

Climate Ready Boston

# Potential District-Scale Coastal Flood Protection Locations Appendix

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# 1. INTRODUCTION

Based on a high-level analysis of existing topography, rights-of-way, and current known urban and environmental conditions as of the summer of 2016, Climate Ready Boston (CRB) identified eleven locations where flood protection systems may provide significant flood risk reduction benefits, although detailed feasibility studies with appropriate public and stakeholder engagement are required in order to better understand the costs and benefits of flood protection in each location.<sup>1</sup> These eleven locations are outlined in Table 1 below. Please refer to Strategy 5 in **Protected Shores** for figures depicting proposed flood protection alignments.

Coastal and riverine hazard data for CRB consist of four flood frequencies (the 10, 2, 1, and 0.1 percent annual chance events) for three different sea level rise scenarios (9 inches, 21 inches, and 36 inches), resulting in twelve total flood scenarios. CRB analysts evaluated the following in order to develop a preliminary understanding of potential project effectiveness:

- Whether, and under which flood scenarios, each alignment could be expected to benefit an area independently or would need to be part of a system of multiple alignments in order to provide flood loss mitigation to the area
- Number of buildings expected to benefit from each proposed alignment or system of alignments
- Annualized<sup>2</sup> structure damage and contents losses preliminarily expected to be mitigated by each proposed alignment or system of alignments
- Number of residents expected to benefit from each proposed alignment or system of alignments
- Land area expected to benefit from each proposed alignment or system of alignments

CRB analysts evaluated independent effectiveness using the area of flood extent for each flood scenario, rather than depth grids. An alignment is no longer considered independently effective when flood waters from other inundation points begin to affect that alignment's benefitting area.

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<sup>1</sup> Important additional factors, including existing drainage systems, underground transportation and utility structures, soil conditions, zoning, as well as any potential external impacts as a result of the project have not been studied in detail.

<sup>2</sup> Annualized benefits can be used to determine project cost effectiveness by applying a discount rate to benefits, capital costs, and maintenance costs over the expected project useful life and evaluating the ratio of the net present value of benefits over costs. A ratio of one or greater typically indicates that a project is cost effective. A ratio less than one, for an evaluation that is based entirely on avoided damage costs, does not necessarily mean that a project is not worthwhile. Cost effectiveness is one lens through which to evaluate the merits of a project.

This Appendix provides a series of tables and figures to help the reader understand the approximate expected benefits that may occur as a result of protection alignments that block various flood sources throughout Boston. This includes:

- An overview of the locations of protection alignments (Table 1)
- A chart and short text explanation that provides the expected independent and system effectiveness of proposed alignments by flood scenario (Table 2)
- Tables with expected benefits for each protection alignment and system of alignments (Table 3 through Table 7). For more detail about how benefits are calculated, please refer to the **Approach and Methodology for Asset Data Collection and Exposure and Consequence Analysis Appendix**.

Note that each protection alignment, or necessary combination of alignments, has one table per sea level rise scenario. When a flood protection system is expected to become effective within a sea level rise scenario, benefits are presented in an additive way: each table represents the amount of benefit added by a certain protection alignment to a system rather than presenting the entire benefit of the whole system.

## 2. ANALYSIS LIMITATIONS

- These estimates consider present day<sup>3</sup> residents and structures in the area, derived using methods outlined in the Asset Data Collection and Exposure and Consequence Analysis Appendix, and do not consider future growth.
- This set of potential locations for district-scale flood protection is not meant to be comprehensive, and additional infrastructure may be necessary to protect specific sites. Additionally, potential district-scale flood protection actions are only one piece of a multi-layered solution that includes prepared and connected communities, resilient infrastructure, and adapted buildings.
- All values within this approach are estimates based on hypothetical and modeled hazard scenarios, and known and unknown data limitations exist. These limitations are described where known. Real impacts of coastal and riverine flooding will differ based on the particulars of the event as it happens.
- The flood protection solutions explored herein are intended to represent optional configurations of one type of mitigation action, and are not intended to be prescriptive. The

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<sup>3</sup> Data collected in 2016, the contents of which are outlined within the Asset Data Collection and Exposure and Consequence Analysis Appendix

ultimate type and alignment of actions selected, as well as the timing and design of those actions, should follow a detailed technical and publicly engaged decision making process that considers factors in addition to flood risk mitigation (such as the social, technical, administrative, political, legal, economic, and environmental ramifications of any potential solution).

**TABLE 1. POTENTIAL FLOOD DEFENSE LOCATIONS AND DESCRIPTION**

Alignment Number	Alignment Name	Potential Alignment Description
1	Piers Park to Central Square	Location 1 focuses on flood entry points along the western and southern edges of the East Boston waterfront. Potential flood protection solutions could consist of a north/south alignment connecting high points near Central Square and Lopresti Park and an east/west alignment connecting high points at Maverick Square and Jeffries Point. The north/south segment could potentially tie into existing green space at Lopresti Park and could help create new waterfront access points along East Boston’s western edge. The east/west segment could potentially tie into existing and planned open spaces along the southern waterfront, such as Piers Park, Brophy Park, and Porzio Park.
2	Porzio Park	Location 2 focuses on a flood entry point in East Boston near where Jeffries Point meets Logan Airport. Potential flood protection solutions could connect high points at Sumner Street and Harborside Drive, near the entrance to the Ted Williams Tunnel, with the potential to tie in to existing green space along Massport’s Harborwalk Park.
3	Wood Island	Location 3 focuses on flood entry points along the northern edge of Logan Airport, just east of the Wood Island T station in East Boston. Potential flood protection solutions could connect high points along Belle Isle Inlet to the northern part of Logan Airport, with the potential to tie into existing green spaces at Constitution Beach or Wood Island Bay Edge Park.
4	Orient Heights	Location 4 focuses on flood entry points near Constitution Beach and along Chelsea Creek in East Boston. Potential flood protection solutions could consist of two segments: an eastern segment by Constitution Beach, connecting high points near Byron Street and Barnes Avenue, and a western segment by Chelsea Creek, connecting high points near Boardman Street and Eagle Street.
5 and 6	Schrafft Center and Sullivan Square	Locations 5 and 6 focus on a major flood entry point at low ground between I-93 and Bunker Hill Street, near Sullivan Square in Charlestown. Potential flood protection solutions could include permanent boundary protection along Bunker Hill Street; temporary barriers at the intersection of Medford Street and Bunker Hill Street; Engine 32/Ladder 9 entrance, and Schrafft’s building driveway; a deployable barrier for the Route 99 trench; regraded and elevated streets near flood entry points to provide perimeter boundary protection; and integrated flood protections and transportation improvements at Sullivan Square.
7	Downtown Waterfront	Location 7 is focused on flood entry points along the low-lying eastern edge of Downtown, starting in the North End and extending to the mouth of Fort Point Channel. Flood defense solutions could include a series of barriers, potentially encompassing floodwalls,

Alignment Number	Alignment Name	Potential Alignment Description
		greenways, or berms. Potential alignments include along the path of the Rose Kennedy Greenway, connecting high ground near Hanover Street in the north with high ground near Oliver Street in the south, or closer to the waterfront, with potential integration with Christopher Columbus Park.
8	New Charles River Dam	Location 8 addresses flooding by the Zakim Bridge/New Charles River Dam. Potential flood protection solutions could include a tide barrier across the mouth of Miller's River; a tide gate and connecting flood protection system just west of Littoral Way; or a deployable barrier across the railroad right-of-way connecting Charlestown and North Station.
9a	Seaport	Location 9a focuses on flood entry points along the edge of the Seaport District, including flooding from Fort Point Channel, Boston Harbor, and the Reserve Channel. The low-lying nature of the Seaport likely requires flood protection connections to high ground across Fort Point Channel. Potential flood protection solutions include a flood gate aimed at preventing storm surge from flowing into the Seaport District from Fort Point Channel. The gate could be placed at a number of locations, including the Northern Avenue Bridge, Seaport Boulevard Bridge, Congress Street Bridge, or Summer Street Bridge. The elevation of Summer Street on either side of the bridge is higher than the 1 percent annual chance flood event elevation with 36 inches of SLR, although other portions of Summer Street are lower. In addition to a gate across Fort Point Channel, flood protection solutions would require either a barrier system to connect to high ground south of West Broadway; perimeter protection near the Reserve Channel; or a gate across the Reserve Channel. Deployable gates would be required at intersections.
9b	Fort Point Channel	This location focuses on flooding along the southwestern portion of the Fort Point Channel, the primary flood pathway for the South End, northeastern Roxbury, and Widett Circle and Newmarket. Potential flood protection solutions could include an alignment along the northwestern edge of the channel, connecting high ground at the US Postal Service facility south of Summer Street to high ground near the Broadway Red Line station; partial filling-in of the channel, with a new waterfront edge that ties back to high ground on either side; or a tide gate crossing the Fort Point Channel.
10	Moakley Park/Columbia Point	Location 10 focuses on flood pathways along the Old Harbor and Savin Hill Cove. Potential flood protection solutions could include a landscaped berm or full elevation of Joe Moakley Park; a water-side alignment along William Day Boulevard; an alignment along Harbor Point; a landscaped berm or alignment running along the waterfront through Old Harbor Park; and an alignment along Old Colony Avenue. Flood defenses at Location 11 are most effective in combination with other defenses, but has potential to benefit Dorchester, South Boston, the South End, and southern portions of Downtown.

TABLE 2. COASTAL FLOOD PROTECTION ALIGNMENT AND SYSTEM EFFECTIVENESS CHART

Focus Area	Alignment Number	Alignment Name	9 inches of sea level rise				21 inches of sea level rise				36 inches of sea level rise			
			10%	2%	1%	0.1%	10%	2%	1%	0.1%	10%	2%	1%	0.1%
East Boston	1	Piers Park to Central Square					C(2)	C(2)	C(2)	C(2,3)	C(2,3)	C(2,3,4)	C(2,3,4)	C(2,3,4)
	2	Porzio Park					C(1)	C(1)	C(1)	C(1,3)	C(1,3)	C(1,3,4)	C(1,3,4)	C(1,3,4)
	3	Wood Island								C(1,2)	C(1,2)	C(1,2,4)	C(1,2,4)	C(1,2,4)
	4	Orient Heights										C(1,2,3)	C(1,2,3)	C(1,2,3)
Charlestown	5 and 6	Schrafft Center and Sullivan Square				C(8)		C(8)	C(8)	C(8)		C(8)	C(8)	C(8)
Downtown	7	Downtown Waterfront												
Downtown	8	New Charles River Dam											C(9,10)	C(9,10)
South Boston	9a <sup>4</sup>	Seaport				C(10)	C(10)	C(10)	C(10)	C(10)	C(10)	C(10)	C(8,10)	C(8,10)
South Boston	9b	Fort Point Channel				C(10)	C(10)	C(10)	C(10)	C(10)	C(10)	C(10)	C(8,10)	C(8,10)
Dorchester	10	Moakley Park/Columbia Point				C(9)	C(9)	C(9)	C(9)	C(9)	C(9)	C(9)	C(8,9)	C(8,9)

Legend

Alignment Expected to be Independently Effective	
Combination of Alignments [C] Expected to be Effective (single alignment expected to lose effectiveness due to expansion of flooded area under this scenario)	C(Alignment Numbers (#))
Limited Exposure to Coastal Flood Risk Expected at this Location	

<sup>4</sup> Reference to Alignment 9 alludes to either 9a or 9b, as the two alignments are meant to be alternative choices to protect against Fort Point Channel flooding.





TABLE 3. EAST BOSTON FOCUS AREA PROTECTION SYSTEM BENEFITS

Potential Citywide Benefits	Location 1: Piers Park to Central Square 9" SLR Scenario	Potential Citywide Benefits	Location 1,2: Piers Park and Porzio Park 21" SLR Scenario	Potential Citywide Benefits	Location 1, 2, and 3: Piers Park, Porzio Park, and Wood Island 36" SLR Scenario
Avoided Losses for One-Time 1% Annual Chance Event	\$185,522,233	Avoided Losses for One-Time 1% Annual Chance Event	\$541,296,332	Avoided Losses for One-Time 1% Annual Chance Event	Locations 1,2, and 3 are not likely independent beyond the 10% annual chance event.
Annualized Losses Avoided	\$6,003,968	Annualized Losses Avoided	\$36,325,210	Annualized Losses Avoided	\$62,994,225
Benefitting Structures	1581	Benefitting Structures	1560	Benefitting Structures	1716
Benefitting Population	10746	Benefitting Population	10499	Benefitting Population	11197
Benefitting Land Area (acres)	262	Benefitting Land Area (acres)	272	Benefitting Land Area (acres)	335

  

Potential Citywide Benefits	Location 2: Porzio Park 9" SLR Scenario	Potential Citywide Benefits	Location 1, 2, and 3: Piers Park, Porzio Park, and Wood Island 21" SLR Scenario	Potential Citywide Benefits	Location 1, 2, 3, and 4: Piers Park, Porzio Park, Wood Island, and Orient Heights 36" SLR Scenario
Avoided Losses for One-Time 1% Annual Chance Event	\$7,654,038	Avoided Losses for One-Time 1% Annual Chance Event	Locations 1 and 2 are an effective combination for the 1% annual chance event. Locations 1, 2, and 3 potentially combine for the 0.1% chance with 21" of SLR.	Avoided Losses for One-Time 1% Annual Chance Event	\$1,156,354,677
Annualized Losses Avoided	\$373,686	Annualized Losses Avoided	\$777,459	Annualized Losses Avoided	\$121,907,421

Benefitting Structures	25
Benefitting Population	63
Benefitting Land Area (acres)	5

Benefitting Structures	1765
Benefitting Population	11324
Benefitting Land Area (acres)	408

Benefitting Structures	2432
Benefitting Population	14797
Benefitting Land Area (acres)	651

Potential Citywide Benefits	Location 4: Orient Heights 9" SLR Scenario
<i>Avoided Losses for One-Time 1% Annual Chance Event</i>	\$1,235,358
<i>Annualized Losses Avoided</i>	\$260,905
<i>Benefitting Structures</i>	443
<i>Benefitting Population</i>	2532
<i>Benefitting Land Area (acres)</i>	109

Potential Citywide Benefits	Location 4: Orient Heights 21" SLR Scenario
<i>Avoided Losses for One-Time 1% Annual Chance Event</i>	\$227,103,477
<i>Annualized Losses Avoided</i>	\$23,385,539
<i>Benefitting Structures</i>	473
<i>Benefitting Population</i>	2704
<i>Benefitting Land Area (acres)</i>	119

TABLE 4. CHARLESTOWN FOCUS AREA PROTECTION SYSTEM BENEFITS

Potential Citywide Benefits	Location 5: Schrafft Center 9" SLR Scenario
Avoided Losses for One-Time 1% Annual Chance Event	\$538,495
Annualized Losses Avoided	\$11,233
Benefitting Structures	3
Benefitting Population	0
Benefitting Land Area (acres)	4

Potential Citywide Benefits	Location 5: Schrafft Center 21" SLR Scenario
Avoided Losses for One-Time 1% Annual Chance Event	Not independently effective beyond 10% annual chance event
Annualized Losses Avoided	\$33,761
Benefitting Structures	3
Benefitting Population	0
Benefitting Land Area (acres)	4

Potential Citywide Benefits	Location 5: Schrafft Center 36" SLR Scenario
Avoided Losses for One-Time 1% Annual Chance Event	Not independently effective beyond 10% annual chance event
Annualized Losses Avoided	\$12,316,428
Benefitting Structures	187
Benefitting Population	415
Benefitting Land Area (acres)	101

Potential Charlestown Benefits	Location 8: New Charles River Dam 9" SLR Scenario
Avoided Losses for One-Time 1% Annual Chance Event	\$3,618,888
Annualized Losses Avoided	\$379,514
Benefitting Structures	1
Benefitting Population	0
Benefitting Land Area (acres)	3

Potential Charlestown Benefits	Location 8: New Charles River Dam 21" SLR Scenario
Avoided Losses for One-Time 1% Annual Chance Event	Not independently effective in Charlestown beyond 10% annual chance event
Annualized Losses Avoided	\$361,889
Benefitting Structures	1
Benefitting Population	0
Benefitting Land Area (acres)	3

Potential Charlestown Benefits	Location 8: New Charles River Dam 36" SLR Scenario
Avoided Losses for One-Time 1% Annual Chance Event	Not independently effective in Charlestown beyond 10% annual chance event
Annualized Losses Avoided	\$419,798
Benefitting Structures	1
Benefitting Population	0
Benefitting Land Area (acres)	4

Potential Charlestown Benefits	Location 5 and 8: Schrafft Center and New Charles River Dam 9" SLR Scenario
Avoided Losses for One-Time 1% Annual Chance Event	Locations 1 and 2 are independently effective at the 1%.
Annualized Losses Avoided	\$112,413
Benefitting Structures	181
Benefitting Population	405
Benefitting Land Area (acres)	100

Potential Charlestown Benefits	Location 5 and 8: Schrafft Center and New Charles River Dam 21" SLR Scenario
Avoided Losses for One-Time 1% Annual Chance Event	\$102,703,155
Annualized Losses Avoided	\$3,405,277
Benefitting Structures	309
Benefitting Population	1188
Benefitting Land Area (acres)	144

Potential Charlestown Benefits	Location 5 and 8: Schrafft Center and New Charles River Dam 36" SLR Scenario
Avoided Losses for One-Time 1% Annual Chance Event	\$237,635,636
Annualized Losses Avoided	\$6,813,865
Benefitting Structures	367
Benefitting Population	1348
Benefitting Land Area (acres)	171

TABLE 5. DOWNTOWN WATERFRONT PROTECTION ALIGNMENT BENEFITS

Potential Citywide Benefits	Location 7: Downtown Waterfront 9" SLR Scenario	Potential Citywide Benefits	Location 7: Downtown Waterfront 21" SLR Scenario	Potential Citywide Benefits	Location 7: Downtown Waterfront 36" SLR Scenario
Avoided Losses for One-Time 1% Annual Chance Event	\$218,740,861	Avoided Losses for One-Time 1% Annual Chance Event	\$382,786,957	Avoided Losses for One-Time 1% Annual Chance Event	\$680,350,119
Annualized Losses Avoided	\$21,244,379	Annualized Losses Avoided	\$39,355,237	Annualized Losses Avoided	\$70,671,741
Benefitting Structures	169	Benefitting Structures	202	Benefitting Structures	232
Benefitting Population	1079	Benefitting Population	1099	Benefitting Population	1100
Benefitting Land Area (acres)	36	Benefitting Land Area (acres)	49	Benefitting Land Area (acres)	60

TABLE 6. SOUTH BOSTON, DORCHESTER, CHARLES RIVER FOCUS AREA PROTECTION SYSTEM BENEFITS

Potential Citywide Benefits	Location 9a: Seaport 9" SLR Scenario	Potential Citywide Benefits	Location 9a and 10: Seaport and Moakley Park/Columbia Point 21" SLR Scenario	Potential Citywide Benefits	Location 9a and 10: Seaport and Moakley Park/Columbia Point 36" SLR Scenario
Avoided Losses for One-Time 1% Annual Chance Event	\$978,415,662	Avoided Losses for One-Time 1% Annual Chance Event	\$29,892,972	Avoided Losses for One-Time 1% Annual Chance Event	Not independently effective beyond 2% annual chance event.
Annualized Losses Avoided	\$61,914,366	Annualized Losses Avoided	\$218,248,766	Annualized Losses Avoided	\$725,255,293
Benefitting Structures	293	Benefitting Structures	4985	Benefitting Structures	5416
Benefitting Population	2275	Benefitting Population	41684	Benefitting Population	45227
Benefitting Land Area (acres)	324	Benefitting Land Area (acres)	1580	Benefitting Land Area (acres)	1715

  

Potential Citywide Benefits	Location 10: Moakley Park/Columbia Point 9" SLR Scenario	Potential Mainland Benefits	Location 8: New Charles River Dam 21" SLR Scenario	Potential Mainland Benefits	Location 8: New Charles River Dam 36" SLR Scenario
Avoided Losses for One-Time 1% Annual Chance Event	\$37,408,373	Avoided Losses for One-Time 1% Annual Chance Event	\$543,040,169	Avoided Losses for One-Time 1% Annual Chance Event	Not independently effective beyond 2% annual chance event.
Annualized Losses Avoided	\$1,051,065	Annualized Losses Avoided	\$24,435,795	Annualized Losses Avoided	\$77,110,214
Benefitting Structures	27	Benefitting Structures	363	Benefitting Structures	498
Benefitting Population	0	Benefitting Population	3616	Benefitting Population	4468
Benefitting Land Area (acres)	37	Benefitting Land Area (acres)	292	Benefitting Land Area (acres)	307

Potential Citywide Benefits	Location 9a and 10: Seaport and Moakley Park/Columbia Point 9" SLR Scenario
Avoided Losses for One-Time 1% Annual Chance Event	Alignments independently effective until 0.1% AEP
Annualized Losses Avoided	\$2,732,886
Benefitting Structures	1281
Benefitting Population	13486
Benefitting Land Area (acres)	853

Potential Mainland Benefits	Location 8: New Charles River Dam 9" SLR Scenario
Avoided Losses for One-Time 1% Annual Chance Event	\$310,502,476
Annualized Losses Avoided	\$13,037,146
Benefitting Structures	106
Benefitting Population	1484
Benefitting Land Area (acres)	85

Potential Mainland Benefits	Location 8,9a, and 10: New Charles River Dam, Seaport, and Moakley Park/Columbia Point 36" SLR Scenario
Avoided Losses for One-Time 1% Annual Chance Event	\$9,396,692,850
Annualized Losses Avoided	\$109,251,308
Benefitting Structures	10621
Benefitting Population	114079
Benefitting Land Area (acres)	3365

TABLE 7. DORCHESTER, FORT POINT CHANNEL, CHARLES RIVER FOCUS AREA PROTECTION SYSTEM BENEFITS

Potential Citywide Benefits	Location 10: Moakley Park/Columbia Point 9" SLR Scenario
Avoided Losses for One-Time 1% Annual Chance Event	\$37,408,373
Annualized Losses Avoided	\$1,051,065
Benefitting Structures	27
Benefitting Population	0
Benefitting Land Area (acres)	3

Potential Citywide Benefits	Location 9b and 10: Fort Point Channel and Moakley Park/Columbia Point 21" SLR Scenario
Avoided Losses for One-Time 1% Annual Chance Event	\$863,621,023
Annualized Losses Avoided	\$40,715,589
Benefitting Structures	4543
Benefitting Population	37256
Benefitting Land Area (acres)	1021

Potential Citywide Benefits	Location 9b and 10: Fort Point Channel and Moakley Park/Columbia Point 36" SLR Scenario
Avoided Losses for One-Time 1% Annual Chance Event	Not independently effective beyond 2% annual chance event.
Annualized Losses Avoided	\$394,966,176
Benefitting Structures	4967
Benefitting Population	40871
Benefitting Land Area (acres)	1146

Potential Citywide Benefits	Location 9b and 10: Fort Point Channel and Moakley Park/Columbia Point 9" SLR Scenario
Avoided Losses for One-Time 1% Annual Chance Event	Alignments independently effective until 0.1% AEP
Annualized Losses Avoided	\$794,803
Benefitting Structures	897
Benefitting Population	10400
Benefitting Land Area (acres)	400

Potential Citywide Benefits (including Charlestown)	Location 9b, 10, and 8: Fort Point Channel, Moakley Park/Columbia Point, and Charles River Dam 36" SLR Scenario
Avoided Losses for One-Time 1% Annual Chance Event	\$5,756,203,840
Annualized Losses Avoided	\$68,565,747
Benefitting Structures	10150
Benefitting Population	109278
Benefitting Land Area (acres)	2765



