



Resilience and Durability to Extreme Weather Pilot Project: Massachusetts Department of Transportation

Resilience and Durability Pilot Projects 2018 – 2020

The Federal Highway Administration (FHWA) partnered with eleven pilot project teams to assess and deploy resilience solutions. This case study is part of a series that summarizes the pilot projects and highlights transportation system resilience efforts at other agencies across the country. For more information, visit

<https://www.fhwa.dot.gov/environment/sustainability/resilience/pilots/extweatherpilot.cfm>.

Summary

The Massachusetts Department of Transportation (MassDOT) assessed vulnerability and floodproofing measures of select public infrastructure. This project is expected to benefit millions of users of the Boston-based transportation infrastructure and key stakeholder agencies.

Key Takeaways

- MassDOT identified infrastructure at-risk of flooding due to sea level rise and storm surge.
- The study resulted in the floodproofing of four locations comprising the TE-434 and MBTA Blue Line Aquarium Station.
- MassDOT is developing SOPs and integrating them with existing emergency management plans to ensure successful and efficient use of floodproofing measures.

Objectives

The primary objective of the study was to implement floodproofing measures to prevent damage to select public infrastructure in Downtown Boston from extreme coastal flooding events. The study aimed to assess Tunnel Egress 434 (TE-434) and the Massachusetts Bay Transportation Authority (MBTA) Blue Line Aquarium Station, with respect to their vulnerability to flooding, evaluate options to mitigate the vulnerabilities, develop bid documents for the selected floodproofing measures, and construct the selected floodproofing measures as quickly as possible to make the TE-434 and MBTA Blue Line Aquarium Station resilient to flooding. Lastly, the study aimed to develop standard operating procedures (SOPs) and integrate them with existing emergency management plans to ensure successful use of floodproofing measures.

Scope

This project focused on floodproofing TE-434 from the Tip O'Neill Tunnel and the MBTA Blue Line Aquarium Station as they are two of the most-at-risk MassDOT non-roadway infrastructure assets. Four locations associated with these assets were assessed, including three headhouses and an emergency egress stair and ventilation structure (Figure 1).



Figure 1. Locations of the Aquarium Station headhouses and Blue Line egress kiosk at Long Wharf.
Source: MassDOT.

Approach

Design Flood Elevations

Each of the locations was assessed to determine the design flood elevation (DFE), or the base elevation beyond which there was a 1% annual chance of exceeding leading to flooding damages and associated costs. The Boston Harbor-Flood Risk Model (BH-FRM), a state-of-the-art hydrodynamic model developed by MassDOT as part of a prior pilot study, was used for these assessments and set the DFEs for the four locations comprising the TE-434 and MBTA Blue Line Aquarium Station.

Vulnerability Assessment and Floodproofing Strategy Evaluation

The vulnerability assessment identified that the greatest threat of damage to TE-434 and the MBTA Blue Line Aquarium Station is from seawater flowing through the station headhouse entrances or from headhouse structures breaking under pressure from flood waters. Each of the four entrances into the tunnels and Blue Line station were evaluated to determine the best ways to protect them from flood water. Proposed floodproofing solutions fall into two categories: (1) using temporary deployable flood barriers to protect entrances and (2) demolishing existing structures and replacing them with reinforced structures that can withstand flood waters.

Several temporary flood barrier types were investigated, including composite, foldable, interlocking flood panels, water-filled barriers, and drop-in flood barriers with anchored posts. After considering City sidewalk requirements (which dictate a minimum of four feet of width on City sidewalks), ease to deploy, and onsite storage, the drop-in flood barriers were selected as the flood barrier to use (Figure 2).



Figure 2. Example of drop-in flood barrier system. Source: MassDOT.

Final Design Issues

The final flood barrier design incorporated considerations from a broad set of existing regulations and stakeholders. In addition to permitting requirements, approvals related to right-of-way, and building code issues, the project design required addressing regulations related to historic preservation, wetlands, and waterways. Contract documents for the barrier design also included restrictions to protect interests of public and private entities that may be affected during construction and eventual deployment of flood barriers. These included a tourism agency, the City of Boston, a hotel, a privately-owned office building, and MBTA departments.

Developing Standard Operating Procedures and Ongoing Monitoring

An SOP is critical for the successful deployment and breakdown of the flood barrier system prior to, during, and after a flood event. MassDOT intends to develop the SOP in coordination with MBTA to identify responsible parties for decision making, the threshold in the flood forecast that should be used to trigger deployment (Table 1), personnel in charge of installing the barrier, communication protocols for notifying other departments and agencies of the impending station shutdown, wayfinding and accessibility considerations for station closures, and alternative transportation

accommodations for riders, if necessary. To ensure effective use of flood barrier systems, ongoing monitoring, including annual training drills and component inspection, is critical. The project team plans to establish such procedures in addition to post-training and post-storm documentation after deployment. This documentation will record times for flood barrier system deployment and log potential problems, while establishing a documentation of lessons learned.

Table 1. Proposed flood trigger elevations for flood barrier deployment action. Source: MassDOT

Forecasted Flood Elevation	Proposed Flood Barrier Deployment Action
Below 12.8 ft.	No flood barriers deployed.
12.8 ft. to 13.5 ft.	Deploy flood barriers at East Station headhouse only. Aquarium Station remains open using Southwest and Marketplace entrances only.
13.6 ft. and above	Deploy flood barriers at East, Southwest, and Marketplace Center entrances. Aquarium Station will be closed.

Key Results & Findings

Flooding Assessment and Floodproofing Solution Determination

DfEs were determined for each of the four locations considered. As part of this, the critical elevations at which flood water would enter the facility were established, followed by a determination of the most appropriate methods of protection. Two of the locations were found to require temporary deployable flood barriers, one location was floodproofed by replacing the structure with reinforced concrete and a floodproof door, and the final location was found to be best floodproofed through constructing both floodproof walls and deploying temporary barriers. These estimated flooding elevations and proposed solutions are summarized by location in Table 2.

Table 2. Summary of vulnerability results. Source: MassDOT.

Location	Existing Structure Elevation (feet)	Estimated Flooding Elevation (feet)	Proposed Floodproofing Solution
Aquarium Station West Headhouse (Marketplace Center)	10.2	12.0	Temporary deployable flood barriers and concrete wall construction.
Aquarium Station East Headhouse	8.8	12.0	Temporary deployable flood barriers.
Blue Line Emergency Egress	9.9	14.8	Replace structure with reinforced concrete and floodproof door.
Aquarium Station Southwest Headhouse	9.6	12.0	Temporary deployable flood barriers.

Project Procurement and Construction

In the interest of making the selected infrastructure resilient to coastal flooding as soon as possible, the study team explored three options to expedite procurement of the flood barriers. Options included MassDOT, the design consultant, or the MBTA pre-purchasing the flood barriers. Due to liability and accountability concerns, the most viable option and the one that was eventually implemented involved the MBTA pre-purchasing the flood barriers which ultimately ensured the flood barriers were on site in advance of construction, even with shipping delays due to COVID-19. Construction started October 2020 and was completed in March 2021.

Lessons Learned

The pilot study resulted in several lessons learned for MassDOT:

- At times coordination issues between MassDOT and MBTA led to delays in the project timeline. Using memoranda of understandings to formally define roles and responsibilities early in the project would have improved the project flow and is recommended for future endeavors.
- To minimize the time necessary for floodproofing procurement and construction, MassDOT found it was helpful to pre-purchase flood barriers. Further, MassDOT concluded that having a dedicated on-call construction contract could facilitate the implementation of smaller low-cost floodproofing solutions.
- Having an understanding of the minimum time required for flood barrier deployment is very important. Certain measures were found to facilitate timely barrier deployment, such as on-site storage of barriers and a single standardized barrier panel size, while other factors were anticipated to cause increases in deployment time, such as emergency evacuation requirements.
- Having a clearly defined SOP is key for successfully deploying and breaking down the flood barrier system. However, challenges persist in determining who will take ownership for making the call to deploy, as well as who will provide staff to deploy and retrieve flood barrier materials.
- MassDOT found that building on previous work, specifically using the BH-FRM, was an excellent example of applying past knowledge and efforts to enhance the ongoing pilot project.

Next Steps

MassDOT has identified next steps to complete this study and for future work, now that floodproofing for the MBTA Blue Line Aquarium Station was completed in March 2021:

- Finish development of the SOP for deployment of flood barriers, including final coordination with stakeholders.
- Incorporate SOP for flood barrier deployment at the MBTA Blue Line Aquarium Station.
- Investigate ways to improve resiliency from coastal flooding at other important roadway assets including the Sumner Tunnel Entrance and Callahan Tunnel exit in East Boston and non-roadway assets such as the Highway Operations Center in South Boston.

For More Information

Resources

MassDOT Final Pilot Report:

<https://www.fhwa.dot.gov/environment/sustainability/resilience/pilots/>

For more on the Boston Harbor Flood Risk Model and Massachusetts Resilience Projects:

<https://www.mass.gov/info-details/climate-change-resiliency>

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