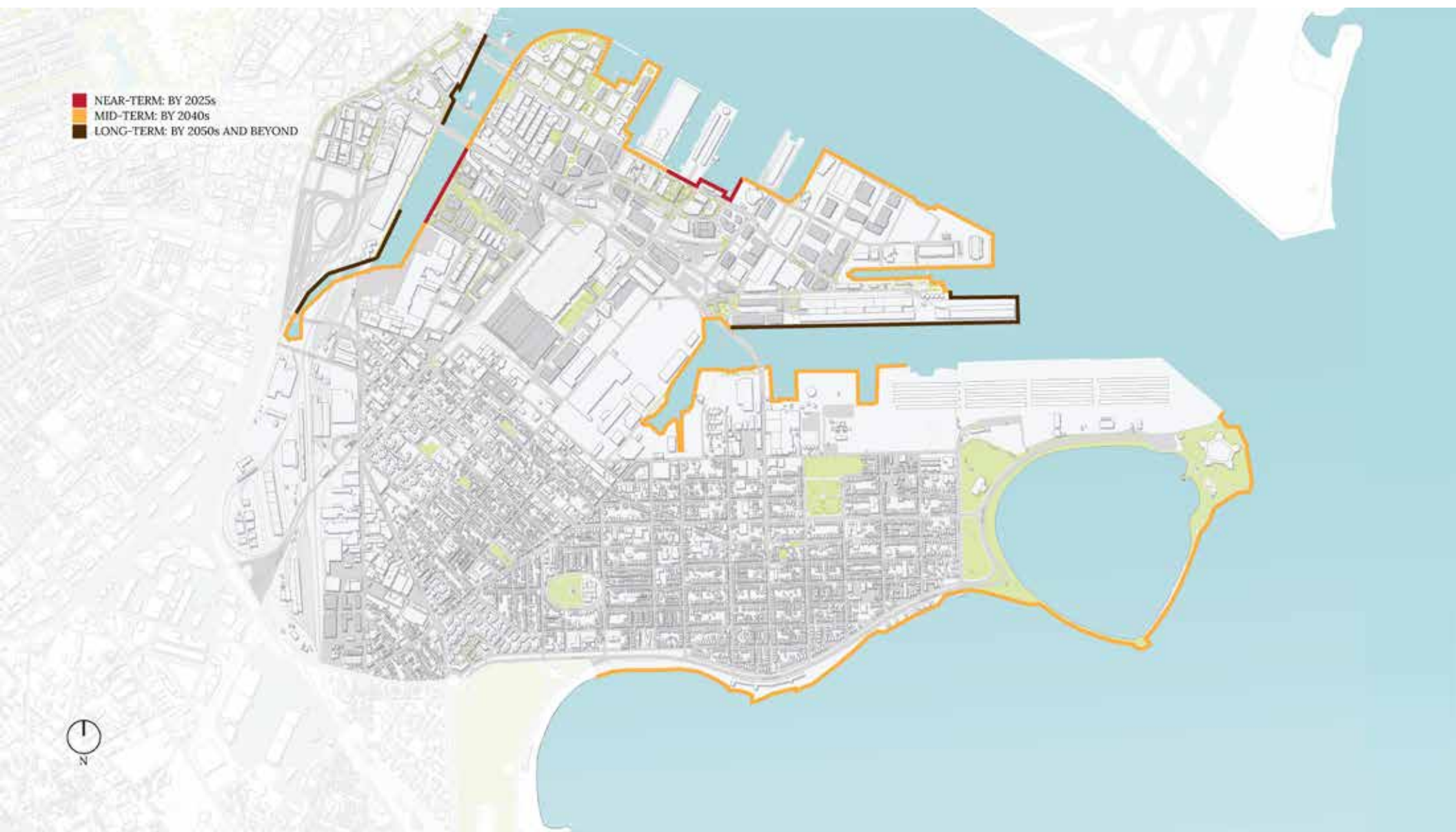
Most actions in South Boston should be complete by the 2040s based on current sea level rise projections. Opportunities to speed up implementation should be taken wherever possible.

NEAR-TERM, MID-TERM, AND LONG-TERM ACTIONS

Near-term actions should be completed as soon as possible.

Mid-term actions should be completed over the next 25 years.

Long-term actions should be completed in the 2050s and beyond.





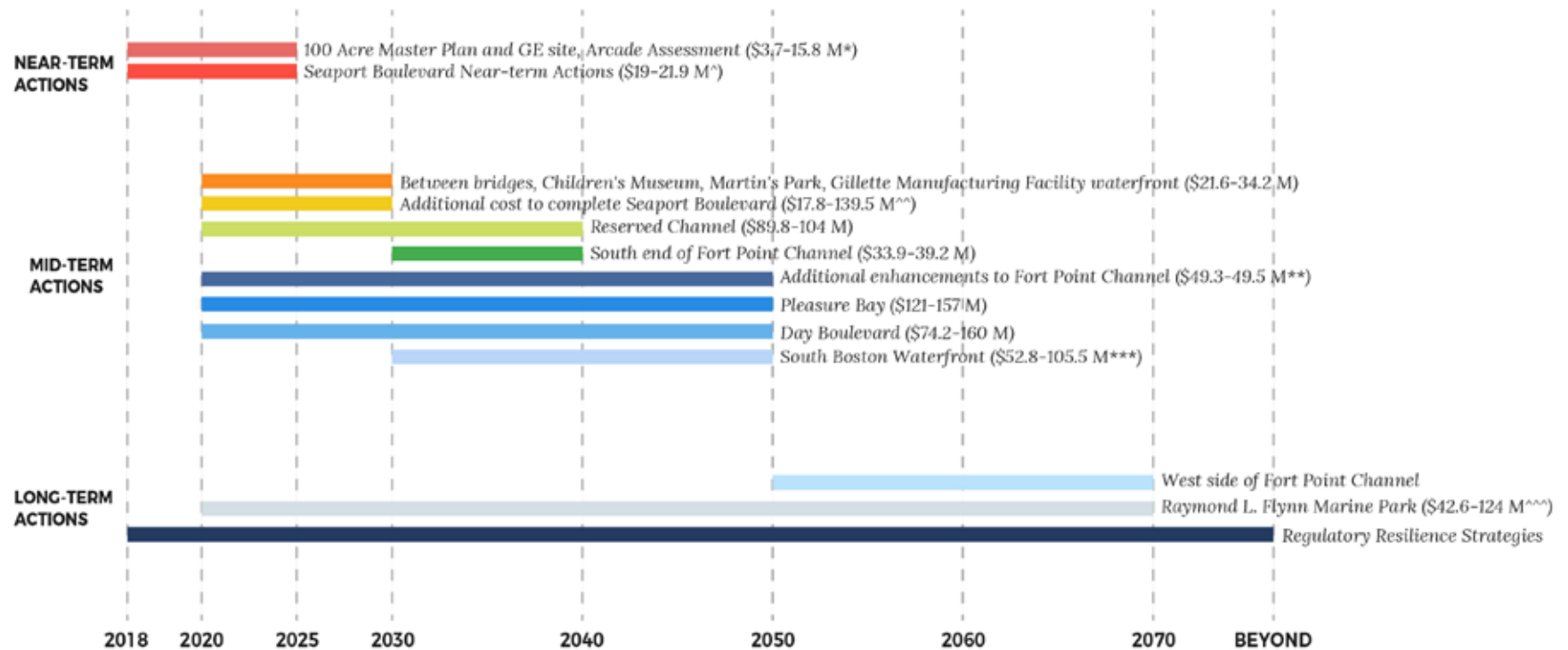
Climate Ready South Boston Open House

PROJECT TIMELINES

Timelines are based on types of projects, location, and property ownership, and include time expected to complete access or easement agreements, project funding, design and permitting of projects, and construction. Projects located on existing land along the shoreline are likely to be more easily permitted than projects in or over the water. Modifications to historic seawalls will also require additional coordination and regulatory review. All timeframes are based on current conditions. To some extent, tasks may be performed concurrently or may overlap, particularly agreements, funding, design, and permitting. Timeframes for specific projects will be determined through more detailed planning, design, and construction scheduling.

Projects will require private property agreements and contracts, as appropriate, and will require permitting through the Massachusetts Environmental Protection Agency, Wetlands Order of Conditions, United States Army Corps of Engineers, Boston Conservation Commission, 401 Water Quality Certification, and Chapter 91, depending on the area, as described in *02 Context and Approach* and in more detail in *04 Regulatory Resilience Solutions*.

RECOMMENDED TIMELINE



* Upper limit includes additional park space

** Costs for Option A only

*** Costs for Options A and B only

^ Costs for Option A only. Does not include costs to floodproof the Fish Piers

^^ Cost range includes Options A and B. Floodproofing of Piers not included. No Dry Dock 4 costs included.

^^^ Floodproofing all structures seaward of Option B would add \$113 - \$131 million. Costs not included

Both costs and phasing plans are estimates and recommendations only, and will require more detailed planning, design, and engineering.

BENEFIT COST ANALYSIS

Loss estimates are based on Climate Ready Boston data from within the study areas, with updates. They include direct physical damages to buildings and their contents and displacement and relocation costs, as defined in the Climate Ready Boston report. For further details, see the Climate Ready Boston Approach and Methodology Appendix.

Stakeholders recommended options that did not leave buildings outside of the alignment and recommended passive solutions over those that would require large mechanical action to be effective in the case of a flood event. Recommended options will need continued coordination with stakeholders, as well as design and technical evaluation in the near term.

The recommended options in the South Boston coastal resilience design strategies could benefit over 40,000 people² and over 5,000 buildings³ from flooding to the 1-percent annual chance flood elevation with 40 inches of sea level rise.

² People estimated to live within the benefitting area as of 2015; does not include any population growth projections.

³ Buildings currently located within the benefitting area; does not include any growth projections.

FUNDING AND FINANCING PATHWAYS

Coastal resilience solutions in South Boston will provide both public and private benefits. Private property, businesses, and residents will experience direct flood risk reduction and benefits to public spaces and infrastructure, such as transportation, as well as the economic and social benefits from reduced risk of disruption. Improved public spaces will benefit residents, workers, and visitors, as well as the businesses around them.

Coastal resilience solutions in South Boston will require a combination of coordinated private and public investment, insurance coverage, improved processes for coordinating and entitling or otherwise permitting protective measures, possible new flood-related public services, and other cooperative actions designed to provide the greatest protection and quality of place benefits, for the lowest collective cost.

In 2018, the University of Massachusetts Boston in coordination with the Barr Foundation, the Green Ribbon Commission, and the City, with support from the [Coastal Resilience Solutions for South Boston](#) project team and others, released a report: [Financing Climate Resilience, Mobilizing Resources and Incentives to Protect Boston from Climate Risks](#). This report outlines the strategies being explored to fund and implement South Boston coastal resilience solutions. Options include public private partnerships, grants, leveraging capital improvement and development plans, a variety of fee, surcharge, and sinking fund methods, and more.

Recommended Coastal Resilience Options in South Boston and Estimated Costs and Benefits

AREA	RECOMMENDED OPTIONS	OPTIONS NOT RECOMMENDED
FORT POINT CHANNEL	Option A (aligns with the perimeter of Fort Point Channel)	Option B (aligns with the mouth of Fort Point Channel)^
SOUTH BOSTON WATERFRONT	Option A (aligned with the shoreline) Option B (makes use of fill)	Option C (mechanical gate) Option D (aligned along Seaport Boulevard)^^^
SEAPORT BOULEVARD	Option A (aligned with the shoreline) Option B (makes use of fill)	Not applicable
RAYMOND L. FLYNN MARINE PARK AND RESERVED CHANNEL	Option A (aligned with the shoreline)	Option B (inland solution)
SOUTH BOSTON NEIGHBORHOOD	Option A (aligns with the perimeter of the neighborhood) Option B (coastal restoration)	Not applicable

ESTIMATED CAPITAL COST*	\$513 million to \$1 billion
ESTIMATED ANNUAL MAINTENANCE COST	\$7.7 million to \$15 million
NET PROJECT BENEFIT**	\$3.9 billion to \$19 billion
BENEFIT-COST RATIO	8.7 to 44.9

**Includes costs for planning, engineering, permitting, construction*

***Net project benefit refers to the benefits minus costs through 2070 using discount rates of 3 percent and 7 percent. Both benefits and costs have been applied incrementally over time based on an estimated project completion schedule and sea level rise changes over time. All losses expected to occur more frequently than monthly have been removed from the analysis.*

^ Option B in Fort Point Channel should not be excluded from future evaluation as it could be combined with Option A in the long term. Other options, such as a levee, could also be considered in the future.

^^ Not recommended as standalone option, but could be considered in conjunction with Options A or B.



Climate Ready South Boston Open House

IMPLEMENTATION TRACKS

Coastal Resilience Solutions for South Boston can be implemented across four “tracks” simultaneously that correlate to the types of partnerships and solutions needed to move the projects forward. Within each of the three geographically based tracks, individual coastal resilience actions have been prioritized for incremental implementation.

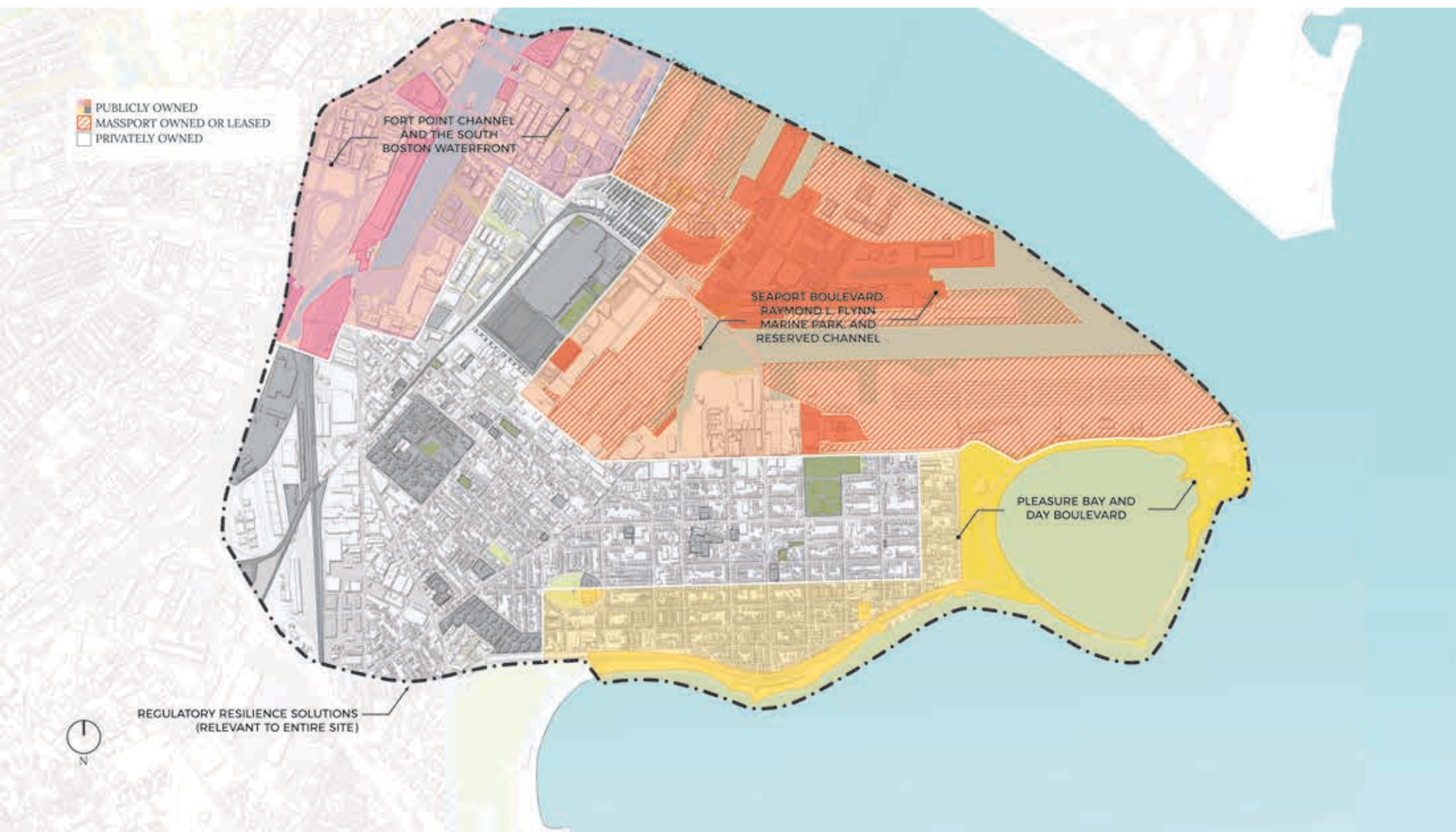
Track 1: Fort Point Channel and the South Boston Waterfront is dominated by private land ownership. Action taken on private land may require agreements, easements, and partnerships in order to implement resilience actions.

Track 2: Seaport Boulevard, Raymond L. Flynn Marine Park, and Reserved Channel includes the highest concentration of City-owned property along the waterfront in South Boston. The majority of the remaining property is either owned by Massport or leased from the City by Massport.

Track 3: Pleasure Bay and Day Boulevard is almost entirely owned and operated by the Department of Conservation and Recreation (DCR). DCR could integrate this area of South Boston into its existing master planning process.

Track 4: Regulatory Resilience Solutions is relevant across all areas and will require partnerships with regulatory and infrastructure bodies, in addition to other stakeholders, to drive the process forward.

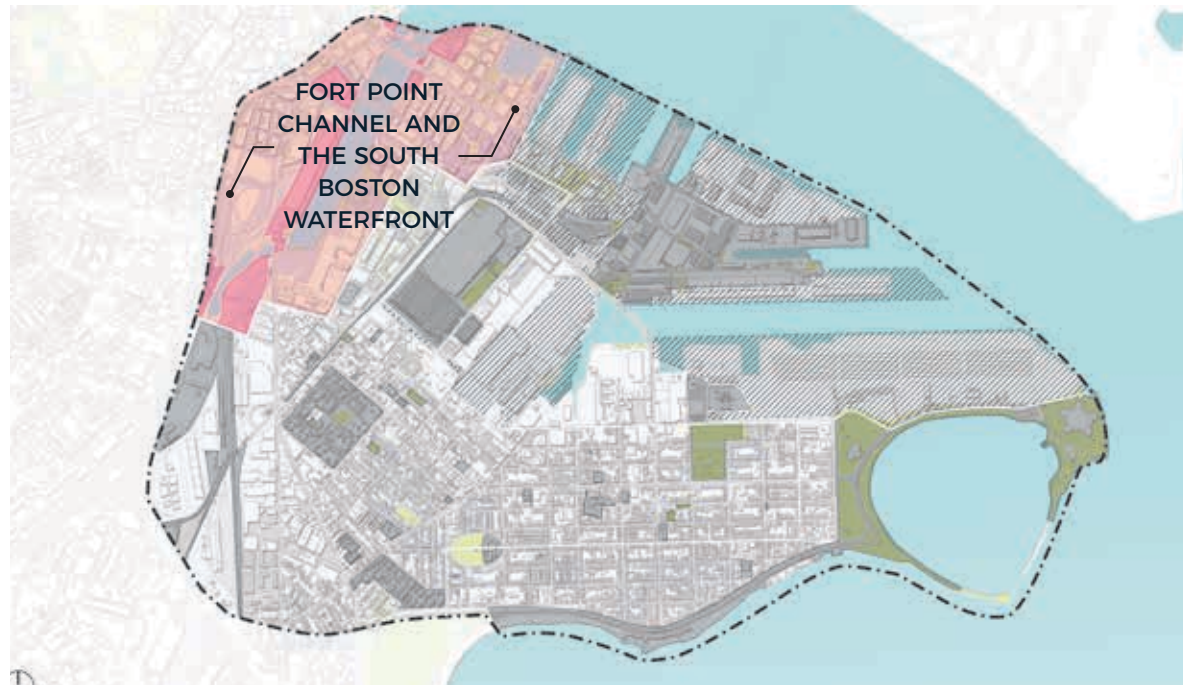
Design Elevation: Unless stated otherwise, all actions are proposed to the 1-percent annual chance flood elevation with 40 inches of sea level rise plus 1 foot of freeboard, and could be adapted to higher elevations in the future.



TRACK 1: FORT POINT CHANNEL AND SOUTH BOSTON WATERFRONT

CHARACTERISTICS:

- » *Predominantly private land ownership*
- » *Stakeholders emphasize public access and amenities in the area*
- » *Opportunities for public private partnerships and philanthropic support to implement resilient solutions*
- » *Heavy regulatory coordination is required for areas where fill is recommended*
- » *Flood protection design is made more complex in space constrained areas*



TRACK 1 ESTIMATED CAPITAL COST (RECOMMENDED OPTIONS):

\$161 million to \$302 million

TRACK 1 ESTIMATED ANNUAL MAINTENANCE COST:

\$2.4 million to \$4.5 million

Track 1 consists of Fort Point Channel and the South Boston Waterfront. The most urgent actions in South Boston's implementation roadmap address the 100 Acres Master Plan current flood pathways. Still, much of the eastern edge of the Fort Point Channel, from Martin's Park to the end of the South Boston Manufacturing Center should be implemented in the near term both due to the extent of flood risk and the ongoing development activity in the area. Flood pathways from Seaport Boulevard and possibly Reserved Channel will affect properties in Track 1 with a 100-percent and 50-percent annual chance probability, respectively, by 40 inches of sea level rise (2070s) without action in those areas.

Track 1: Reduced Exposure and Loss Expected as a Result of Coastal Resilience Solutions

	1-PERCENT ANNUAL CHANCE ELEVATION WITH NO SEA LEVEL RISE	1-PERCENT ANNUAL CHANCE ELEVATION WITH 9 INCHES OF SEA LEVEL RISE	1-PERCENT ANNUAL CHANCE ELEVATION WITH 21 INCHES SEA LEVEL RISE	1-PERCENT ANNUAL CHANCE ELEVATION WITH 40 INCHES SEA LEVEL RISE
REDUCED NUMBER OF RESIDENTS EXPOSED	700+	1,360+	Track 1 coastal resilience solutions must be combined with Track 2 coastal resilience solutions to be effective at mitigating loss across the Track 1 area at these flood elevations.	
REDUCED NUMBER OF BUILDINGS EXPOSED	45	105		
EXPECTED REDUCTION IN DIRECT PHYSICAL DAMAGES AND RELOCATION COSTS	\$90 million	\$386 million		

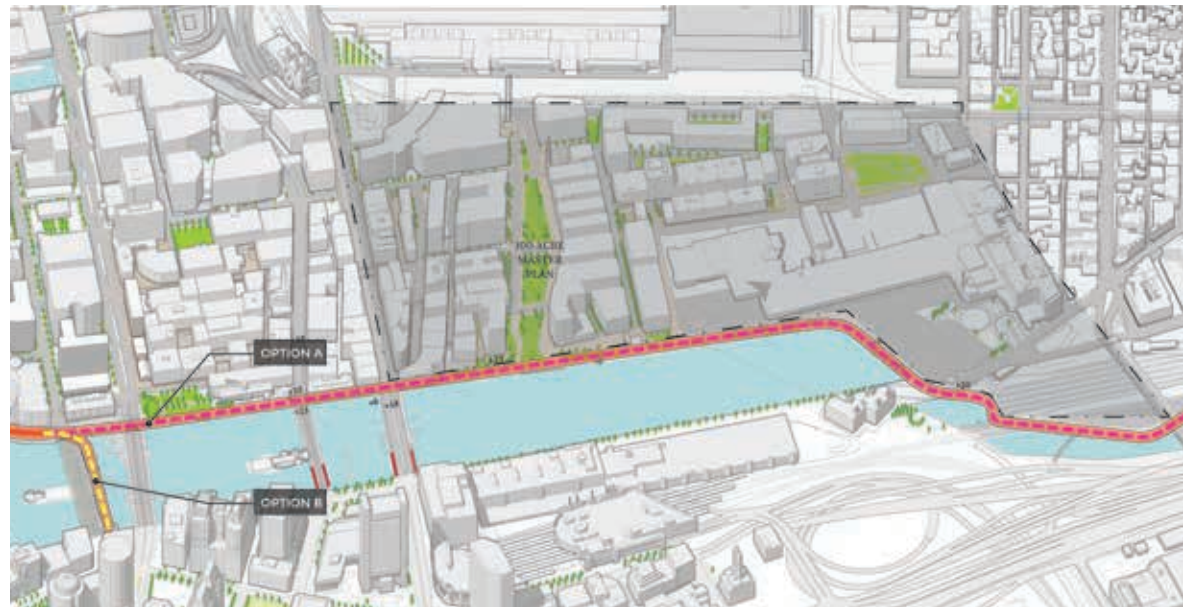
*Exposure and expected impacts are relative to specific flood elevations, and not specific flood events. It is very rare that flood elevations are even across a landscape during a given event.

^Does not include west side of the Fort Point Channel. Values do not include structures that would be seaward of the coastal resilience design strategy and require independent flood mitigation. Zero and 9 inch sea level rise 1-percent annual chance flood elevations do not include any statistics for the South End, which begins to be affected at higher flood elevations.

RECOMMENDED OPTIONS IN FORT POINT CHANNEL

The recommended mid-term option in the Fort Point Channel is Option A, which is a 4 to 6 foot-tall perimeter solution on the east side of the channel. Option A can be completed incrementally, whereas Option B cannot; therefore, Option A will provide more immediate necessary flood risk reduction, and can be adapted to higher elevations over time. It will be more costly and technically challenging to adapt Option B to higher elevations over time. In the long term, it could be appropriate to combine Options A and B. Resilience improvements on the west side of the Fort Point Channel will be required in the long term (2050s and beyond), but are outside of the scope of this study.

By the 2040s, elevating the waterfront from Martin's Park to the South Boston Manufacturing Center will provide a continuous line of protection with opportunity to significantly enhance the existing waterfront. In order to be effective, the resilient coastal design solution on each property must tie into the neighboring property. Once near- and mid-term actions in the Fort Point Channel area, described below, are implemented, over 1100 residents and over 100 buildings would be protected up to the 1-percent annual chance event with 9 inches of sea level rise. Although the design height exceeds this elevation, flooding from other areas could impact these properties. When



RECOMMENDED OPTION

OPTION A

Option A aligns with the perimeter of the Fort Point Channel.

OPTION B

Option B aligns with the mouth of the Fort Point Channel.

combined with protections on the South Boston Waterfront, Seaport Boulevard, Raymond L. Flynn Marine Park, and Reserved Channel, the number of people and buildings protected in the area is much higher.



Long-term coastal resilience solutions in Fort Point Channel could build on the proposed near- and mid-term solutions to further enhance resilience and enjoyment of the area. The footbridge and accompanying recreational area in the center of the channel are intended as examples only and are not included in project cost estimates.

Costs of Recommended Coastal Resilience Design Option in Fort Point Channel



Implementation Period	Area	Capital Cost Range	Annual Maintenance Cost Range
Near-term	1. 100 Acres Master Plan	\$2M to \$12M	\$0.03M to \$0.18M
	2. GE Headquarters	\$1M to \$4M	\$0.02M to \$0.06M
	3. Arcade	*	*
Mid-term	4. South Boston Manufacturing Center (by 2030)	\$3M to \$13M	\$0.05M to \$0.19M
	5. Boston Children's Museum (by 2030)	\$5M to \$6M	\$0.08M to \$0.09M
	6. Between Bridges (by 2030)	\$9M to \$10M	\$0.13M to \$0.15M
	7. Martin's Park (by 2030)	\$4M to \$5M	\$0.07M to \$0.08M
	8. South End of the Fort Point Channel (2030s)	\$34M to \$39M	\$0.51M to \$0.59M
Long-term	Additional Enhancements to Fort Point Channel	\$49.3M to 49.5M	\$0.74M
Total		\$108M to \$139M	\$1.6M to \$2.1M

**In the near-term, the Arcade will require an engineering assessment to determine whether it is structurally sound to withstand flooding to the 1-percent annual chance flood elevation with 9 inches of sea level rise. In the mid-term, the Arcade will require more significant action to reduce flood risk to the target elevation, the 1-percent annual chance elevation with 40 inches of sea level rise.*

NEAR-TERM ACTIONS

1. 100 Acres Master Plan: The 100 Acres Master Plan property located between the GE Headquarters site and the P&G/Gillette South Boston Manufacturing Center is currently undeveloped. The park planned for the area can be designed to accommodate an elevated walkway and reduce risk from a significant current and future flood pathway. In the near term, a 6 foot-tall berm (to elevation 14 NAVD88) along the waterfront could provide the foundation for future improvements. Likewise, given funding availability in the near-term, a full 40 foot-deep elevated park space can be implemented without precluding future development. Near-term cost estimates for this area range from \$2 to \$12 million depending on the extent of initial elevated park space development. It is also worth exploring leveraging these actions to improve stormwater storage.

2. GE Headquarters: GE is taking the lead on adaptation for future flood risks and sets an example. The GE project comprises a new building, new Harborwalk and open space, and a retrofitted wharf building elevated above the 0.2 percent annual chance flood elevation with 21 inches of sea level rise. The Harborwalk transitions up from existing grade to form a berm that protects the buildings and can be integrated into a district scale solution. For longer term flood risks (40 inches of sea level rise) the site will need to be modified with greater elevation. The project's open space setback from the water's edge would be adaptable to higher elevations.

Modifications to current designs could extend flood mitigation further inland, as well as increase the length of time the improvements will be effective against flooding and sea level rise. Optional improvements to Necco Court, which forms a flood pathway inland from the waterfront, include a flood gate across the street, elevating a portion of the street (not costed), or flood wall or berm at the Harborwalk in front of the street. To the south of GE, options include a berm or elevated parkspace that ties into the adjoining 100 Acres Master Plan property. Preliminary options for the GE Headquarters site cost \$1 to \$4 million. The lowest cost option is a 6 foot-tall waterfront berm designed to tie into adjoining properties.

3. Arcade: A more detailed engineering analysis, estimated at \$40,000, is required to understand the structural integrity of the buildings and the nature of the flood protection solution that would be most feasible for this area along the channel. A separate flood wall is likely needed immediately adjacent to the building facade. A design elevation higher than the base elevation (1-percent annual chance water elevation with 9 inches of sea level rise) may require significant modification of the arcade. This is the only area along the Channel where near-term action is expected to be lower than the target elevation. Action is necessary in the mid-term to achieve the target elevation and create the continuous flood protection perimeter necessary along the east side of the Channel.

MID-TERM ACTIONS

4. South Boston Manufacturing Center: The South Boston Manufacturing Center is a manufacturing facility that has been in place for around a century and requires an active relationship with the waterfront for business continuity. Options include a 4 to 5 foot-tall flood wall or elevated Harborwalk and park space. Similar to the 100 Acres Master Plan site, the cost range in this area is \$3 million to \$13 million and depends upon the nature and extent of park space integrated into the solution at the time of implementation.

5. Boston Children's Museum: The Children's Museum is initiating a planning process to renovate its grounds and integrate resilience improvements. Flood protection measures of 4 feet above existing grade to meet the target elevation can be integrated in the landscape as planters, steps, and other features. The museum is exploring longer term measures that may include expanding the waterfront and access to the water. Preliminary options for the Boston Children's Museum property range from \$5 to \$6 million.

6. Between Bridges: The area between the Summer Street and Congress Street bridges has structures overhanging the water with an abutting walkway. An alleyway between the structures is a flood pathway. Recommended actions include bulkhead improvements and a 5 to 6 foot sister wall blending into the structures. The alleyway would receive a localized flood gate and the adjoining bridge needs guardrail improvements under both options. The cost range is \$9 to \$10 million.

7. Martin's Park: Martin's Park is under construction. Resilience improvements are being integrated into the current design to avoid costly renovations that will be necessary before 2030. The cost to plan, engineer and design, permit, and construct a four foot berm with park space across the existing property is roughly \$4 to \$5 million. An unknown portion of this cost is likely captured within the existing design of the park, which elevates portions of the waterfront.

8. South End of the Fort Point Channel: Flood protection options (i.e., elevated Harborwalk, flood walls, berms to a height of 4 to 5 feet above existing grade) are \$34 to \$39 million and will cut off a long term flood pathway to the South End. Higher cost in this area is due to the length of flood protection required and the multiple bridges. It may be feasible to integrate flood protection into current planned improvements to Cabot Yard.

LONG-TERM ACTIONS

All long-term recommendations along the east side of Fort Point Channel could cost \$108 million to \$139 million, including the near-term and mid-term costs above. These include additional actions, as follow:

- » Installing flood protection actions at the Arcade to the target 1-percent annual chance flood elevation with 40 inches of sea level rise
- » Additional boardwalk and park space enhancements along the waterfront for social and recreational benefit

No additional height over the target elevation (14 feet NAVD88) is included in this estimate.

RECOMMENDED OPTIONS IN SOUTH BOSTON WATERFRONT

MID-TERM ACTIONS

Options A and B are recommended to move forward for further evaluation. Along the South Bay Harbor Trail from the federal courthouse to the marina, at the end of Pier 4, and in the existing Fan Pier Civic Park, both Options A and B would elevate and renovate or enhance park space over existing land. Where space is more constrained, such as the southern edge of the federal courthouse, the western edge of the marina, the eastern edge of Pier 4, and the front of ICA, Option A proposes floodwalls, bulkheads with backfill, and boardwalk over water to retain and enhance existing enjoyment of the waterfront. Option B is similar to Option A, but proposes filling in new park space over water in front of the ICA and along the western edge of the marina. A roadway and pedestrian gate would be required for both options at Northern Avenue Bridge.

Options A and B range in cost from \$53 million to \$106 million, respectively. While Option B would not particularly increase effectiveness, it would add benefit in the form of improved recreational space and access to the waterfront over Option A. An interim option to explore would expand the harborwalk even further over the marina than proposed by Option A, without the use of fill. Like the fill option, this option would not increase flood risk reduction, but would improve access and enjoyment of the waterfront.



RECOMMENDED OPTIONS

OPTION A	OPTION B	OPTION C	OPTION D
Option A provides flood protection along the <u>perimeter</u> of the South Boston Waterfront, making use of existing available space.	Option B <u>fills in a portion of the marina</u> to expand public space and recreation areas.	Option C includes a <u>new Harborwalk or levee across the marina entrance</u> with a floodgate for boat entry and exit.	Option D would use Seaport Boulevard as a floodwall in the form of a raised center roadway with planters.

Both Options A and B can be completed incrementally, will include all properties within the flood protection alignment, and can be adapted to higher elevations over time. Further evaluation and coordination is required to determine whether Option A or B would be more appropriate in the mid term, though Option A could be adapted into Option B over time, and as regulatory change to facilitate Option B is achieved (see 04 Regulatory Resilience Solutions).

Option D could be combined with Options A or B to provide a second line of defense in the long term.

Costs of Recommended Mid-term Coastal Resilience Options in the South Boston Waterfront

Implementation Period	Area	Capital Cost Range	Annual Maintenance Cost Range
Mid-term	South Boston Waterfront (2030s and 2040s)	\$53M to \$106M	\$0.8M to \$1.6 M



Recommended Option A

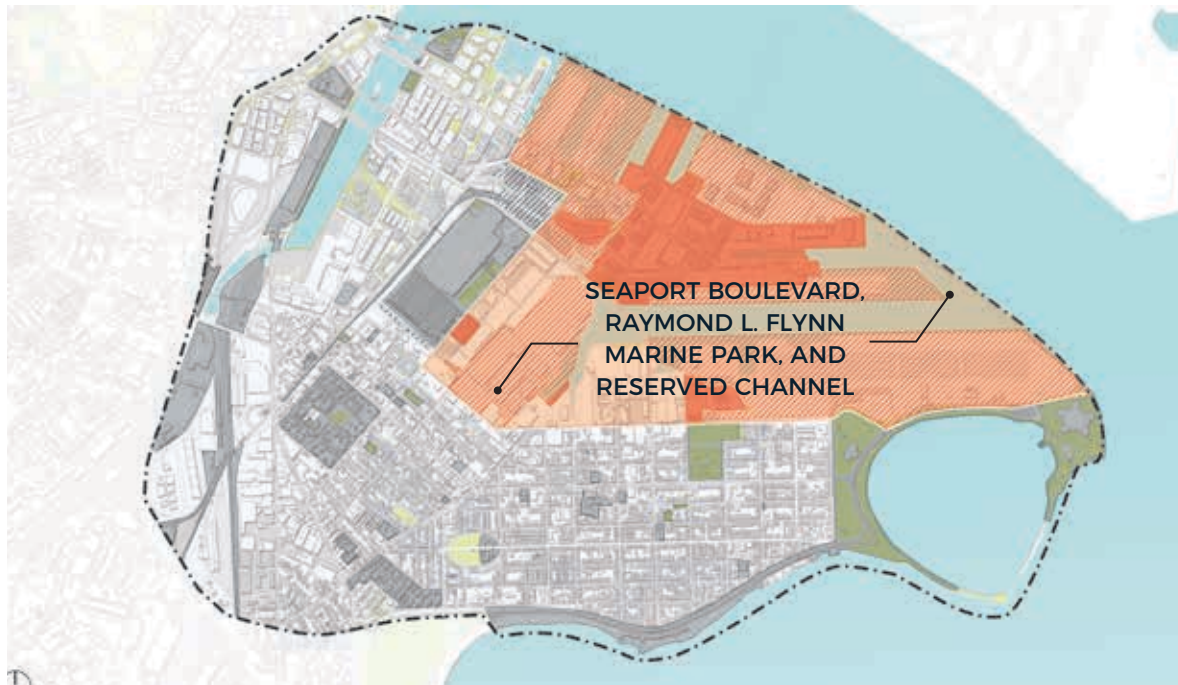


Recommended Option B

TRACK 2: SEAPORT BOULEVARD, RAYMOND L. FLYNN MARINE PARK, RESERVED CHANNEL

CHARACTERISTICS:

- » *Predominantly Massport and City land ownership*
- » *Stakeholders emphasize maintenance of operations*
- » *Opportunities to leverage planned capital improvements and new development / redevelopment*
- » *Technical solutions must accommodate ship to shore activities in multiple areas*



**TRACK 2 ESTIMATED CAPITAL
COST (RECOMMENDED OPTIONS):**

\$234 million to \$389 million

**TRACK 2 ESTIMATED ANNUAL
MAINTENANCE COST:**

\$3.6 million to \$5.8 million

Track 2 consists of Seaport Boulevard, the Raymond L. Flynn Marine Park and the Reserved Channel. The most urgent actions in this area address flood pathways along Seaport Boulevard. Low-lying land to the east of the Fish Pier is at current risk of coastal flooding. Two additional flood pathways begin to the east of the Pavilion. These flood pathways combine with others in the Raymond L. Flynn Marine Park and Reserved Channel to inundate both the Raymond L. Flynn Marine Park and Pappas Way to the edges of the South Boston neighborhood. Longer-term, measures are designed to be high enough to provide effective flood protection from the 1-percent annual chance flood with 40 inches of sea level rise (2070s). Coastal resilience actions in Seaport Boulevard, Raymond L. Flynn Marine Park, and Reserved Channel, in addition to those proposed in South Boston Waterfront and the east side of Fort Point Channel are all required to prevent flooding in inland areas of South Boston from flooding at the 5-percent annual chance flood elevation with 9 inches of sea level rise. Flood protection along Seaport Boulevard could independently mitigate over \$30 million in losses in the form of direct physical damage to buildings, as well as their contents and inventory, and displacement and relocation costs by the 2030s.

Track 2: Reduced Exposure and Loss Expected as a Result of Coastal Resilience Solutions

Track 2 coastal resilience solutions will mitigate exposure and impacts from flooding with 0 sea level rise, as well as 9, 21, and 40 inches of sea level rise. Nevertheless, with 21 and 40 inches of sea level rise, Track 2 strategies become interdependent with Track 1.* ^

	1-PERCENT ANNUAL CHANCE ELEVATION WITH NO SEA LEVEL RISE	1-PERCENT ANNUAL CHANCE ELEVATION WITH 9 INCHES OF SEA LEVEL RISE	1-PERCENT ANNUAL CHANCE ELEVATION WITH 21 INCHES SEA LEVEL RISE	1-PERCENT ANNUAL CHANCE ELEVATION WITH 40 INCHES SEA LEVEL RISE
REDUCED NUMBER OF RESIDENTS EXPOSED	170+	930+	Track 2 coastal resilience solutions must be combined with Track 1 coastal resilience solutions to be effective at mitigating loss across the Track 2 area at these flood elevations.	
REDUCED NUMBER OF BUILDINGS EXPOSED	5	146		
EXPECTED REDUCTION IN DIRECT PHYSICAL DAMAGES AND RELOCATION COSTS	\$29 million	\$757 million		

*Exposure and expected impacts are relative to specific flood elevations, and not specific flood events. It is very rare that flood elevations are even across a landscape during any given event.

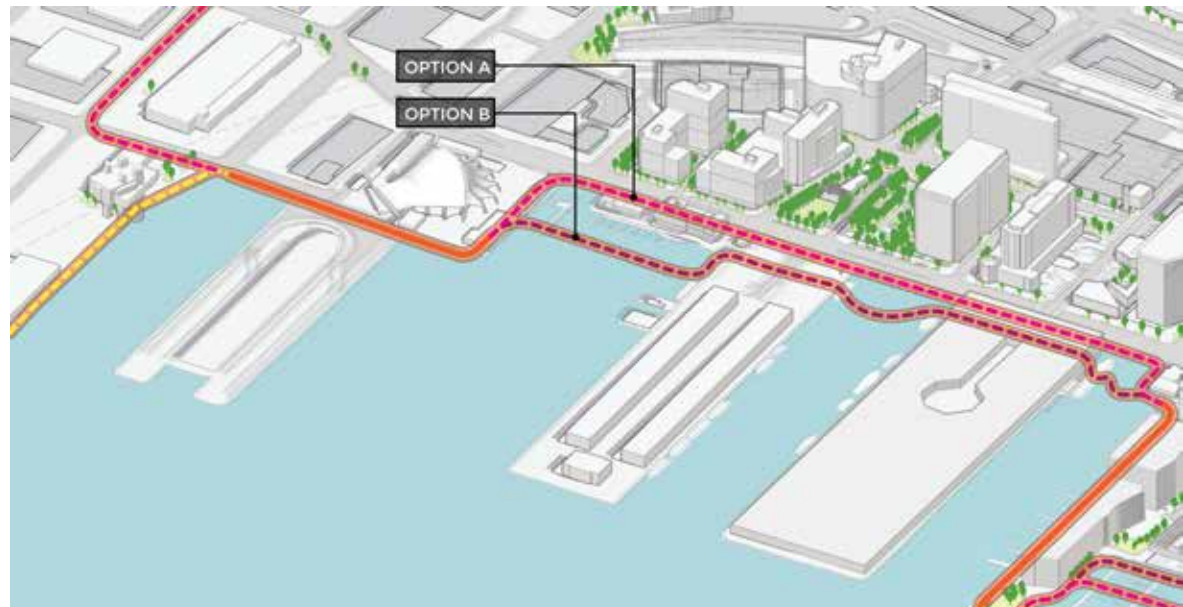
^Values do not include structures that would be seaward of the coastal resilience design strategy alignment and require independent flood mitigation.

RECOMMENDED OPTIONS IN SEAPORT BOULEVARD

The recommended near-term approach for Seaport Boulevard is Option A. Option A proposes lower floodwalls with possible boardwalks over water extending behind and on either side of the World Trade Center. At the Fish Pier, the flood walls would need to extend across the property and provide flood gates for vehicular access. Coordination with Massport will help determine the width of the gates to avoid impacting existing operations. New park space over existing land can be integrated to the west and far east of dry dock 4. Structures outside of the coastal resilience design solution will require independent floodproofing.

Option A is recommended because it makes use of existing space, could be implemented more quickly than Option B, and is expected to be less disruptive of existing maritime operations than Option B.

Near-term actions are to the 1-percent annual chance elevation with 9 inches of sea level rise plus 1 foot of freeboard but would be adapted in the mid- to long-term to the target elevation (the 1 percent annual chance elevation with 40 inches of sea level rise plus one foot of freeboard). The lower elevation is recommended by stakeholders in the near term with Option A as it would be less disruptive to existing sight lines than a higher elevation.



RECOMMENDED OPTION

OPTION A

Option A aligns with the existing shoreline and makes use of existing space along Seaport Boulevard.

OPTION B

Option B builds out into the water to expand the waterfront, providing flood protection and limiting impacts to sight lines. Option B would require fewer mechanical gates than Option A.

Over time, Option A can be expanded to improve waterfront access, and would not preclude implementation of Option B in the mid or long term.

Costs of Coastal Resilience Design Options in Seaport Boulevard

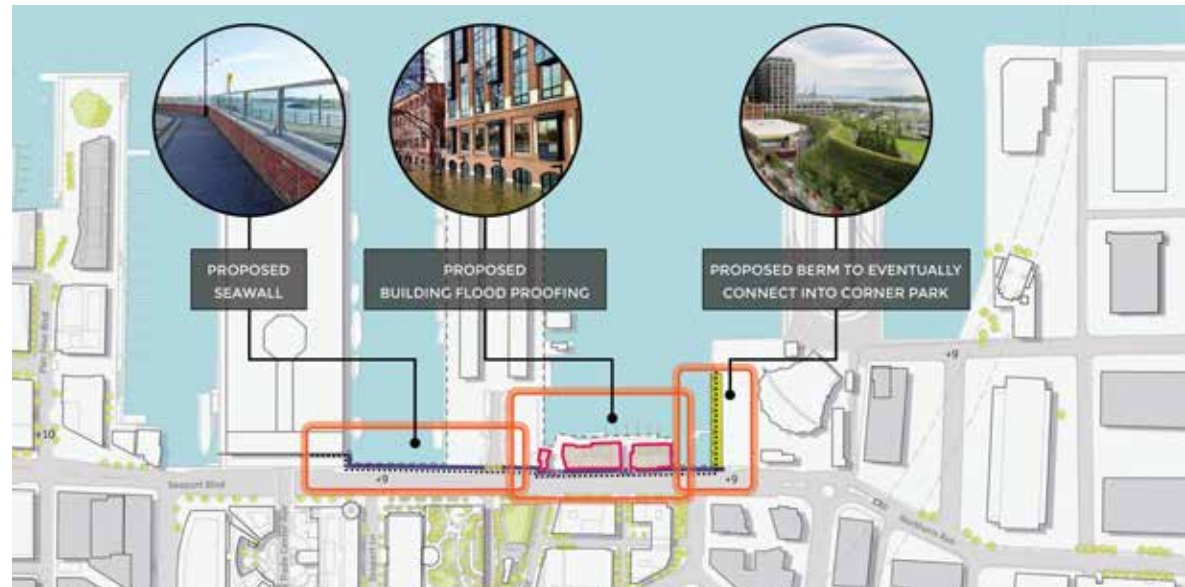
Implementation Period	Area	Capital Cost Range	Annual Maintenance Cost Range
Near-term	Seaport Boulevard between World Trade Center and Blue Hills Bank Pavillion	\$19M to \$22M	\$0.28M to \$0.33M
Mid-term	Remainder of Seaport Boulevard	\$18M to \$140M	\$0.27M to \$2M
Total		\$37M to \$161M	\$0.55M to \$2.4M

Massport has undertaken a comprehensive approach to address resilience of its infrastructure and operations in South Boston, including a Maritime Flood Operations plan and floodproofing of critical facilities. Massport remains committed to ensuring the long term viability of the district.



NEAR-TERM ACTIONS

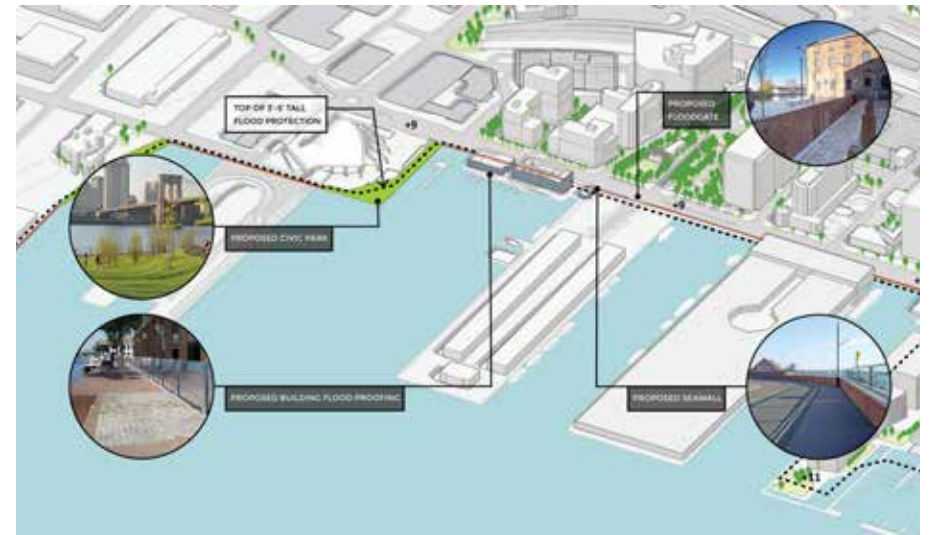
The near-term action area for Seaport Boulevard begins between the World Trade Center and the Fish Pier and extends to the Blue Hills Bank Pavilion above Northern Avenue. Near-term flood protection would consist of new seawalls, dry floodproofing buildings seaward of the coastal resilience solutions (not included in costs), and a small earthen berm to reduce current flood risk while providing flexibility for future height or design adaptation. Design considerations and coordination with local stakeholders will be required to avoid disruption of existing maritime uses in the area. The cost will be between \$19 million and \$22 million, not including floodproofing of the buildings on the pier (expected to cost an additional \$29 to \$33 million).



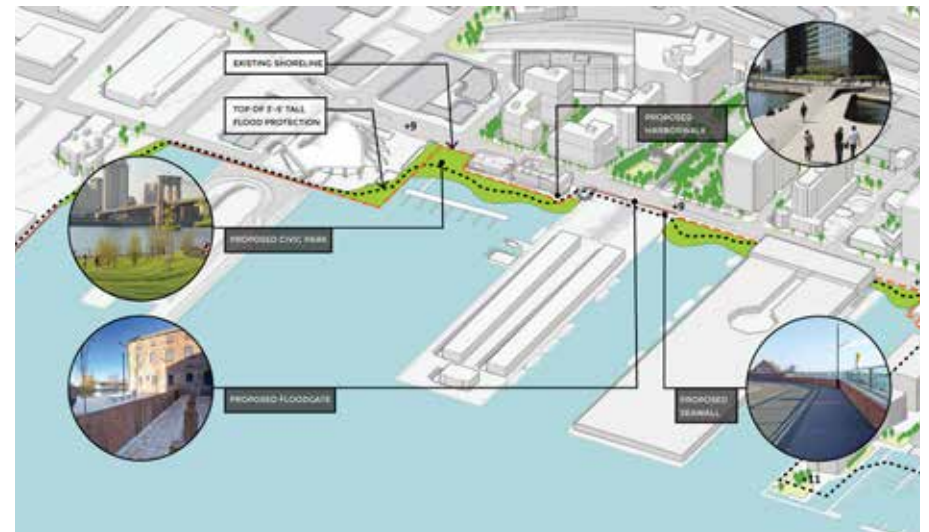
Near-term strategies along Seaport Boulevard

MID-TERM ACTIONS

Flood resilience actions are needed along the remainder of Seaport Boulevard and around Dry Dock 4 in the mid-term (by 2030), and actions on neighboring properties must tie into one another to provide a seamless layer of flood risk reduction. The cost range to complete all recommended coastal resilience actions along Seaport Boulevard is \$37 million to \$42 million for Option A (this number includes the cost of the near-term actions, but does not include flood resilience for the buildings outside of the alignment on the Fish Pier). Option B, which would include the restaurants, is expected to cost \$140 million to \$161 million, not including the costs of any near-term actions. Floodproofing of the Fish Pier and World Trade Center could cost \$113 million to \$131 million. Both actions could be developed to the 1-percent annual chance elevation with 40 inches of sea level rise plus one foot of freeboard, and be adaptable to higher elevations. Further engagement is required to determine the recommended option for mid-term implementation. Currently, stakeholders are torn between the need to maintain existing maritime operations (Option A) and enhance access to the waterfront (Option B). It is possible that the design process could reconcile both perspectives.



Option A (Recommended)



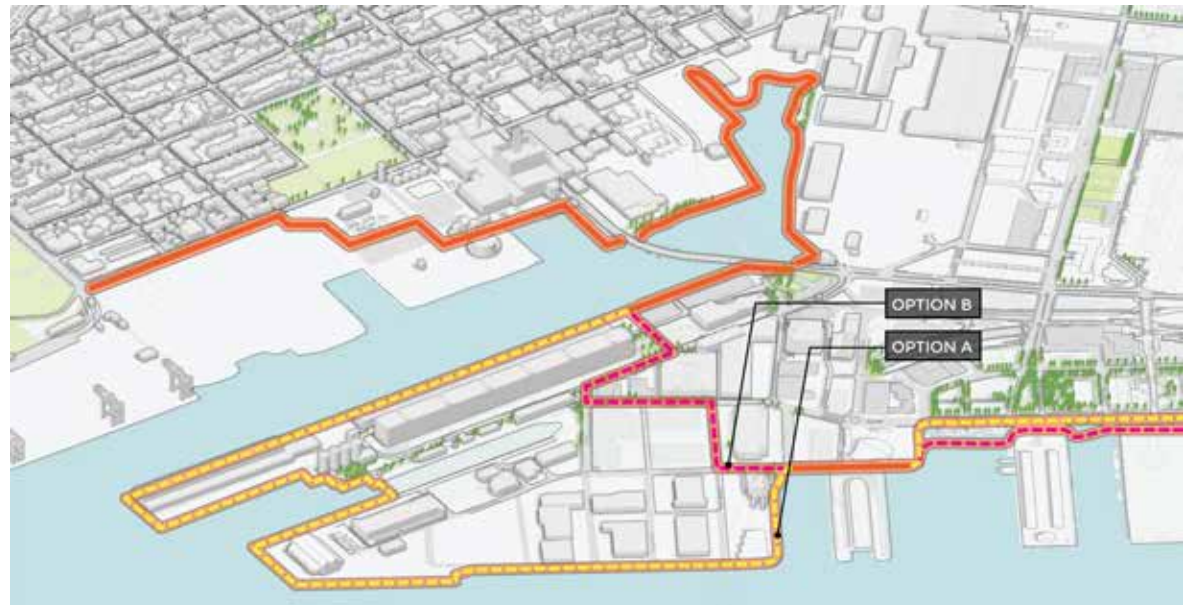
Option B

RECOMMENDED OPTION IN RAYMOND L. FLYNN MARINE PARK AND RESERVED CHANNEL

The recommended mid-term and long-term coastal resilience option in the Raymond L. Flynn Marine Park and long Reserved Channel consists of resilience actions along the perimeter of the waterfront (Option A). Option A will protect the highest number of properties and present the least amount of operational disruption. Nevertheless, careful design would be required to prevent disruption of current or planned ship to shore connections. The total cost for all actions proposed in the area is expected to range between \$197 million and \$228 million.

MID-TERM ACTIONS

Raymond L. Flynn Marine Park: Option A proposes a variety of flood protection design solutions, depending on the area. The area of the Massport Marine Terminal may be appropriate for an earthen berm. Bulkhead and backfill with a small new park space is proposed at the harbor side of Seafood Way. A combination of floodwall and new green space is proposed adjacent to the waterfront to the west of Seafood Way. A tide gate will be required at the dry dock, though enhanced park space may be possible immediately to the south of the dry dock, at the curve of Dry Dock Ave. A floodwall is proposed along the waterfront at the Flynn Cruiseport Boston at the Black Falcon Terminal.



RECOMMENDED OPTION

OPTION A

Option A provides flood protection along the perimeter of the Raymond L. Flynn Marine Park and Reserved Channel.

OPTION B

Option B aligns flood protection along roadways interior to the Marine Park to cut off the flood pathway. Option B would require floodproofing and additional adaptive action seaward of the solution.

Reserved Channel: There is opportunity in Reserved Channel to make use of living shoreline, elevated boardwalk, and new habitat and green space at the base of the channel, in addition to elevated roadways and reinforced guardrails on Summer Street. The option extends further inland to the east of the Exelon New Boston Generating Station in the form of a proposed floodwall with access gates and potential park space adjacent to the neighborhood seaward of Christopher J. Lee Playground.

Proposed actions along Pappas Way and in front of the former Edison Power Plant in Reserved Channel, and at the drydock in the Raymond L. Flynn Marine Park will need to be in place prior to 2030 as these areas are at risk to flooding from at least the 20-percent (1 in 5) annual chance flood elevation with 9 inches of sea level rise (2030s).

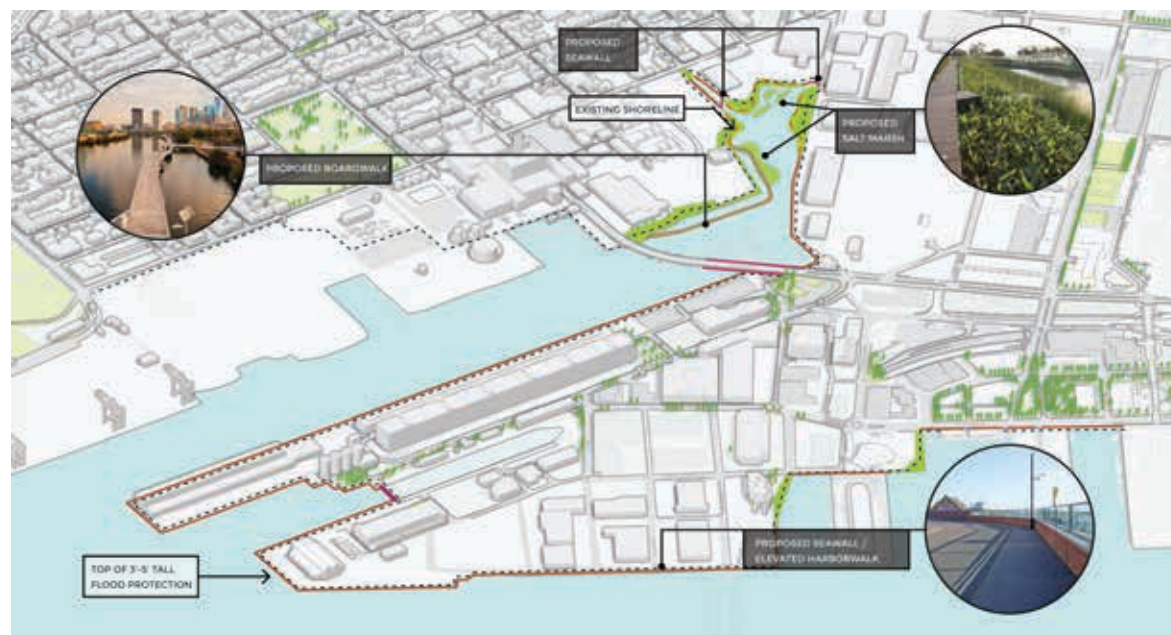
Actions in the southern basin of the Reserved Channel, immediately adjacent to the Conley Terminal, and through the majority of the Raymond L. Flynn Marine Park should be in place by some time in the 2030s, as these areas are at risk to the 5-percent (1 in 20) annual chance flood event with 9 inches of sea level rise (2030s).

LONG-TERM ACTIONS

The Flynn Cruiseport Boston at the Black Falcon Terminal is at lower risk and requires action by the 2060s, though may require more site specific flood risk evaluation to confirm this timeframe is appropriate.

Costs of Recommended Mid-term and Long-term Coastal Resilience Design Option in the Raymond L. Flynn Marine Park and Reserved Channel

Implementation Period	Area	Capital Cost Range	Annual Maintenance Cost Range
Mid-term	Raymond L. Flynn Marine Park (by 2030 and 2030s)	\$108M to \$124M	\$1.6M to \$1.9M
Mid-term and Long-term	Reserved Channel (by 2030, 2030s, and 2060s)	\$90M to \$104M	\$1.4M to \$1.6M
Total		\$197M to \$228M	\$3.0M to \$3.4M



Option A (Recommended)

TRACK 3: PLEASURE BAY AND DAY BOULEVARD

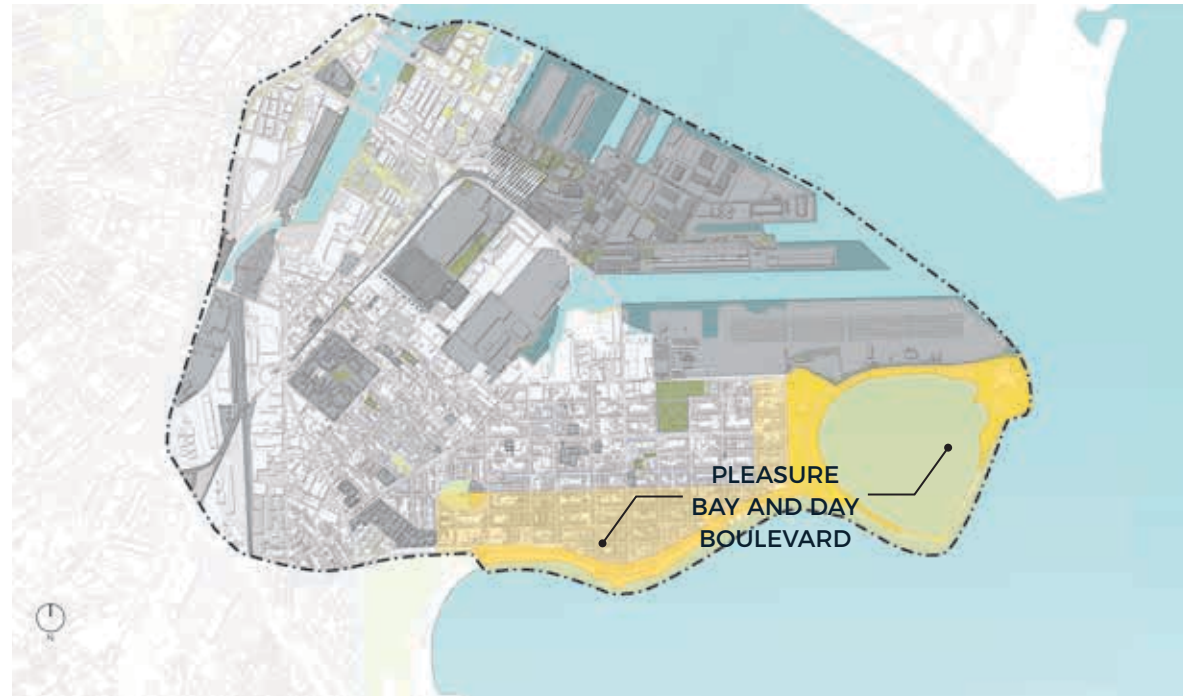
CHARACTERISTICS:

- » *Predominantly Commonwealth / Department of Conservation and Recreation land ownership*
- » *Emphasis on amenity retention*
- » *Could fit within DCR's existing master planning process*

FEMA provides funding for post-disaster restoration of engineered and regularly nourished and maintained, but not natural beaches. It would be useful for the Commonwealth to conduct a beach nourishment evaluation and develop a master plan with the City for the beaches at Pleasure Bay and along Day Boulevard. Resilient design can be integrated with the engineering of the beach to provide the following benefits:

- » Protect the beach amenities in the case of a storm event
- » Support eligibility for federal funding in the case of a presidential disaster declaration.

Resilient design of the beaches will mitigate risk to residential property north of Day Boulevard.



TRACK 3 ESTIMATED CAPITAL COST (RECOMMENDED OPTIONS):

\$210 million to \$299 million

TRACK 3 ESTIMATED ANNUAL MAINTENANCE COST:

\$3.2 million to \$4.5 million

Track 3 includes Pleasure Bay and Day Boulevard. While 13 waterfront homes and properties are at risk of flood loss from the 1-percent annual chance flood elevation with 9 inches of sea level rise, the majority of the historical South Boston residential neighborhood is at relatively low flood risk due to its presence on relatively high ground. Near Pleasure Bay at 40 inches of sea level rise, the residential neighborhood is not expected to see significant inland flooding beyond Farragut Road, though the beaches are expected to flood at least annually (2070s). Flooding along Day Boulevard is expected to be more severe and could extend a block inland at both the 1 percent annual chance elevation with 9 inches of sea level rise (2030s) and the 1-percent chance elevation with 40 inches of sea level rise (2070s). The flood extent doesn't change significantly over this time period because the grade changes to significantly higher ground. Nevertheless, the parks and beaches risk destruction, erosion, and loss of use due to coastal storms under current flood risk conditions.

Coordination between the City and DCR is needed in the near term to develop a master plan for the area that will yield mid- and long-term flood resilience for continued use and enjoyment of the waterfront.

Track 3: Reduced Exposure and Loss Expected as a Result of Coastal Resilience Solutions

Track 3 coastal resilience solutions will independently mitigate exposure and impacts from flooding with 0, 9, 21, and 40 inches of sea level rise.*^ **Please note that this does not include reduced losses to the beach, roadway, tourism, quality of life, and recreational value in this area. Without action, there will be significant loss of important community assets that has not been quantified.**

	1-PERCENT ANNUAL CHANCE ELEVATION WITH NO SEA LEVEL RISE	1-PERCENT ANNUAL CHANCE ELEVATION WITH 9 INCHES OF SEA LEVEL RISE	1-PERCENT ANNUAL CHANCE ELEVATION WITH 21 INCHES SEA LEVEL RISE	1-PERCENT ANNUAL CHANCE ELEVATION WITH 40 INCHES SEA LEVEL RISE
REDUCED NUMBER OF RESIDENTS EXPOSED	No residents in area	No residents in area	145	620+
REDUCED NUMBER OF BUILDINGS EXPOSED	3	13	41	130
EXPECTED REDUCTION IN DIRECT PHYSICAL DAMAGES AND RELOCATION COSTS	\$0.39 million	\$11 million	\$41 million	\$77 million

*Exposure and expected impacts are relative to specific flood elevations, and not specific flood events. It is very rare that flood elevations are even across a landscape during any given event.

^Does not include statistics for any structures seawards of the coastal resilience design strategy.

PLEASURE AND DAY BOULEVARD OPTIONS

Further engagement and evaluation is required to determine whether Option A or B provide the recommended approach for Pleasure Bay or Day Boulevard. Option B provides the most protection to existing beaches and would leverage natural features to reduce flood risk to waterfront properties. Option B would also support possible FEMA funding for beach restoration in the case of future presidential disaster declarations. Nevertheless, Option B is the more costly option and would require periodic beach nourishment, requiring increased maintenance over time when compared to adaptation features constructed on land.

This area has more design flexibility than other areas of South Boston. For example, the public right-of-way between Columbia Drive and the beach could be adapted to sea level rise through elevated roadways, Harborwalk, beach nourishment, flood walls, and more. DCR and the City can explore combinations of options and conduct further evaluation through a coordinated master plan.

MID-TERM ACTIONS

Pleasure Bay: Option A involves reinforcing the existing flood wall along Conley Terminal and elevating and enlarging the perimeter of the Bay. The option would have the simultaneous benefit of providing flood protection and expanding access to the perimeter of Pleasure Bay. Option B would elevate and enhance Marine Park to mitigate inland flooding, but would not protect the perimeter of Pleasure Bay.



OPTION A

Option A is characterized by coastal hardening and is aligned with the perimeter of the neighborhood, including Pleasure Bay and a floodwall/raised Harborwalk at Day Boulevard.

OPTION B

Option B is characterized by coastal restoration and inland flood protection through the Marine Park and along Day Boulevard/Columbia Road. Option B excludes Pleasure Bay and the neighborhood's southern beaches, and involves beach nourishment and Farragut Road park elevation.

** These options can be mixed and matched. For example, Option A for Day Boulevard could be paired with Option B for Pleasure Bay and vice versa.*

Some road elevation and renovation of existing park space would be required near the intersection of Farragut Road and Day Boulevard.

Day Boulevard: Option A is aligned with the harborwalk behind the Carson Beach L and M street beaches, and behind the L Street Bathhouse. Independent floodproofing would be required for structures seaward of the coastal resilience design solution. Option B includes Option A recommendations, but adds dune and beach restoration in order to provide additional protection and retention of the beaches.



Option A (Recommended)



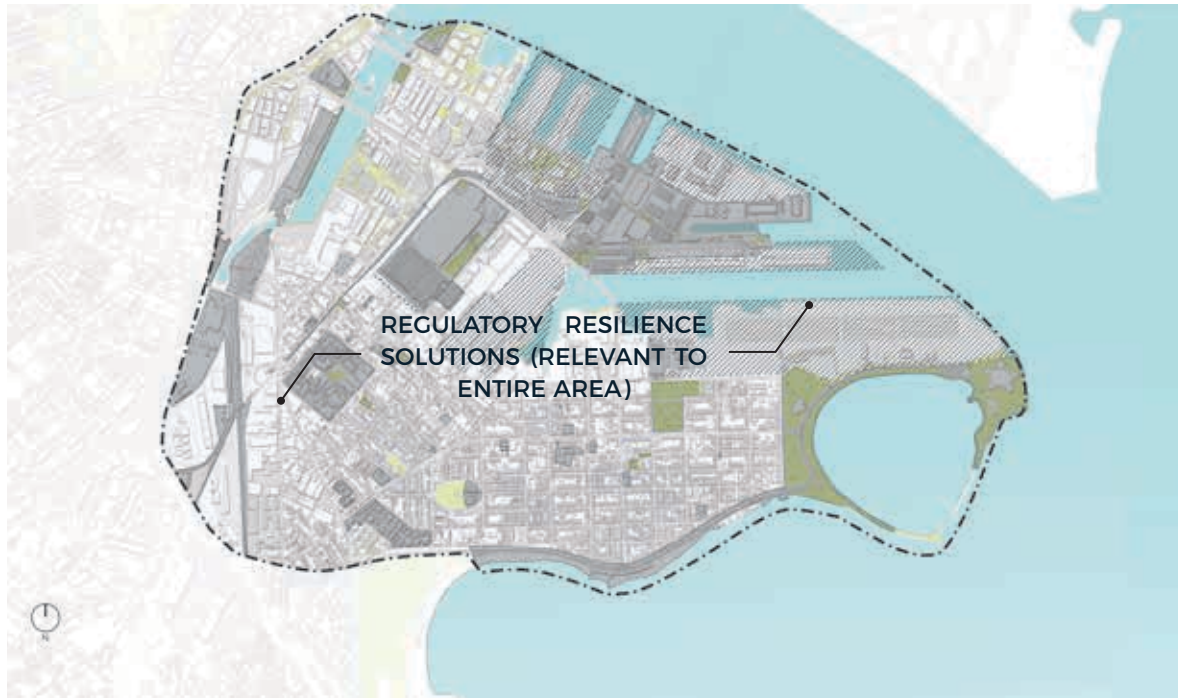
Option B

TRACK 4: REGULATORY RESILIENCE STRATEGIES

Near-term actions in Fort Point Channel and Seaport Boulevard need to be implemented before regulatory change proposed in 04 *Regulatory Resilience Strategies* is likely to be accomplished. Mid-term actions in Fort Point Channel, South Boston Waterfront, and Seaport Boulevard may benefit from near- to mid-term changes in standards or how resilience projects are reviewed by regulators.

Steps that the City can take by the 2040s to change the regulatory landscape include:

- » **Boston Planning and Development Agency:** Develop a Flood Resilience Overlay District that establishes design guidelines based on anticipated future flood levels. Incorporate more stringent standards or flexible incentives into the sections of City Ordinances and Zoning Code that incorporate elements of Chapter 91, Wetlands Regulations, and the Massachusetts Building Code.
- » **Massachusetts Department of Environmental Protection Waterways, MassDEP Wetlands, and U.S. Army Corps of Engineers:** Adapt review and permitting processes for fill projects to consider flood protection needs and sea level rise, in accordance with 04 *Regulatory Resilience Strategies*.
- » **City of Boston Conservation Commission:** Consider local wetlands ordinance that provides consistent standards regarding fill projects which provide flood protection and other benefits, and mitigation requirements for such projects.
- » **Massachusetts Historical Commission and Boston Landmarks Commission:** Identify near-term retrofitting opportunities for historic buildings and infrastructure that will expedite MassHistoric review of coastal resilience solutions, particularly in the Fort Point Channel.



Next steps that the City can take by the 2040s for private property and infrastructure resilience strategies include the following and are detailed in 04 *Regulatory Resilience Strategies*:

- » Pilot a South Boston retrofit program for site-specific flood mitigation projects such as structure elevation, wet floodproofing, and dry floodproofing activities. FEMA grant programs target mitigation of properties with repetitive losses from natural hazards, but will consider projects with expected increased risk due to changing conditions such as sea level rise.
- » Continue and expand Infrastructure Coordination Committee efforts to establish integrated design standards, implementation strategies, and financing mechanisms to achieve long-term flood risk resilience.

Next Steps

The following actions constitute immediate next steps

Area	Actions
Fort Point Channel and the South Boston Waterfront	<ul style="list-style-type: none"> » Continue engagement with property owners and stakeholders » Complete agreements with near-term action area property owners » Advance near-term recommended option to engineering and design » Coordinate with property owners to initiate the Arcade engineering study
Seaport Boulevard, Raymond L. Flynn Marine Park, and Reserved Channel	<ul style="list-style-type: none"> » Initiate more detailed planning process for the area to advance and refine options (City and Massport in coordination with stakeholders)
Pleasure Bay and Day Boulevard	<ul style="list-style-type: none"> » Initiate more detailed planning process for the area to advance and refine options (City and DCR in coordination with stakeholders)
Regulatory Resilience Solutions	<ul style="list-style-type: none"> » Coordinate design standards for infrastructure agencies » Continue discussions with agencies that regulate fill and construction in/over water; U.S. Army Corps of Engineers, Massachusetts Department of Environmental Protection Wetlands, MassDEP Waterways, Boston Conservation Commission, Department of Conservation and Recreation, Massachusetts Office of Coastal Zone Management » Develop Flood Resilience Overlay District that enables stricter design standards in the future floodplain

