Increasing the Coastal Resilience of Vulnerable Wastewater Infrastructure on the Massachusetts Coast and Islands – Two Case Studies

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Overview

- Background
- Two Case Studies
  1. Town of Wareham
  2. Town of Oak Bluffs
- Questions
Background
Vulnerability to Coastal Storms

- Financial damages
  - FEMA: 8 out of the top 10 costliest natural disasters in the United States were caused by coastal storms
- Change in frequency and intensity of storms
  - Global sea level rise
  - Updated FEMA FIRM Maps
- Existing infrastructure not protected to newly defined flood elevations
  - Changing design standards
- Loss of service for critical infrastructure
FEMA coastal flood hazard zones/base flood elevation
Changing Storm Frequency and Intensity

- 1983 FEMA Firm Map
- Zone A10 = 15 ft MSL
- Zone B = Area between 100 yr and 500 yr flood
- Zone C = Areas outside 500 yr flood

- 2012 FEMA Firm Map
- AE Zones = 16, 17
- VE Zones = 17, 21, 22
Sea level rise projections

- NOAA sea level change projections
- 20 year projection used for all proposed mechanical improvements
- 50 year projection used for all proposed structural improvements

NOAA = National Oceanic and Atmospheric Administration
## Freeboard Requirements

<table>
<thead>
<tr>
<th>Previous design standard</th>
<th>Updated design standards</th>
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<tbody>
<tr>
<td>• Design to 100 year flood elevation</td>
<td>• More stringent minimum freeboard requirements</td>
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<tr>
<td>• No required minimum freeboard</td>
<td>• TR-16</td>
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<tr>
<td></td>
<td>• Critical equipment = 3 ft</td>
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<tr>
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<td>• Non-critical equipment = 2 ft</td>
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<td></td>
<td>• ASCE 24-14 – Flood Resistant Design and Construction, 2014</td>
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<td></td>
<td>• Referenced in Massachusetts draft 9th Building Code</td>
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<td>• Specifies minimum freeboard requirements based on criticality of infrastructure</td>
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Freeboard Requirements
ASCE 24-14

• 4 Flood Design Classes

• Flood Design Class 3 Structures
  Buildings and structures that pose a high risk to the public and a significant
disruption to the community if they are unable to perform their intended
function due to flooding. *ASCE 24-14 specifically includes water and
sewage treatment in this category.*

• Flood Design Class 4 Structures
  Buildings and structures that contain essential facilities and services
necessary for emergency response and recovery and *ancillary structures
that allow continuous functioning of a Flood Design Class 4 facility
after an emergency.*
<table>
<thead>
<tr>
<th>Condition</th>
<th>ASCE 24-14 Minimum Freeboard Requirement</th>
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<tbody>
<tr>
<td></td>
<td>Flood Design Class 3</td>
</tr>
<tr>
<td>Minimum elevation of dry flood-proofing of non-residential portions of mixed-use buildings</td>
<td>Zone AE</td>
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<tr>
<td></td>
<td>Zone VE and Coastal Zone AE</td>
</tr>
<tr>
<td>Minimum elevation of wet flood-proofing</td>
<td>Zone AE, Zone VE and Coastal Zone AE</td>
</tr>
</tbody>
</table>

Source: ASCE 24-14: Flood Resistant Design and Construction

Notes:
(1) The DFE is obtained from a community adopted flood hazard map if a community has adopted a flood hazard map that depicts flood hazard areas in addition to the SFHA's shown on FEMA's FIRM maps.
Design approach – determine design flood elevation

Design Flood Elevation (DFE) =
Base Flood Elevation (BFE) + Sea Level Rise + Freeboard
Coastal Resilience Strategies

Dry Flood Proofing

- Preventing flood water from entering structure (make structure watertight)
- Reinforce structure to withstand forces of a hydrostatic flood load
Coastal Resilience Strategies

Wet Flood Proofing

- Allow flood waters to infiltration the structure
- Protect contents of building from water damage (elevate or floodproof)
Two Case Studies
Case Study 1 | Town of Wareham

- 54 miles of coastline
- 43 pump stations and 1 wastewater treatment plant
- 29 pump stations in 100 year flood zone
Approach

• Town needed methodology to prioritize pump station retrofits
• Risk and Vulnerability Assessment
• Assessed annual flood risk for each vulnerable station
Risk and Vulnerability Assessment

1. Determine Design Flood Elevations

2. Determine which components will be damage/ruined in 1% storm (100 year) and replacement costs

3. Determine estimated monetary total loss:
   FEMA Benefit Cost Analysis (BCA) Software

4. Flood Risk ($) = (Threat of Likelihood) x (Total Loss)
Risk and Vulnerability | Example 1

Onset Pier
- 6 pump stations dependent on Onset Pier
- Large structural load on building
- Potential erosion risk
- All equipment will be inundated in 1% storm
- Electrical eq, generator, mechanical equipment

Total Losses
- Structure
- All mechanical equipment
- Impact on upstream pump stations
Risk and Vulnerability | Example 2

**Leonard Street**
- No dependent pumping stations
- Minimal equipment damage
- Submersible pumps
- No ASCE 24-14 Flood Design Class 4 Infrastructure (hospitals, fire dept, police dept etc) in sewershed

**Total Losses**
- Minimal equipment damage
Coastal Resilience Design Phase

- Three high priority wet pit/dry pit stations
  - Narrows Pump Station
  - Hynes Field Pump Station
  - Cohasset Narrows Pump Station

- All three stations serve:
  - Multiple dependent pump stations
  - Critical Infrastructure
Priority Pump Stations

Narrows

Hynes Field

Cohasset Narrows
Priority Pump Stations

- Existing equipment not waterproof
  - Equipment damage
  - Electrical damage

- Potential structure collapse

- Dry flood proofing
Flood Proof Doors

Pedestrian Flood Door (Single)

Pedestrian Flood Door (Paired)
Flood Planks
Sealing Potential Entry Points
Waterproof Epoxy Spray System
Structural Reinforcement
Maintaining Power

- Provide enough generator fuel for:
  - 48 hours under peak flow, or
  - 96 hours under average flow

- Install 160 gal additional fuel:
  - Narrows
  - Hynes Field
Next Steps

Apply for funding for:
• Final design of priority pump stations
• Construction of emergency bypass
Case Study 2 | Town of Oak Bluffs

- Northern part of Martha’s Vineyard
- 3 pump stations in vulnerable locations and 1 wastewater treatment plant
Location of existing pump stations
FEMA flood map
(location of existing pump stations)
Duke’s County Avenue Pump Station

Area served by this pump station
• Largest pump station in Oak Bluffs
• Serves nearly the entire sewered population

Problems
• Codes prohibit generator to be indoors
Duke’s County Avenue Pump Station

Mitigation (this project)

• Wet flood proof
• New diesel generator
  – Outdoors adjacent to the pump station building
  – On steel platform on concrete pad
Lake Avenue Pump Station

Area Served by this pump station
- Main business/commercial district in Oak Bluffs

Problems
- Generator connection point inaccessible during flood (Town has portable generator)
Mitigation (this project)

- Wet-flood proof
- Install power conduit from Duke’s County Avenue Pump Station to Lake Avenue Pump Station
  - Nearly 1000 linear feet of electrical ductbank
Next steps

Seek funding to address the long term mitigation solutions for three vulnerable pump stations

1. **Our Market Pump Station**
   - Watertight hatch in submersible pump station
   - Install controls in an immersible enclosure (NEMA 6P)

2. **Lake Avenue Pump Station**
   - Watertight hatch in submersible pump station
   - Mount new control panel in Duke’s County Ave Pump Station

3. **Duke’s County Avenue Pump Station**
   - Wooden building in vulnerable location putting electrical equipment at risk
Questions?

Thank you!
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Coastal Resilience Measures

Dry Flood Proof Stations
- Structurally reinforce walls
- Flood proof doors
- Install barriers on penetrations below DFE
- Block up windows below DFE
- Apply waterproof coating to outside of building
- Emergency egress
Structural Reinforcement

- Cohasset Narrows
  - Reinforced masonry walls
  - Carbon Reinforcing Strips
Returning to Operation if Station Goes Down
Emergency Bypass Connection