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CITY OF BOSTON PUBLIC WORKS DEPARTMENT

CLIMATE RESILIENT DESIGN STANDARDS AND GUIDELINES

for protection of public rights-of-way

executive summary

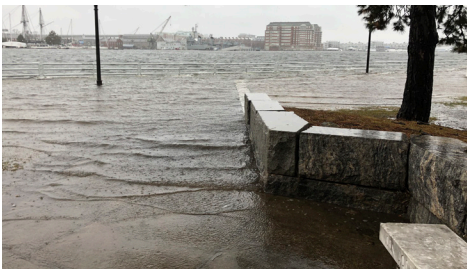
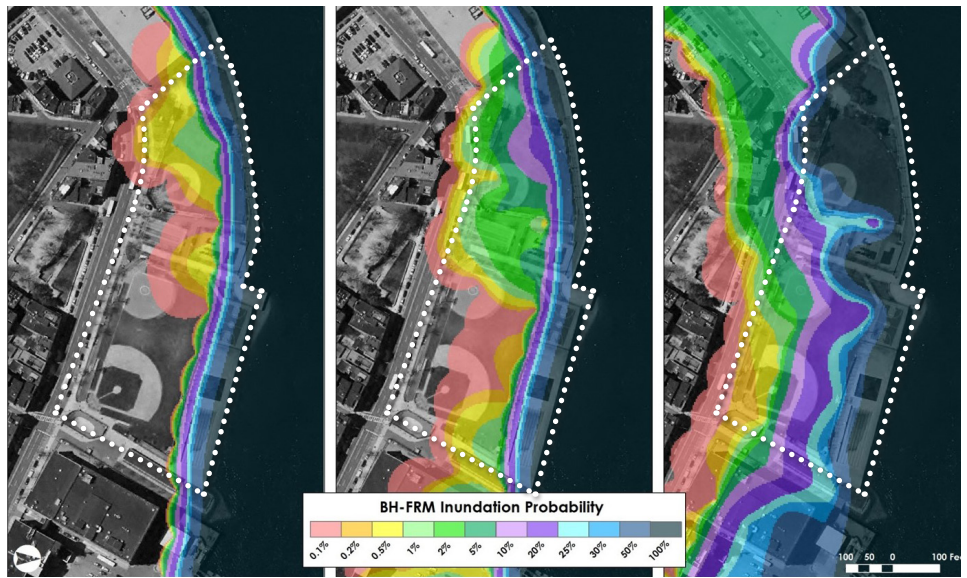
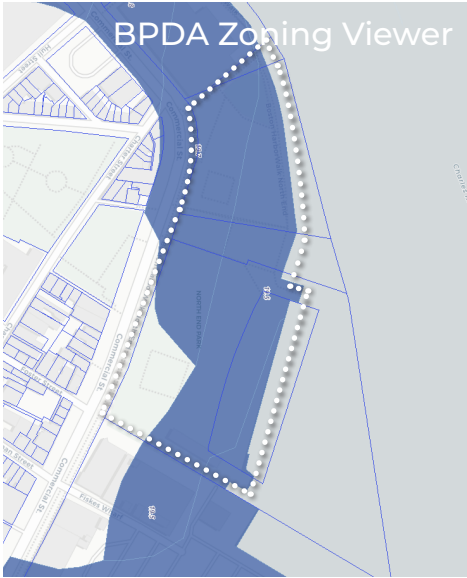
The City of Boston has prepared Climate Resilient Design Standards and Guidelines to address both acute and chronic flooding due to sea level rise (SLR) and storm surge to protect the public rights-of-way. The guidelines provide climate design adjustments for design of flood barriers and a process for evaluating design, operations, maintenance, and cost considerations. Four sample barrier types and sample sites were selected to provide example design considerations and real-world context for designing flood protection for the right-of-way.

Through multiple initiatives, the City of Boston (the City) is preparing for 40 inches of SLR by 2070. The Climate Ready Boston initiative is working to identify vulnerabilities throughout Boston and provide conceptual solutions with the Coastal Resilience Solutions for East Boston and Charlestown final report completed in 2017, the South Boston neighborhood study currently underway, and more neighborhood-based studies to follow. The City of Boston has experienced significant coastal flooding during two Nor'easters in 2018. Recent findings of the *Feasibility of Harbor-wide Barrier Systems: Preliminary Analysis for Boston Harbor*, prepared by the Sustainable Solutions Lab at UMass Boston, indicate that shore-based climate adaptation solutions have significant advantages over a harbor-wide strategy for Boston. With the growing number of conceptual solutions, emphasis on shore-based flood protection, and urgency for action, the City of Boston proactively identified that a framework for climate resilient design standards and guidelines was needed. These guidelines are meant to augment existing city design standards by considering climate impacts and managing segmental shore-based flood protection projects over time.

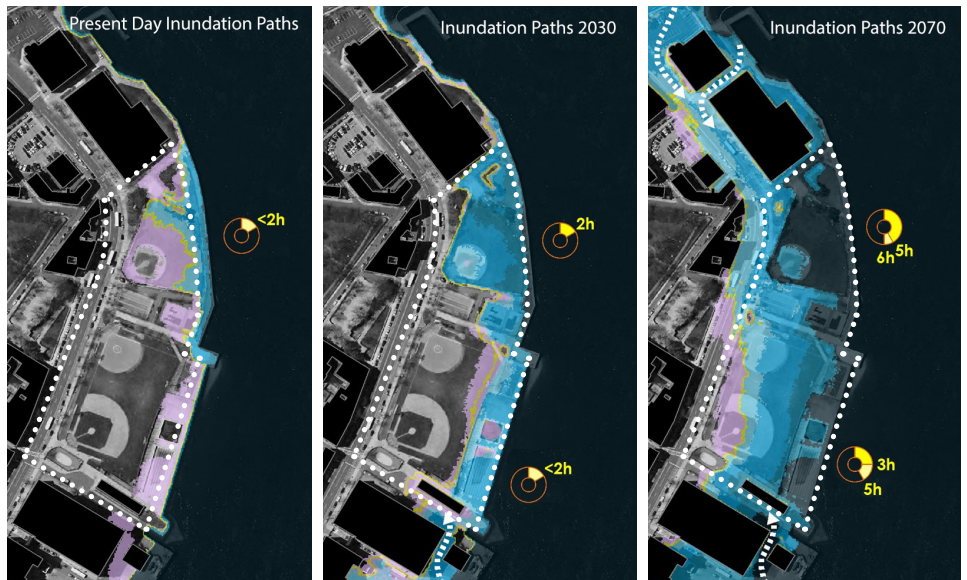
The Boston Public Works Department (BPWD) led the Project Team, with support from the Boston Planning and Development Agency (BPDA), Climate Ready Boston, Weston & Sampson, and a technical advisory group.

The goals of the Climate Resilient Design Standards and Guidelines include:

- Establish resilience design guidelines for discrete priority projects and for segmental adaptation projects to achieve flood protection by 2070, with the option to add an additional 2 ft. of protection in the future.
- Translate the Climate Ready Boston concepts into feasible engineering and operational solutions that focus on protecting public right-of-way from flooding due to tidal and storm surge events.
- Provide a menu of sample flood protection options with engineering design considerations, preliminary cost estimates, as well as operations and maintenance guidance.



FLOODING DURING THE MARCH 2, 2018 NOR'EASTER AT LANGONE PARK & PUPOLO PLAYGROUND (ABOVE)



CLIMATE PROJECTIONS

The project team used previous climate studies developed for the City of Boston and surrounding municipalities as a starting point for selecting preliminary climate adjustments for design of flood protection structures including SLR and storm surge, extreme precipitation, and extreme temperatures. The Boston Harbor Flood Risk Model (BH-FRM), prepared by the Woods Hole Group, is used as the basis for SLR information and design. The City of Boston Planning & Development Agency has developed a sea level rise layer in their zoning viewer using the BH-FRM and 2070 projections. The guidelines' climate design adjustments are structured by "useful life" with projections for the 2030, 2050, and 2070 time horizons (where data were available) for consistency with Climate Ready Boston studies. Useful life represents the extended service life of most infrastructure, which is generally longer than design life (e.g., 50 years vs. 30 years). The useful life estimates should inform the selection of design elevations for increased infrastructure resilience, with a goal of 2070 flood protection. As the impacts of climate change do not end in 2070, the guidelines also consider how an additional 2 ft. of flood protection can be achieved as part of the current design.

DESIGNING FLOOD PROTECTION

Climate resilience embodies a wide spectrum of policy, design, and engineering strategies. Engineering adaptation includes a combination of retreat, protection, and accommodation strategies.

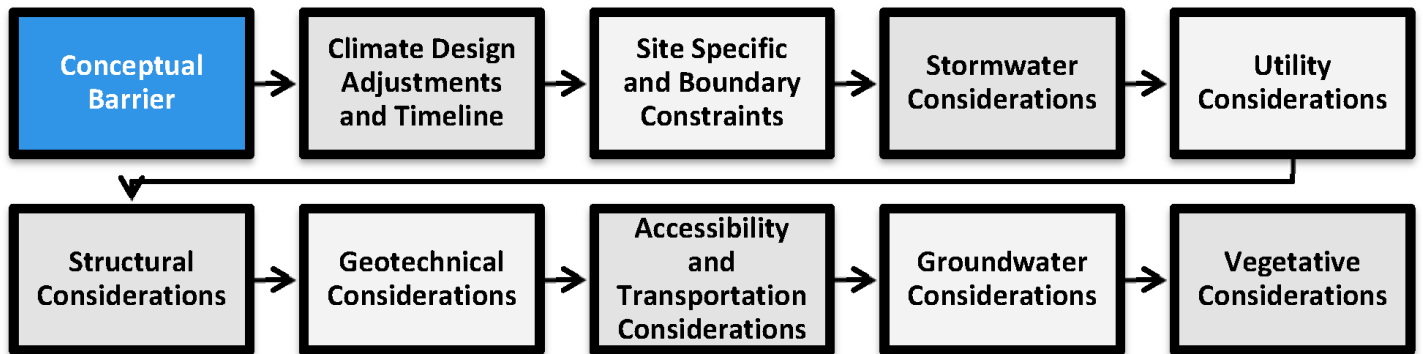
Flood barrier opportunities are being identified during Climate Ready Boston neighborhood studies and other projects around the City. The approach for flood barrier selection should include a unified vision for waterfront protection and public improvement. The process should seek to identify a solution that integrates with the physical environment and community needs and desires. Coordination with the City of Boston Public Works Department, Environment Department, Transportation Department, Planning & Development Agency, Mayor’s Office, Boston Water and Sewer Commission, MassDOT, MBTA, Private Property Owners, and others may be required for implementation, funding, and operations and maintenance (O&M). All projects that propose a flood barrier should also evaluate legal and local acceptability and develop a communications and stakeholder engagement plan.

Although the guidelines are focused on flood protection and barriers, a combination of adaptation planning strategies should be considered for all designs. Nature and nature-based solutions provide numerous co-benefits, such as mitigation, heat relief, and value creation; they should be considered city-wide solutions where they can be successfully implemented. The Climate Ready Boston principles of effectiveness, feasibility, design life and adaptability, social impacts, equity, value creation, and environmental impact should be considered for all projects as part of the design process.

The guidelines are organized to intuitively lead users through the process of advancing a conceptual flood barrier for projected climate conditions by evaluating applicable design considerations, operation and maintenance procedures, and related costs. The document is not a comprehensive list of all potential considerations that may be encountered during design of flood protection barriers. Engineers and design professional should use these considerations to augment the existing standard of care provided for projects, understand technical challenges associated with barriers, and identify opportunities to create value wherever feasible.

DESIGN CONSIDERATIONS

There are several design considerations that will affect the barrier selection and incremental phasing of the project.



This is not a comprehensive list of all factors that will be taken into account for design, but is intended to help design professionals consider how climate change will impact design and what additional studies will be needed to advance conceptual barrier designs.

OPERATIONS AND MAINTENANCE (O&M) AND COST CONSIDERATIONS

Each flood barrier will require identification of operations and maintenance (O&M) associated with design features and parties responsible for O&M. Stormwater management behind barriers may require significant capital and annual O&M costs in addition to the barrier features. An opinion of probable construction costs and life cycle costs should be prepared.

BARRIER SELECTION

The conceptual barrier may be advanced or modified based on design, operations and maintenance, and cost considerations. Additional feasibility studies and respective costs should be identified to advance design and steps towards implementation. Designers may consider redevelopment of the area, system redundancy and reliability, short-term versus long-term approaches, permitting strategy, and incremental phasing with a timeline for adaptation.

SAMPLE FLOOD BARRIERS

The City selected four sample flood barrier types from conceptual recommendations made in previous Climate Ready Boston studies. In the guidelines, each sample flood barrier includes a description of the barrier and assumptions, sample design considerations, sample drawings, sample operations and maintenance considerations, incremental adaptation considerations, and sample opinions of probable cost. All sample barriers assumed an elevation change of 4 ft. for 2070 design flood elevation.



VEGETATED BERMS

Construct a vegetated berm as a flood barrier, with the goals of creating open space and additional value along Boston's waterfront.



HARBORWALK FLOOD BARRIER

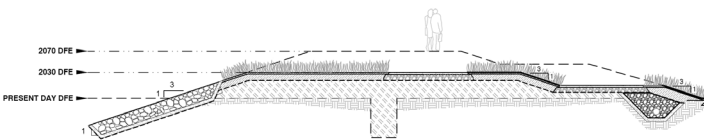
Transform the existing Boston Harborwalk into a flood barrier that maintains pedestrian connectivity to the waterfront.

RAISED ROADWAYS

Raise roadways to act as a flood barrier (or as emergency access routes).

TEMPORARY FLOOD BARRIERS

Deploy temporary flood barriers as short-term solutions, while long-term solutions are designed, permitted, and constructed.



SAMPLE DESIGN DRAWING AND VISUAL RENDERING OF THE VEGETATED BERM BARRIER (ABOVE)

The City selected sample barriers and sites as examples to prepare design, O&M, and cost considerations. The sample locations are intended to provide practical context with related opportunities and challenges. The guidelines do not reflect intentions of the City to proceed forward with design or implementation at these locations. Additional studies as described in the guidelines will be required to design and implement a comprehensive solution.

FLOOD BARRIER	SAMPLE SITE	SAMPLE OPPORTUNITIES	SAMPLE CHALLENGES
VEGETATED BERM	Existing ~1 mile stretch of open space along the existing Harborwalk	Incremental phasing; open space waterfront park	Not owned by the City of Boston; North and West flood pathways are still a threat for flooding behind the barrier
HARBORWALK BARRIER	Harborwalk supported by a stone masonry seawall located between two wharfs and a public park	Greenspace behind harborwalk; minor grade changes; deployable handrails	Flood barrier does not extend to ends of flood path; flood water will go around (flank) barrier
RAISED ROADWAY	City-owned street with residential and commercial properties at back of sidewalk	Block flood pathway; new development of area	Requires substantial redevelopment of abutting properties and neighborhood; Designated Port Area

The City understands that deployable flood barriers are currently being used to protect private properties from flooding. If temporary flood barriers are proposed, it is recommended that they be used for existing construction; where long-term solutions are being designed, permitted, and constructed; as well as for gaps and crossings of new flood barriers where permanent protection is not currently feasible. As such, the guidelines for deployable flood barriers provide a comparison matrix and a framework for evaluating and selecting appropriate deployable barriers. The guidelines provide several temporary flood defense barriers currently available. The City does not endorse the products included in the matrix. Additional flood barriers can be added to the matrix by others during the design and selection process.

The menu of flood barrier options provided in these guidelines is not a comprehensive list and does not include all possible scenarios, opportunities, or challenges that may be encountered as these projects progress from concept to implementation. The guidelines are intended to be an online living document that is regularly updated with new information as climate projections are revised and projects are implemented. The sample flood barrier engineering drawings (cross-sections) developed for the guidelines are attached.

