Executive Summary

In the City of Boston (the City), storm sewer systems typically collect rainfall runoff and discharge by gravity into a receiving waterbody (e.g., Boston Harbor, Fort Point Channel, Neponset River, etc.). If the sea level ("tailwater") is sufficiently high, discharge by gravity is limited or no longer possible, which can lead to surcharging and interior flooding during intense rain events. As such, storm sewers require tailwater conditions below a particular threshold to function as designed, and Sea Level Rise (SLR) is slowly increasing these tailwater elevations. During extreme storm events ("named" storms such as hurricanes or nor'easters), the combined effect of SLR and storm surge could restrict or prevent stormwater discharge in many locations, leading to widespread flooding throughout the City, even if the shoreline is protected from the direct impact of storm surge by measures such as shoreline elevation or barriers. Considering this, the Boston Water and Sewer Commission (Commission) undertook the *Coastal Stormwater Discharge Analysis* to achieve the following goals:

1. Identify Commission owned outfalls that are vulnerable to higher sea levels, and which may not function (i.e., discharge stormwater) as intended due to future SLR and storm surge (herein referred to as coastal flood vulnerable outfalls).
2. Develop conceptual designs at an initial set of locations to adapt the Commission-owned outfalls with the greatest coastal flood vulnerability.
3. Create a planning framework that could be used to continue to adapt the remainder of the Commission's coastal flood vulnerable outfalls. [1]

The *Coastal Stormwater Discharge Analysis* builds on the Citywide flood modeling that the Commission completed during the *Inundation Model* project. The *Inundation Model* project led to the creation of a two-dimensional (2D) model, using PCSWMM software, capable of predicting the extent and duration of flood inundation within the City for a variety of extreme wet weather events. Model predictions (generated during the *Coastal Stormwater Discharge Analysis* and *Inundation Model* projects) were used to identify outfalls with the greatest coastal flood vulnerability, and to quantify the flood reduction benefits associated with the concepts developed as part of this project.

The *Coastal Stormwater Discharge Analysis* project was undertaken in the context of the City's ongoing Climate Ready Boston (CRB) program. The CRB program was established to evaluate climate related vulnerabilities throughout the City, including those related to SLR and storm surge, and is developing concepts for shoreline protection for each neighborhood. As shown in **Table ES-1**, shoreline protection (implemented via the CRB program) provides coastal flood protection of land surfaces from SLR and storm surge, while the concepts developed as part of the *Coastal Stormwater Discharge Analysis* facilitate stormwater discharge from existing outfalls during these types of conditions. As documented in this report, the Commission's proposed concepts were designed for consistency (i.e., considering timing and location) with planned CRB shoreline adaptations where possible. As the CRB program continues to evolve over time, the Commission's assumptions in this project will also need to be revisited.

[1] It is important to note that this project only considered outfalls owned by the Commission. Outfalls owned by other agencies may be coastal flood vulnerable, and require protection as part of a comprehensive adaptation strategy.

Table ES-1: Benefits of CRB Shoreline Protection and Coastal Stormwater Adaptations

Adaptation Program	Shoreline Protection *(for SLR and Storm Surge)*		Stormwater Discharge
	Sunny Day Flooding (SLR Only)	*Overland Coastal Flooding (Storm Surge)*	*Rainfall + SLR + Storm Surge*
Climate Ready Boston	✓	✓	
Coastal Stormwater Discharge Analysis		✓	✓

For the purpose of this project, "coastal flood vulnerability" was defined as an elevation of 13.8 feet NAVD88 (20.3 feet BCB) or less; this elevation is the approximate peak flood elevation during a 100-year tropical storm event in Boston in 2070, based on projections from the Massachusetts Coast Flood Risk Model. **Figure ES-1** depicts coastal flood vulnerable outfalls as well as vulnerable land areas in the City, based on this stated threshold. Note that watersheds and outfalls that drain to the Charles River were not classified as coastal flood vulnerable since the Charles River Dam (and pump station) currently protects these outfalls from high sea levels (and future MassDCR programs/projects are anticipated to continue to harden the dam under future climate conditions).

In order to identify the first set of coastal flood vulnerable outfalls in the Commission's storm drain and combined sewer systems for development of conceptual designs, a comprehensive framework for identification, screening, and prioritizing outfalls was developed. **Table ES-2** contains the criteria that were used to screen and rank outfalls.

Once the outfalls were screened using this tool, field investigations were performed throughout a variety of neighborhoods at the 31 highest ranked locations to further evaluate the outfalls/locations with respect to coastal flood risk vulnerabilities and opportunities (or constraints) for implementation of coastal stormwater discharge concepts. The final subset of sites that advanced to the conceptual design phase was developed based on coordination with Commission staff and consideration of where the Climate Ready Boston initiative data indicated near-term shoreline protection being proposed. A total of 37 outfalls (multiple outfalls were grouped into one solution/location where possible) were advanced to conceptual design, as shown in **Figure ES-2**.

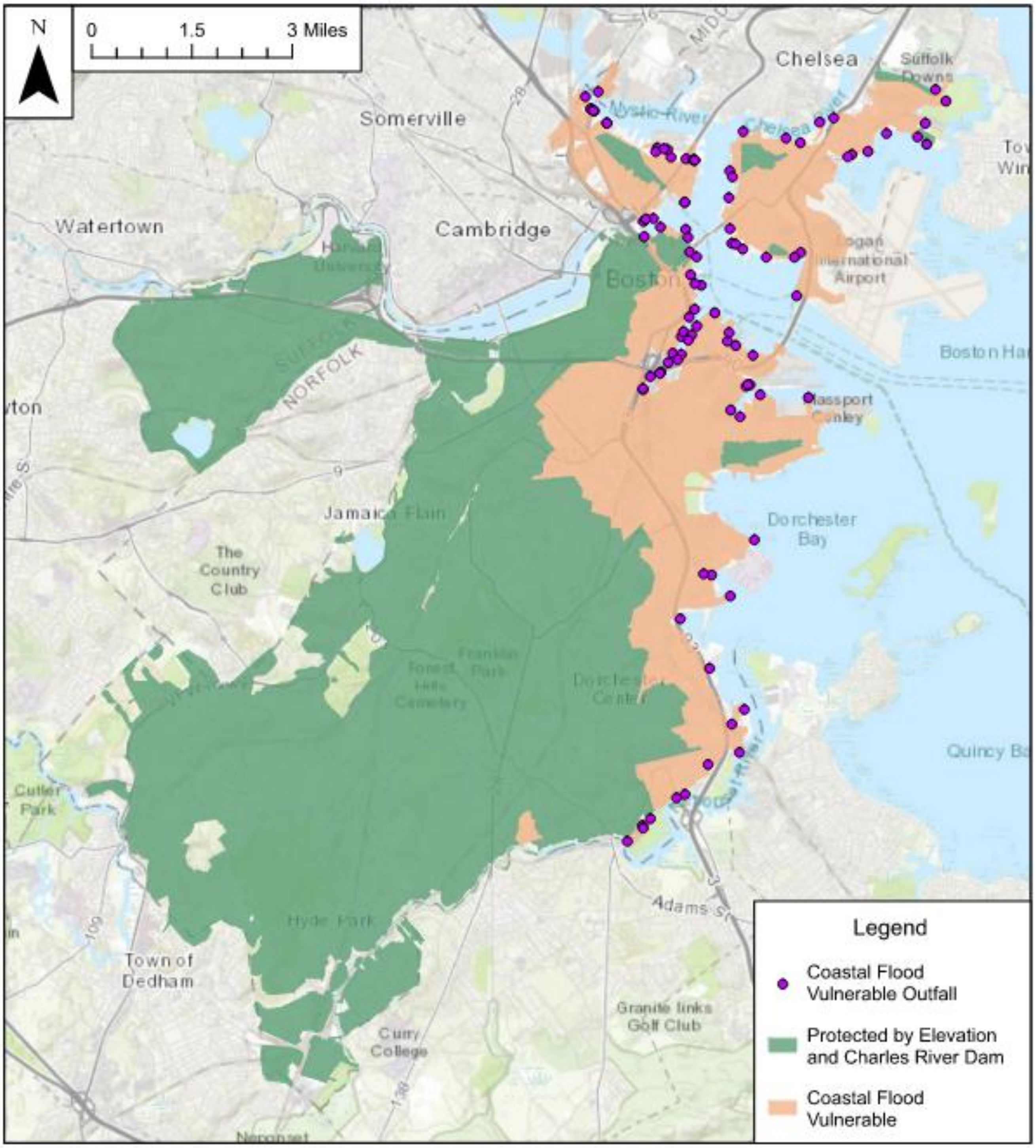


Figure ES-1: Coastal Flood Vulnerability in Boston

Table ES-2: Outfall Ranking Criteria

Category	Criteria	Definition	Data Source
Physical Considerations: Infrastructure Importance and Vulnerability	Discharge Volume	Discharge volume from modeled outfalls for 10-year, 24-hour, design storms and nor'easter and tropical events	BWSC Inundation Model Simulations
	Invert Elevation	Scoring to be done based on ranked list of outfall invert elevations	BWSC (GIS, tile maps)
	Outfall Size	Diameter/dimensions of immediate upstream pipe from GIS	BWSC (GIS, tile maps)
Tributary Area Characteristics (upstream considerations)	Flooded Area	Flooded area from Inundation Model simulations within tributary areas	BWSC Inundation Model Simulations
	Transportation Routes	Length of roadways classified as evacuation routes, transit, and commuter rails within tributary area	MassGIS and BPDA
	Critical Facilities	Number of Critical Facilities in Tributary Area	BWSC "Contact List of Centers"
	Population	Number of Residents within Tributary Area	Boston Open Data (2010 Census)
	Economic Importance	Number of employees within tributary area	risQ (LODES* database and ACSS*)
	Land Use	Land ownership of parcels adjacent to/containing outfalls within tributary area	Boston Open Data (2016 Parcels) BWSC "Open Space"
	Environmental Justice/Social Vulnerability	Social vulnerability of residents within tributary	risQ (LODES* database and ACSS*)

1. *LODES – Longitudinal Origin-Destination Employment Statistics
2. *ACSS – American Community Survey and Statistics

Outfalls identified through this process were prioritized for further desktop analysis to verify physical vulnerability to SLR and storm surge, and site visits were conducted to characterize site constraints and opportunities for conceptual design of a stormwater discharge solution. The criteria described in **Table ES-2** were used directly to "score" and rank each Commission-owned outfall in this desktop analysis step. In recognition of the fact that different stakeholders may value (i.e., weight) some criteria more than others, a PowerBI (Power "Business Intelligence") dashboard was developed to provide the Commission the ability to adjust the weight of criteria ("on the fly," resulting in automated updates to the priority list when a criterion changes).

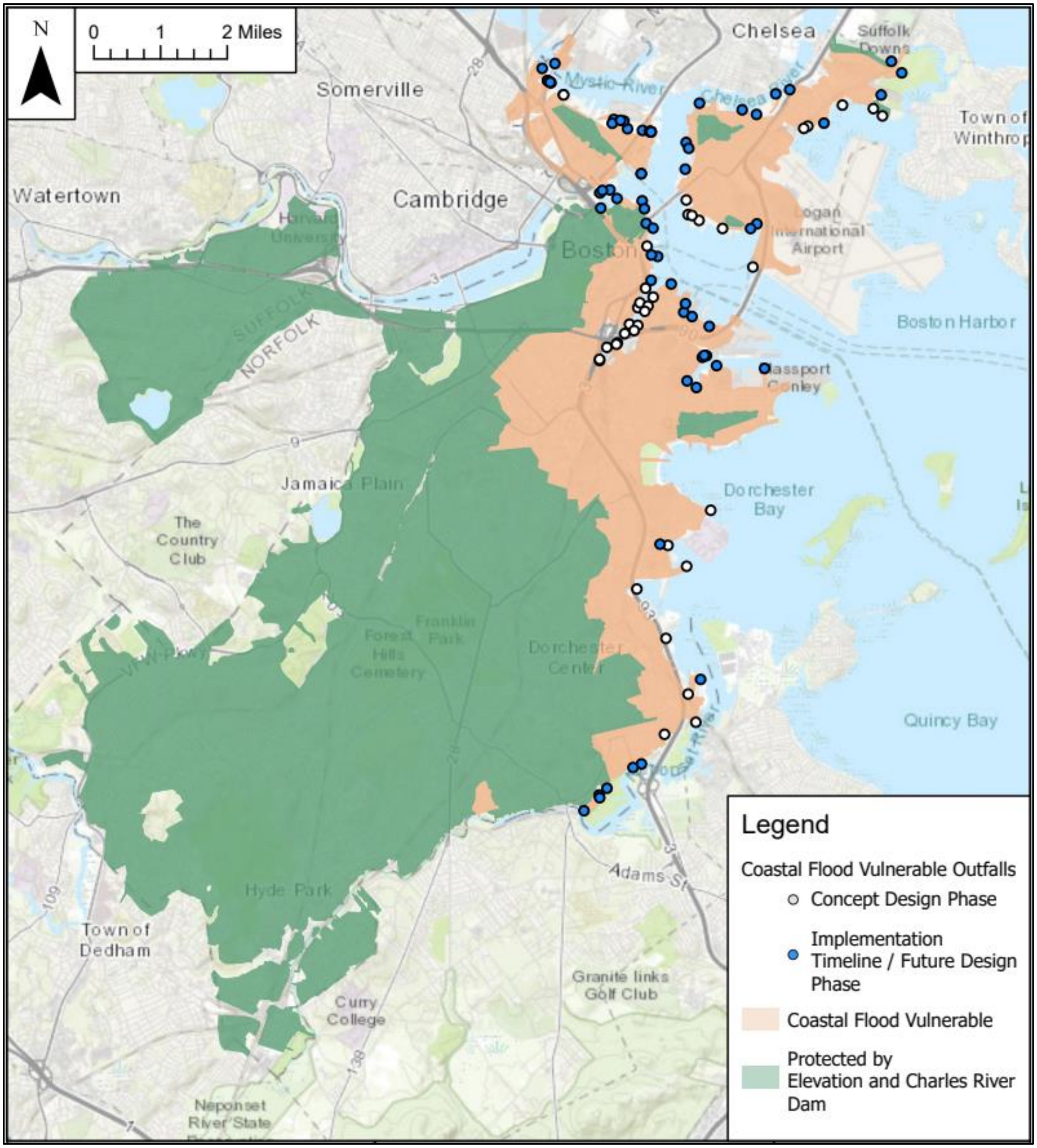


Figure ES-2: Commission-Owned Vulnerable Outfalls by Concept Design Phase

While the Commission's intent is ultimately to address all vulnerable outfalls (and their associated drainage areas), more detailed conceptual solutions were developed for these initial outfalls as a starting point; beyond these initial locations (covering 37 outfalls), a plan was developed (the "Implementation Timeline") for replicating these types of detailed solutions to the remainder of the Commission's outfalls.

As schedule and budget planning is advanced in the coming years, the Commission (or another entity) may carry out a similar level of conceptual design at these other outfalls as well.

Two different wet weather events were used in this project to develop conceptual designs and evaluate flood reduction benefits as described below:

- 100-year tropical storm – used to evaluate the flood reduction benefits of the proposed solutions (this storm is consistent with the approach that CRB is taking with regard to a 1% chance storm for analysis purposes). A rainfall hyetograph (and other parameters including storm speed and direction) for this storm event was developed during the *Inundation Model Project*). The 100-year tropical storm results in 9.58 inches of rainfall in 48 hours.
- 2070 projected 10-year 24-hour design storm – used to size proposed infrastructure solutions (since the Commission's collection system is understood to generally have capacity to convey flows from a 10-year storm). This storm event was developed by updating the Commission's previous design storm using up-to-date rainfall distributions and precipitation projections. The 2070 projected 10-year design storm results in 6.18 inches of rainfall in 24 hours.

This project utilized SLR and storm surge predictions that the Commission obtained during the *Inundation Model Project* from the Massachusetts Coast Flood Risk Model (MC-FRM). The SLR values applied in MC-FRM are consistent with the standards for the Commonwealth of Massachusetts developed by Coastal Zone Management. The MC-FRM utilizes a "High" SLR scenario. This scenario is based on the relative SLR projections under RCP 8.5 (a "worst case scenario" of increasing atmospheric carbon concentrations) and represents elevations that have a 99.5% probability of not being exceeded within the respective timeframes. In 2030, that amounts to an increase of 1.3 ft in Boston from a baseline condition (2008 centered tidal epoch), and in 2070 that amounts to an increase of 4.3 ft.

The concept solutions developed in this project were analyzed using coastal conditions that include 2070 projected SLR and storm surge resulting from a 100-year tropical storm. The peak water surface elevation (WSE) predicted by the MC-FRM during these conditions is approximately 13.8 ft NAVD88 (varies by location).

For each conceptual design location, a combination of conveyance, storage, and pumping alternatives were evaluated to develop a solution that improves the discharge of stormwater (and reduces upstream flooding), with the most feasible alternative(s) selected based on site characteristics and system configuration. Where possible, nature-based features were incorporated into these conceptual designs. The conceptual designs were developed at 11 locations to protect a total of 37 Commission owned outfalls from SLR and storm surge. **Together with shoreline protection measures (identified by CRB) and installation of tide gates, these conceptual solutions could protect 71% of the coastal flood vulnerable land area in Boston.**

Each concept design was summarized in a succinct package (**Appendix G**) that includes an overview of the proposed concept, basis of design summary/assumptions, flood reduction benefits (2D model results), economic benefits (damage analysis), project cost estimate, conceptual design drawings/schematics, as well as considerations for implementation and adaptability.

Construction cost opinions were developed for each concept. These cost opinions include estimates that are considered to be AACE (Association for the Advancement of Cost Estimating) International Class 4, which has a typical accuracy range of -30% to -15% on the low side and +20% to +50% on the high side.

Table ES-3 presents total project costs (including an approximation of design and construction engineering) for each location. The costs in **Table ES-3** for Fort Point Channel and Dorchester Bay Basin exclude the storm surge barriers. Design and Construction Administration costs are calculated based on 20% of the total cost (less design contingency). **Table ES-4** presents sub-totals for the storm surge barriers alone, including two different types of barriers for the Fort Point Channel location. **Appendices L and M** include detailed cost estimate backup data.

The estimates are comprised of unit costs calculated from a combination of detailed takeoff, forced takeoff, factoring, and allowances. Design contingency carried is at 50% based on the status of the design, the nature of the project, the estimate classification, and estimator judgment for most locations and features. The two projects which are the furthest along in the design process, the Fort Point Channel and Dorchester Bay Basin storm surge barriers, carried a 35% contingency, as the more-developed designs inherently have less uncertainty. The reason for the difference in estimating level is that the storm surge barrier designs needed to be advanced to a slightly higher level of detail to accurately capture the potential construction costs (including temporary costs, such as cofferdam construction).

The estimates include direct and indirect construction costs, as well as markups that represent contractor and subcontractor overhead and profit, escalation to midpoint of construction for labor and materials, bonds/insurance, and contract allowances. The assumed timeframe for construction work is late-2030's, evident in the assumed escalation (based on 15 years from date of pricing to expected midpoint of construction).

Items that are excluded in the cost estimate include:

- Land/property easements/purchase/transfers
- Microtunneling or other costs related to railroad or major highway crossings (applies to Dorchester Bay Basin storm sewers)
- Improvements related to Climate Ready Boston projects (shoreline protection)
- Site restoration above and beyond current site conditions

Table ES-3: Concept Cost Estimate Subtotals (Exclusive of Storm Surge Barriers)

	Airport	Charlestown Schrafft Center	Columbus Park	Constitution Beach	Davenport Creek	Dorchester Bay Basin[2]	East Boston Greenway	East Boston Waterfront	Fort Point Channel[1]	Old Harbor Park	Joseph Finnegan Park
Direct Construction Costs	$7,236,248	$11,596,079	$4,731,915	$7,615,841	$17,902,197	$48,774,375	$2,936,938	$6,256,022	$8,968,000	$7,012,000	$9,246,000
Indirect Construction Costs	$1,447,250	$2,319,216	$946,383	$1,523,168	$3,580,439	$9,754,875	$587,388	$1,251,204	$1,794,000	$1,402,000	$1,849,000
Mark-Up (incl. escalation)	$9,645,964	$15,544,944	$6,366,233	$10,209,454	$24,110,121	$65,740,034	$3,926,783	$8,373,533	$11,858,649	$9,319,302	$12,443,046
Construction Sub-total	**$18,329,462**	**$29,460,239**	**$12,044,521**	**$19,348,463**	**$45,592,757**	**$124,269,284**	**$7,451,109**	**$15,880,759**	**$22,620,649**	**$17,733,302**	**$23,538,046**
Design Continency	$8,833,538	$14,197,762	$5,804,479	$9,324,537	$21,972,243	$59,888,716	$3,590,892	$7,653,220	$10,901,147	$8,545,899	$11,343,712
Sub-total	**$27,163,000**	**$43,658,001**	**$17,849,000**	**$28,673,000**	**$67,565,000**	**$184,158,000**	**$11,042,001**	**$23,533,979**	**$33,521,796**	**$26,279,201**	**$34,881,758**
Design & Construction Administration	$3,666,000	$5,893,000	$2,409,000	$3,870,000	$9,119,000	$24,845,000	$1,491,000	$3,177,000	$4,524,000	$3,547,000	$4,708,000
Total Project Cost	**$30,829,000**	**$49,551,001**	**$20,258,000**	**$32,543,000**	**$76,684,000**	**$209,003,000**	**$12,533,001**	**$26,710,979**	**$38,045,796**	**$29,826,201**	**$39,589,758**

Notes:

1. Fort Point Channel location excludes the storm surge barrier estimate; includes only the pump station
2. Dorchester Bay Basin location excludes the storm surge barrier estimate; includes only the conveyance and diversion structures

Table ES-4: Storm Surge Barrier Cost Estimate Subtotals

	Fort Point Channel[1]			Dorchester Bay Basin
	Submerged Axis Flap Gate *(4 gates)*	**Submerged Axis Flap Gate - South Location** *(3 gates)*	**Vertical Lift Gate**	**Vertical Lift Gate**
Remaining Design Development & BWSC Construction Administration	$60,553,000	$49,851,000	$36,350,000	$14,169,000
Direct & Indirect Construction Costs Total (Marked-up)*	$329,465,000	$271,236,000	$197,328,000	$76,917,000
Escalation (15 Years)	$240,119,000	$197,682,000	$143,867,000	$56,078,000
Design Contingency	$136,506,000	$112,381,000	$81,788,000	$31,881,000
Total	**$766,643,000**	**$631,150,000**	**$459,333,000**	**$179,045,000**

Notes:

1. Fort Point Channel location excludes the pump station estimate; includes only the storm surge barrier portion of the cost.

In addition, Hazen and its subconsultant, risQ, Inc. (recently acquired by Intercontinental Exchange, Inc.), developed estimates of economic impact (i.e., damage) on the physical environment (i.e., buildings, etc) due to flooding both with and without the solutions in place. This damage analysis included calculations of three metrics:

- Replacement value (of buildings) – total value of the impacted buildings in each area, based on rebuild cost; this is a conservative number as it assumes the entire structure needs to be rebuilt regardless of flood depth/duration; a structure is included in the cost if flooding is predicted to encroach it
- Physical damage (to buildings) – presented as both minimum, maximum values (and a simple average of the two numbers)
    - Minimum values are based on the affected buildings as indicated by the minimum predicted depth of flooding in the area and the lower value of replacement cost estimates (a range was evaluated)
    - Maximum values are based on the affected buildings as indicated by the maximum predicted depth of flooding in the area and the higher value of replacement cost estimates (a range was evaluated)
- Lost Usage - Gross Domestic Product (GDP) impairment, presented as both minimum, maximum (and a simple average of the two numbers); includes:

- Business interruption for commercial and industrial properties
- Lost rental income and property taxes for residential properties

Model-predicted flooding data (in the form of GIS shapefiles) from the 2D Inundation Model simulations, for the 100-year tropical storm event, were input into risQ's economic database/framework. Two scenarios were evaluated: 1) Shoreline protection only (CRB proposed projects), and 2) Shoreline protection + conceptual solution (flood mitigation) + installation of tide gates on all coastal flood vulnerable outfalls. Economic impacts before and after the solutions are implemented were calculated, for each "area of interest", which correspond to the outfall tributary areas at each conceptual design location.

This Section provides a concise summary of the economic damage analysis performed, but for additional detail please refer to **Section 7** of this report and **Appendix K** for complete documentation. Values reported in **Table ES-5** are shown in 2022 dollars and are reported in thousands for simplicity.

Table ES-5: Economic Damage Analysis Results (Thousands of Dollars)

Area	Scenario	Replacement Value of Impacted Buildings	Min Physical Damage	Max Physical Damage	Average Physical Damage	Min Lost Usage	Max Lost Usage	Average Lost Usage
Fort Point Channel	Shoreline Protection Only	20,470,236	2,938,938	5,105,728	4,022,333	1,842,013	3,894,824	2,868,419
Fort Point Channel	Conceptual Solution	4,616,728	676,619	1,145,390	911,005	86,588	225,193	155,891
Joseph Finnegan Park	Shoreline Protection Only	152,077	24,789	41,516	33,153	46,119	77,888	62,004
Joseph Finnegan Park	Conceptual Solution	30,029	4,290	7,025	5,658	12,606	21,034	16,820
Old Harbor Park	Shoreline Protection Only	310,681	45,805	76,698	61,252	27,815	76,874	52,345
Old Harbor Park	Conceptual Solution	0	0	0	0	0	0	0
East Boston Waterfront	Shoreline Protection Only	482,821	69,255	115,439	92,347	7,805	22,399	15,102
East Boston Waterfront	Conceptual Solution	6,789	987	1,665	1,326	8	29	19
Constitution Beach	Shoreline Protection Only	519,621	52,906	89,495	71,201	22,837	42,692	32,765
Constitution Beach	Conceptual Solution	166,283	2,382	3,991	3,187	6,055	10,115	8,085
East Boston Greenway	Shoreline Protection Only	12,754	2,008	3,392	2,700	20	54	37

Area	Scenario	Replacement Value of Impacted Buildings	Min Physical Damage	Max Physical Damage	Average Physical Damage	Min Lost Usage	Max Lost Usage	Average Lost Usage
East Boston Greenway	Conceptual Solution	0	0	0	0	0	0	0
Dorchester Bay Basin	Shoreline Protection Only	1,408,902	186,031	315,066	250,549	326,320	866,024	596,172
Dorchester Bay Basin	Conceptual Solution	467,912	50,691	84,433	67,562	78,449	225,660	152,055
Davenport Creek	Shoreline Protection Only	161,816	22,380	37,466	29,923	10,053	17,382	13,718
Davenport Creek	Conceptual Solution	0	0	0	0	0	0	0
Columbus Park	Shoreline Protection Only	4,432,483	714,699	1,239,409	977,054	1,232,970	2,281,389	1,757,180
Columbus Park	Conceptual Solution	1,258,120	186,800	324,124	255,462	370,274	867,807	619,041
Charlestown Schrafft Center	Shoreline Protection Only	115,431	14,032	24,831	19,432	8,625	36,397	22,511
Charlestown Schrafft Center	Conceptual Solution	6,281	757	1,262	1,010	0	$2	$1
Boston Logan Airport	Shoreline Protection Only	883,069	125,137	214,588	169,863	74,862	199,502	137,182
Boston Logan Airport	Conceptual Solution	54,545	5,787	10,028	7,908	2,490	8,319	5,405

Notes:

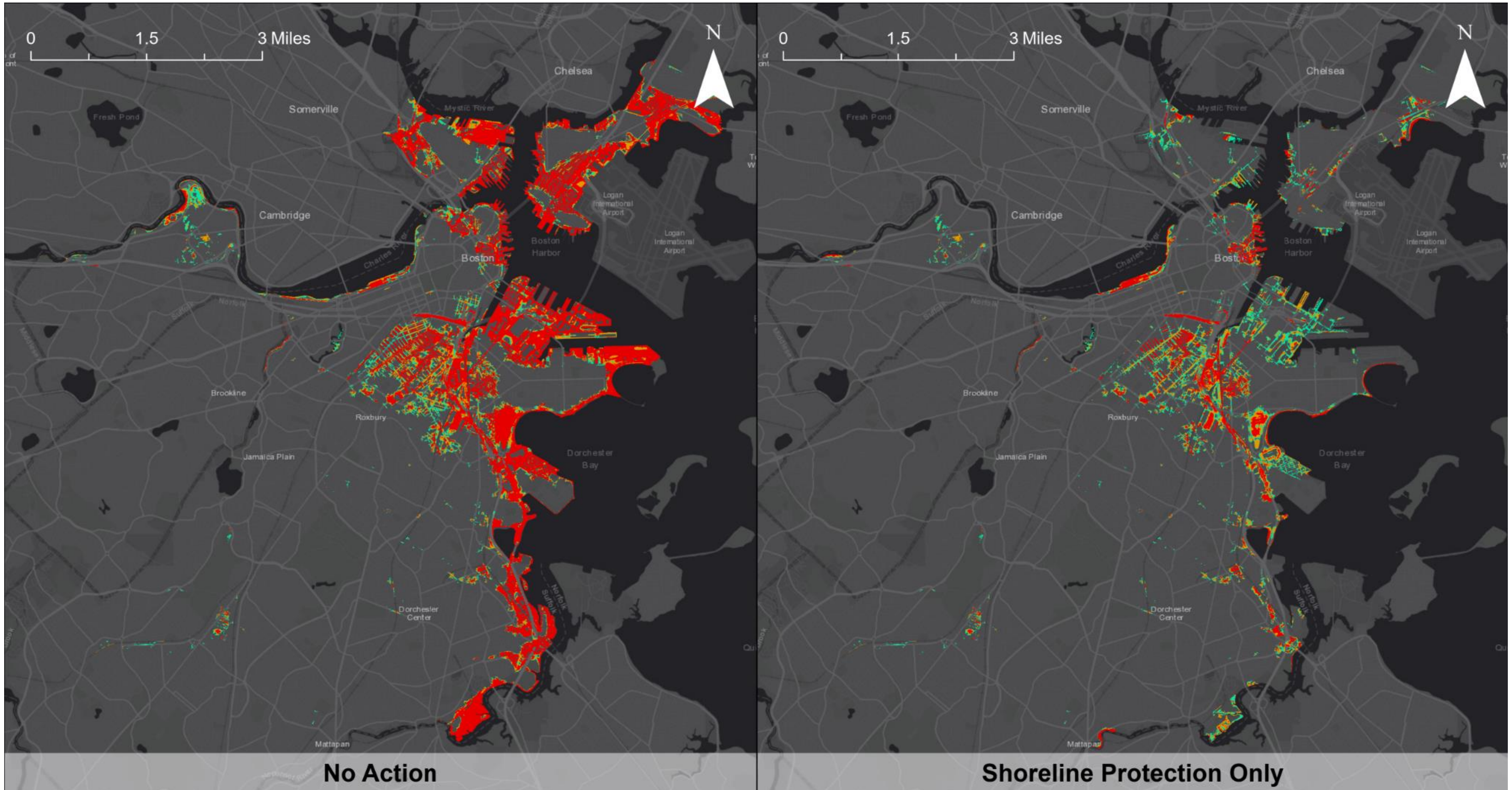
1. Costs are presented in 2022 dollars (no net present value assumed)

Although no net present value was assumed for the damage estimates presented in **Table ES-5**, a comparison of estimated project costs with damage estimates illustrates that the coastal stormwater adaptations developed as part of this project have the potential to avoid significant losses (in exceedance of estimated project costs) during future extreme storm events.

At the conclusion of the project, 2D coastal flood model simulations were performed at all conceptual design locations simultaneously to evaluate the cumulative effectiveness of the proposed conceptual solutions. **Figure ES-3** depicts a comparison of "no action" model predictions during a 100-year tropical storm event in 2070 versus a scenario including complete shoreline protection (i.e., CRB projects completed). As this figure illustrates, shoreline protection alone reduces peak flood depths and extents throughout the City, but does not fully alleviate substantial interior flooding in many neighborhoods and drainage areas, including the area tributary to the Fort Point Channel.

Figure ES-4 depicts a comparison of the shoreline protection scenario versus a scenario that includes shoreline protection in addition to the proposed coastal stormwater concepts documented in this report, as well as tide gates on all coastal flood vulnerable BWSC owned outfalls. As shown in this figure, the coastal stormwater discharge concepts and tide gates substantially reduce flooding compared to shoreline protection only. This comparison illustrates the effectiveness of the concepts documented in this report, and the need to closely coordinate shoreline protection with coastal stormwater discharge adaptations and installation of tide gates on coastal flood vulnerable outfalls. Additional flooding that could result from unprotected non-Commission outfalls was not accounted for in these simulations or in this project.

It is important to note that this project did not include an analysis of outfalls owned privately or by other agencies. These outfalls should be accounted for and adapted in the future. Unprotected outfalls (without tide gates) have the potential to serve as conduits that "bypass" shoreline protection measures (and adapted Commission outfalls). As such, identification and protection of these other outfalls are crucial elements of a complete Citywide adaptation program.



Max Depth

- Flood Depth > 4 in and < 1 ft
- Flood Depth > 1 ft and < 2 ft
- Flood Depth > 2 ft

Boston Water and Sewer Commission

Hazen

Simulation Parameters	
Storm Type	100 yr Tropical
Rainfall Depth	9.6 inches
Peak WSE 2070 SLR + 100 yr Surge	13.8 ft NAVD88

Figure ES-3: No Action versus Shoreline Protection Only Flood Scenarios

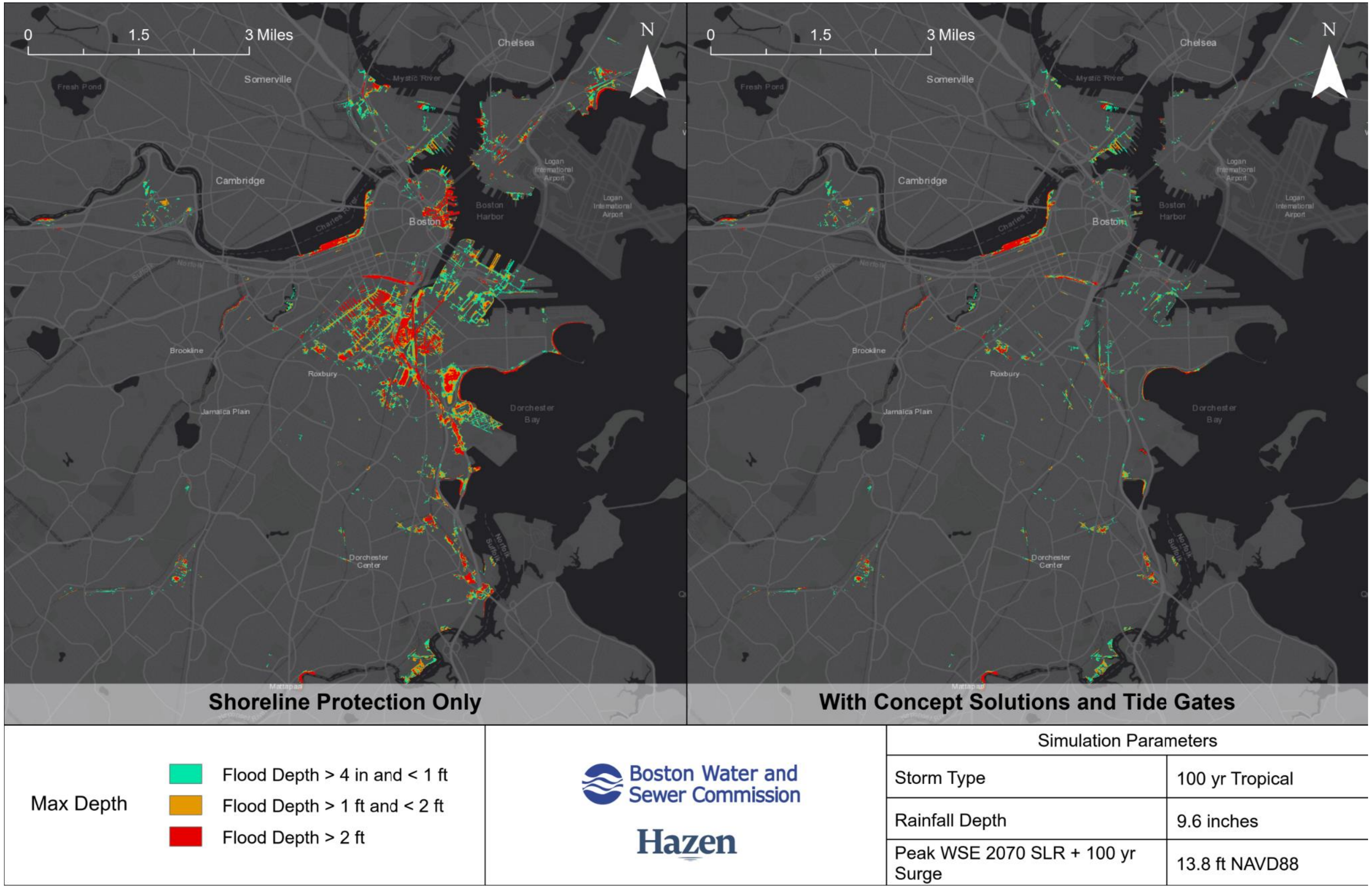


Figure ES-4: Shoreline Protection Only versus With Concept Solutions Flooding Scenarios

The concepts developed during this project provide benefits beyond the shoreline; the coastal stormwater adaptations in this report could substantially reduce flooding across the City (when paired with shoreline protection) and offer benefits to multiple agencies and sectors. Given the large potential benefits and impact of the concepts, there are many potential auxiliary funding opportunities for these concepts, including potential for federal funding assistance.

Considering the broad scope and the substantial cost of constructing and maintaining these concepts, it may be prudent to consider the creation of new agency, consisting of multiple agencies/stakeholders (including the Commission) responsible for funding, maintaining, and operating solutions with regional benefits. Possible stakeholder entities for a new "Massachusetts Coastal Defense Agency" are illustrated in **Figure ES-5.**

Figure ES-5: Massachusetts Coastal Defense Agency

The City is working with the U.S. Army Corps of Engineers (ACOE) on the CRB program. The Commission has submitted drafts of the conceptual designs that were developed as part of this project to the City for comment. After the ACOE completes their review of adaptation strategies proposed for Boston, it may impact the proposals/concepts documented in this report. It is recommended that after ACOE submits their findings, that the Commission revisit these recommendations and update them as necessary.

This project is an important milestone in the Commission's climate adaptation efforts. The concepts developed as part of this project were designed to be replicable and scalable, allowing the Commission to adapt outfalls in coordination with the City as CRB is implemented. In addition, the following conclusions can be drawn:

- Shoreline protection (via CRB) is important to prevent "sunny day" flooding due to SLR. Despite this, substantial Citywide flooding is still expected to occur during future rain events due to the effects of higher sea levels on coastal flood vulnerable outfalls.
- Regionalized solutions (such as the FPC Storm Surge Barrier or Dorchester Bay Basin) have the potential to adapt a large number of Commission outfalls (and portion of the coastal flood vulnerable drainage area in Boston) without the need for distributed pump stations. The Commission (and City) should continue efforts to implement regionalized solutions with significant Citywide benefits.
- Installation of tide gates on coastal flood vulnerable outfalls is an important near-term measure that can be taken to reduce the impacts of higher sea levels. Despite this, many coastal flood vulnerable outfalls require additional adaptation to ensure stormwater discharge is still possible during extreme rain events (with higher sea levels).
- It is important that coastal flood outfalls owned by other entities/agencies are identified and protected as necessary. Unprotected coastal flood vulnerable outfalls have the potential to "bypass" adaptations implemented by the City and the Commission.
- 2D flood modeling results indicate that implementation of the concepts documented in this report has the potential to substantially reduce flooding during future extreme storm events and avoid significant monetary/economic losses. Given the large cost and regionalized benefits of these projects, the creation of a new agency, consisting of multiple agencies/stakeholders (including the Commission) responsible for funding, maintaining, and operating these solutions should be considered.

As a next step, the Commission should continue coordination with the City as the CRB program is implemented. Commission-owned coastal flood vulnerable outfalls that align with areas being adapted by CRB should be prioritized for final design and construction efforts. The conceptual designs developed as part of this project are intended to be replicable, as outlined in **Section 8 - Implementation Timeline** and **Appendix E**, and can serve as a starting point for adaptation design efforts at these locations.