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

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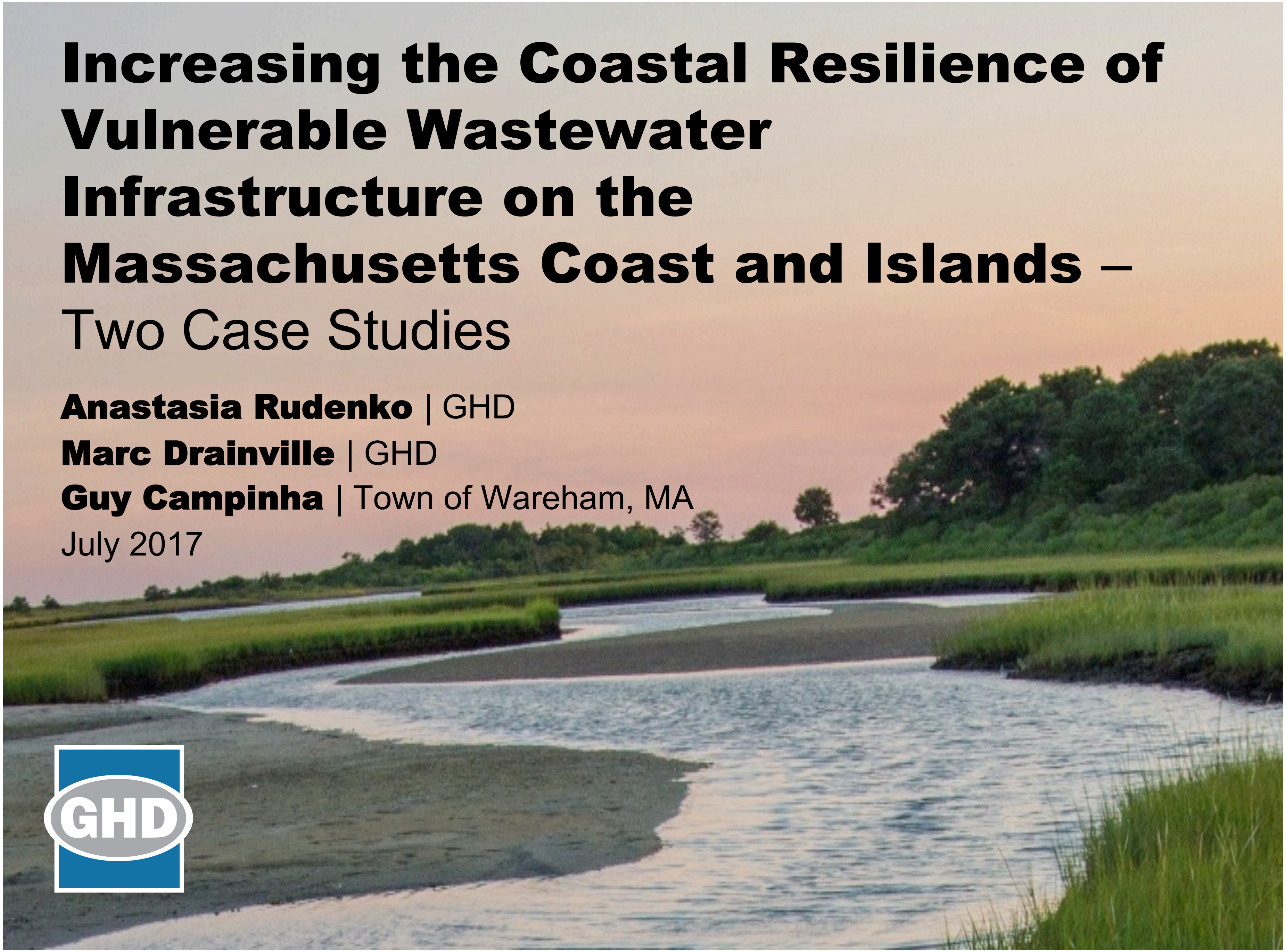
July 2017



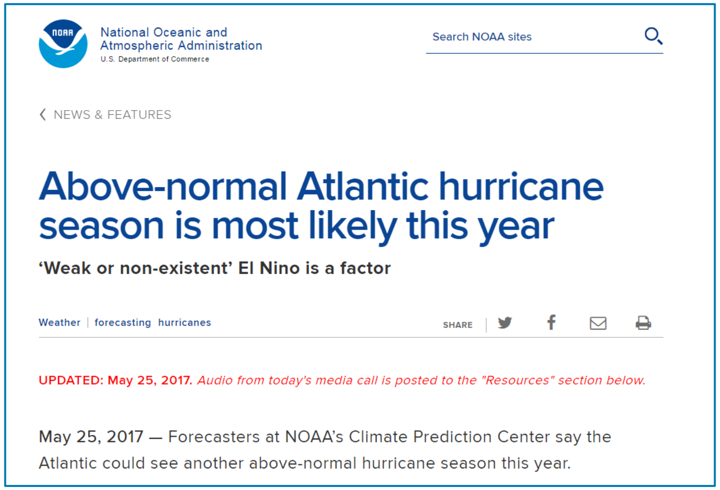
Overview

- 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


National Oceanic and Atmospheric Administration
U.S. Department of Commerce

Search NOAA sites

NEWS & FEATURES

Above-normal Atlantic hurricane season is most likely this year

'Weak or non-existent' El Nino is a factor

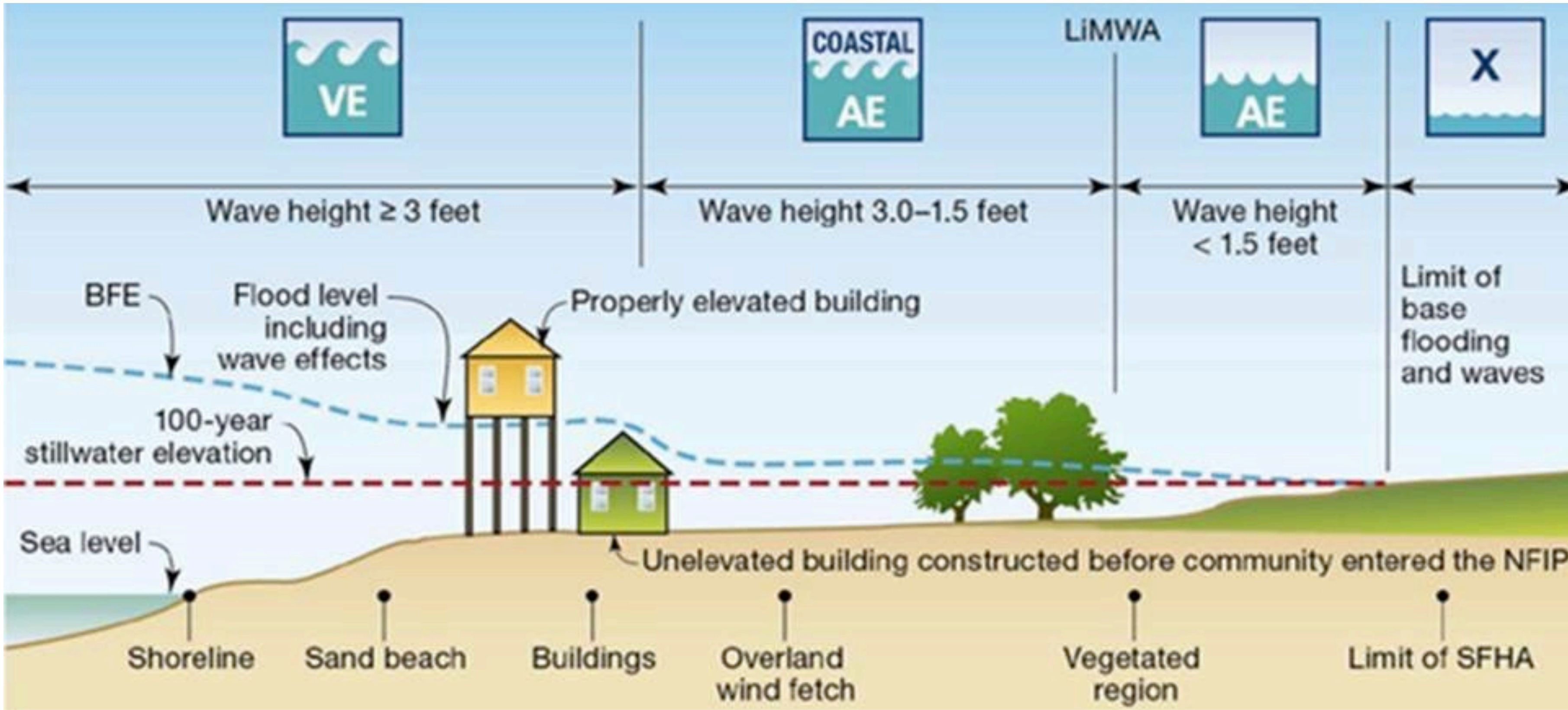
Weather | forecasting hurricanes

SHARE

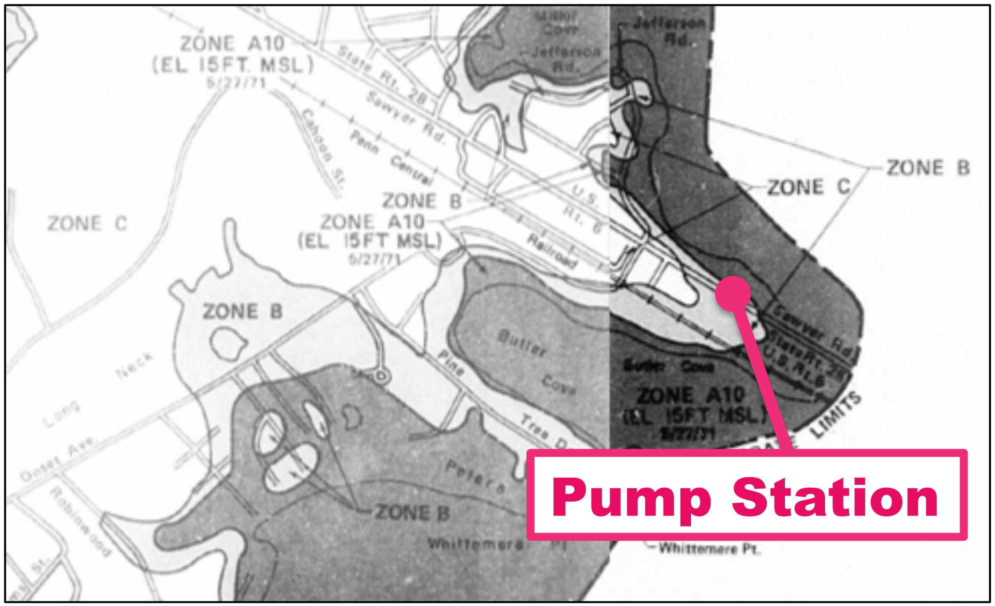
UPDATED: May 25, 2017. *Audio from today's media call is posted to the "Resources" section below.*

May 25, 2017 — Forecasters at NOAA's Climate Prediction Center say the Atlantic could see another above-normal hurricane season this year.

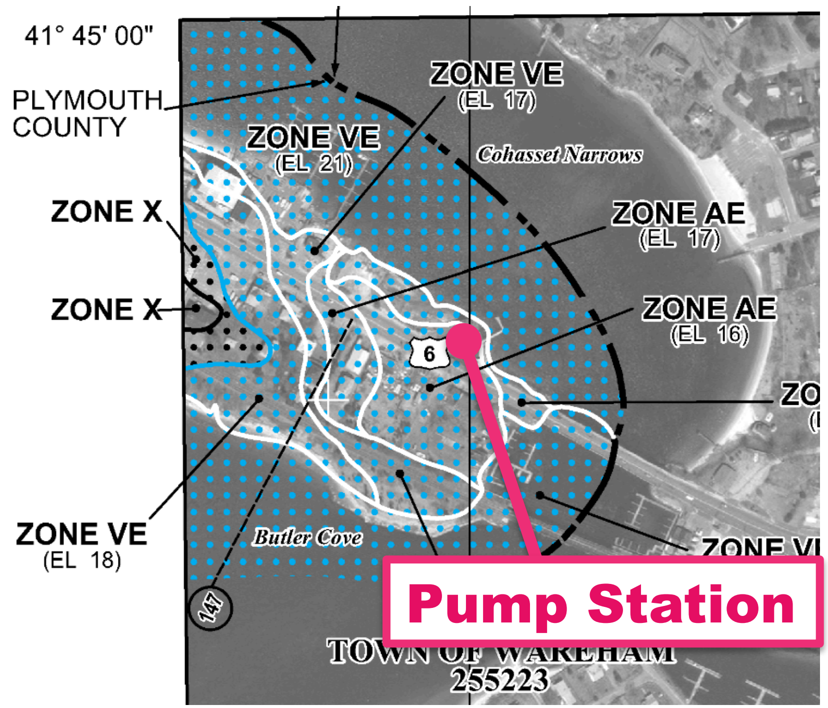
FEMA coastal flood hazard zones/base flood elevation



Changing Storm Frequency and Intensity



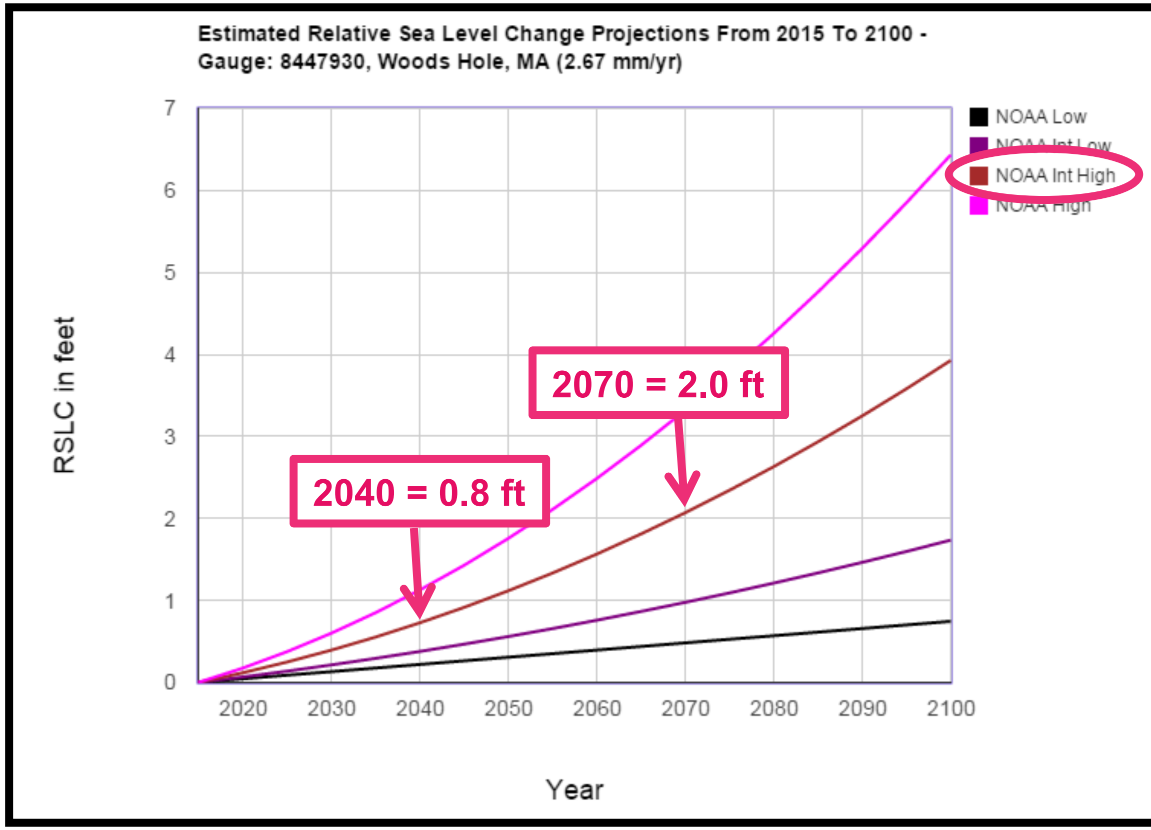
- 1983 FEMA Firm Map
- Zone A10 = 15 ft MSL
- Zone B = Area between 100 yr and 500 yr flood
- Zone C = Areas outside 500 yr flood



- 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

Previous design standard	Updated design standards

• Design to 100 year flood elevation
• No required minimum freeboard
	• More stringent minimum freeboard requirements
	• TR-16
	    • Critical equipment = 3 ft
	    • Non-critical equipment = 2 ft
	• ASCE 24-14 – Flood Resistant Design and Construction, 2014
	    • Referenced in Massachusetts draft 9th Building Code
	    • Specifies minimum freeboard requirements based on criticality of infrastructure

Freeboard Requirements
ASCE 24-14

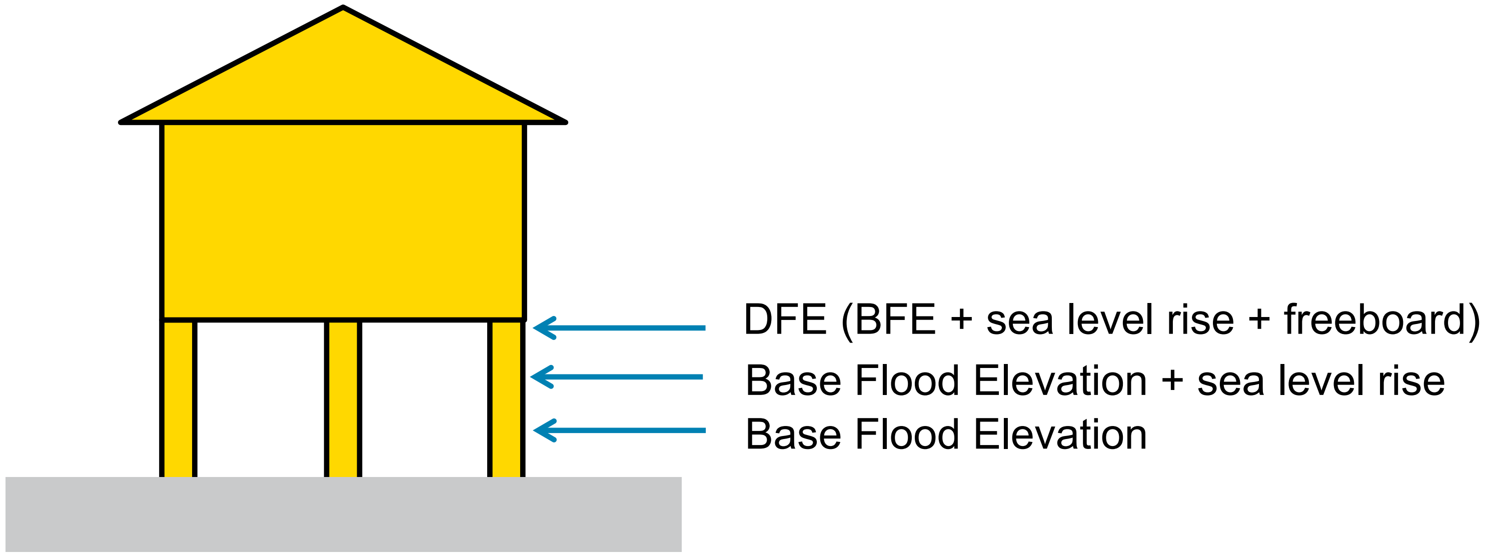
- **4 Flood Design Classes**
- **Flood Design Class 3 Structures**
  Buildings and structures that pose a high risk to the public and a significant disruption to the community if they are unable to perform their intended function due to flooding. **ASCE 24-14 specifically includes water and sewage treatment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

Condition		ASCE 24-14 Minimum Freeboard Requirement	
		Flood Design Class 3	Flood Design Class 4
Minimum elevation of dry flood-proofing of non-residential portions of mixed-use buildings	Zone AE	BFE + 1 foot or DFE, whichever is higher	BFE + 2 feet or DFE, or 500 year flood elevation, whichever is higher.
	Zone VE and Coastal Zone AE	Not permitted.	Not permitted.
Minimum elevation of wet flood-proofing	Zone AE, Zone VE and Coastal Zone AE	BFE + 1 foot or DFE, whichever is higher.	BFE + 2 feet or DFE, or 500 year flood elevation, whoever is higher

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

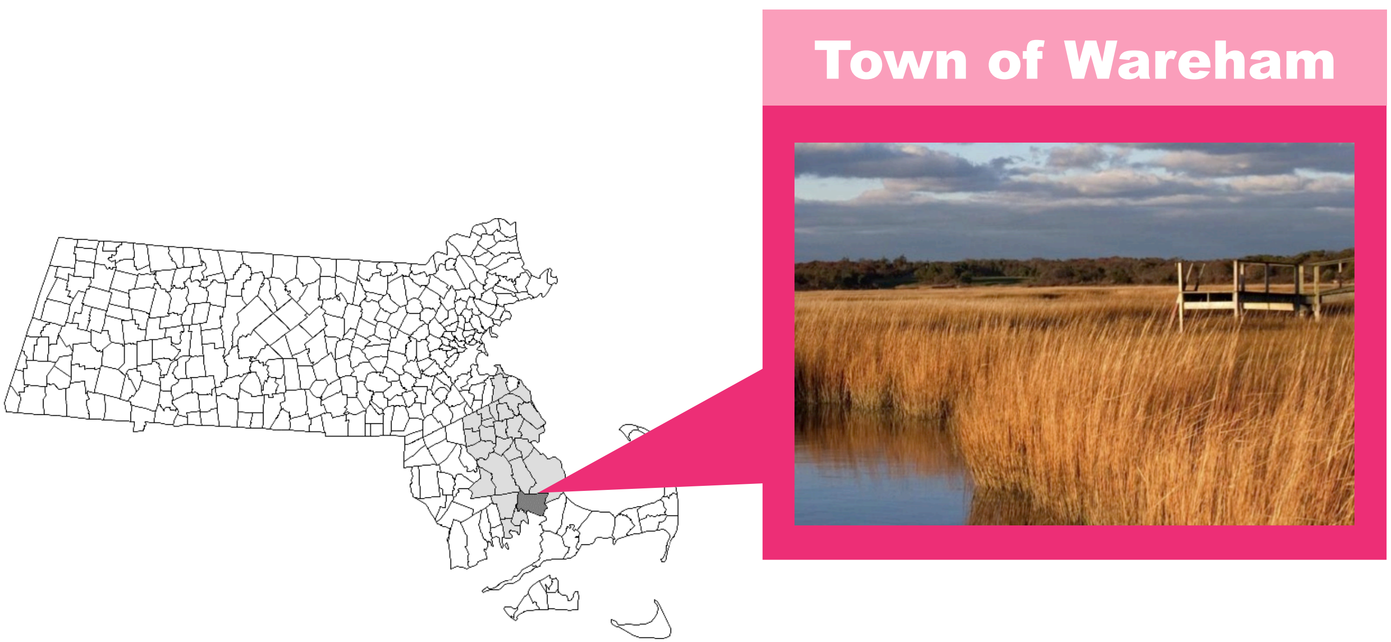
Wet Flood Proofing

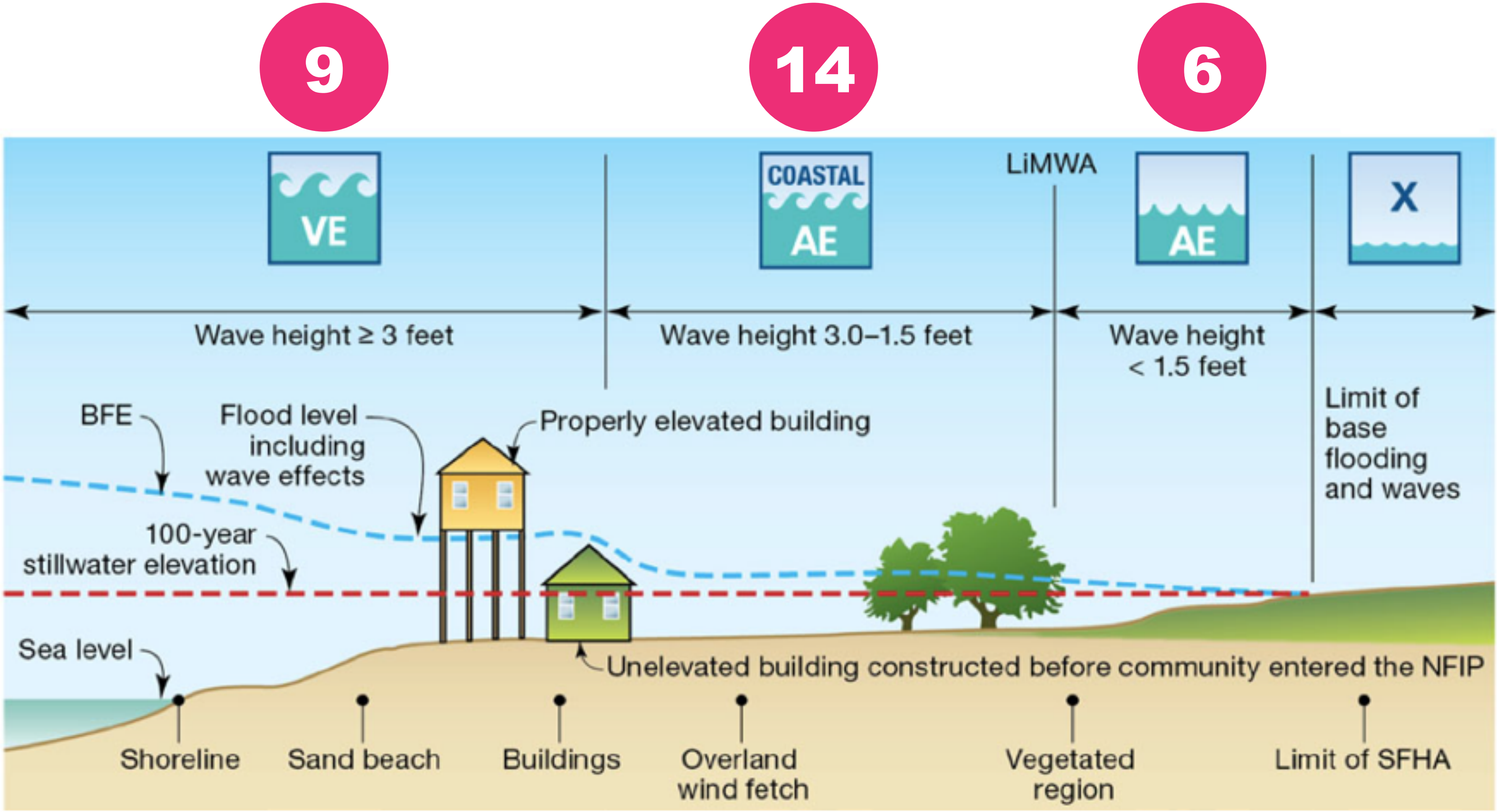
- Allow flood waters to infiltration the structure
- Protect contents of building from water damage (elevate or floodproof)

Two Case Studies

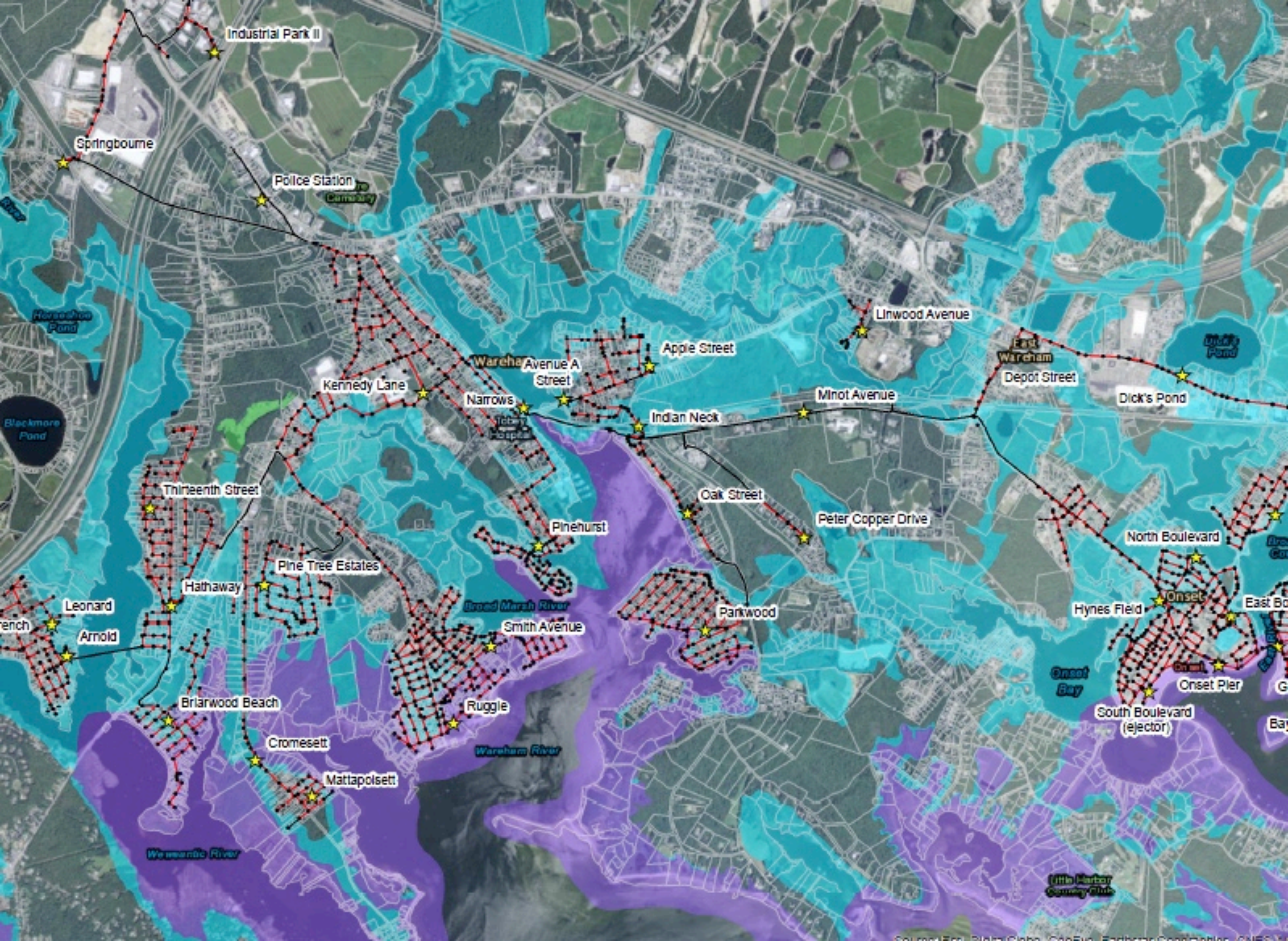
Case Study 1 | Town of Wareham

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





9
14
6
VE
COASTAL
AE
LiMWA
AE
X
Wave height ≥ 3 feet
Wave height 3.0–1.5 feet
Wave height
< 1.5 feet
Limit of
base
flooding
and waves
BFE
Flood level
including
wave effects
Properly elevated building
100-year
stillwater elevation
Sea level
Unelevated building constructed before community entered the NFIP
Shoreline
Sand beach
Buildings
Overland
wind fetch
Vegetated
region
Limit of SFHA



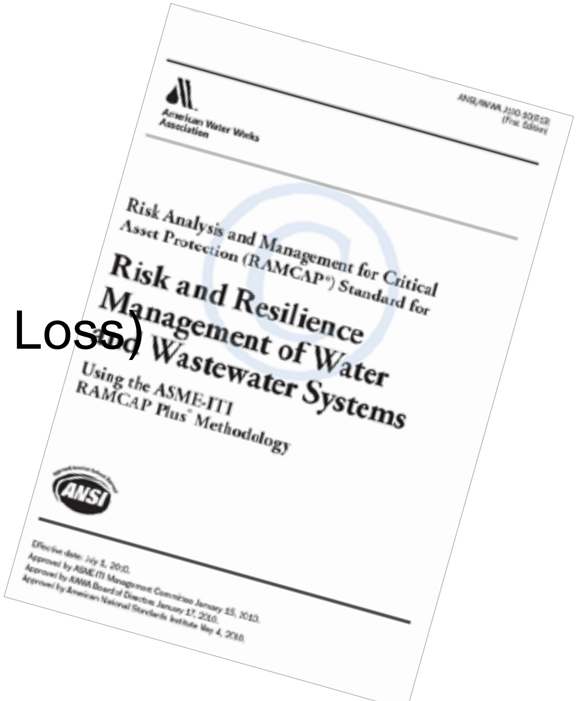
Industrial Park II
Springbourne
Police Station
Linwood Avenue
Apple Street
Avenue A Street
Kennedy Lane
Narrows
Indian Neck
Minot Avenue
Depot Street
Dick's Pond
East Wareham
Thirteenth Street
Oak Street
Peter Copper Drive
Pinehurst
North Boulevard
Pine Tree Estates
Hathaway
Leonard
Arnold
Broad Marsh River
Smith Avenue
Parkwood
Hynes Field
Onset
Onset Pier
Onset Bay
Briarwood Beach
Ruggle
South Boulevard (ejector)
Cromesett
Wareham River
Mattapoisett
Wewantic River
Blackmore Pond
Horseshoe Pond
Little Harbor Country Club

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)


American Water Works Association

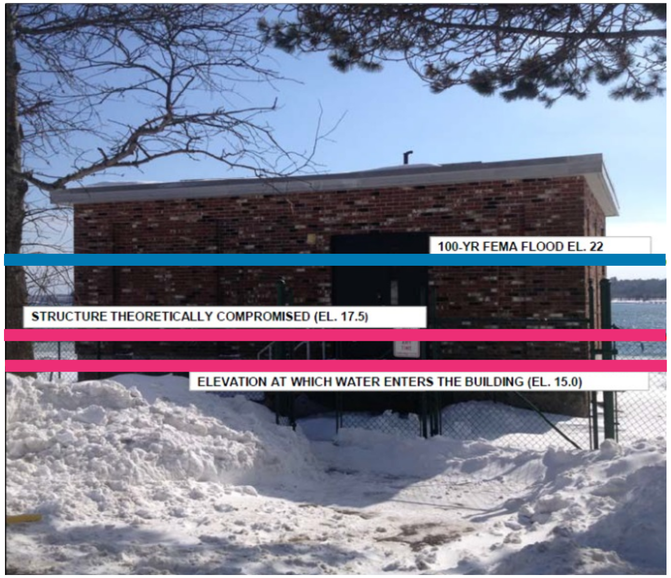
Risk Analysis and Management for Critical Asset Protection (RAMCAP®) Standard for

Risk and Resilience Management of Water and Wastewater Systems

Using the ASME-ITI RAMCAP Plus® Methodology

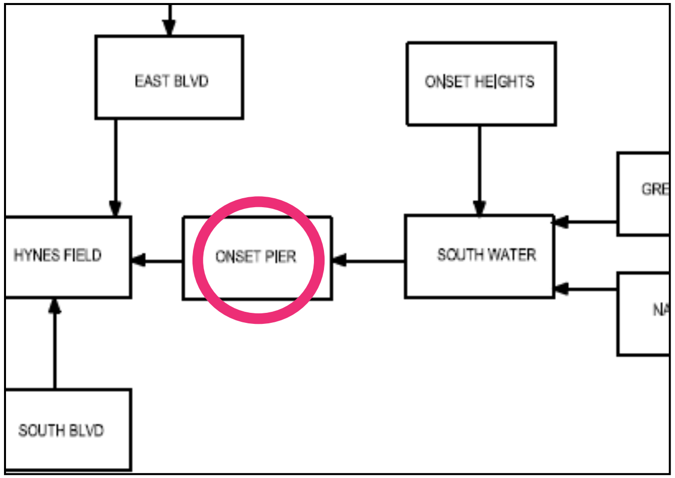
ANSI

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

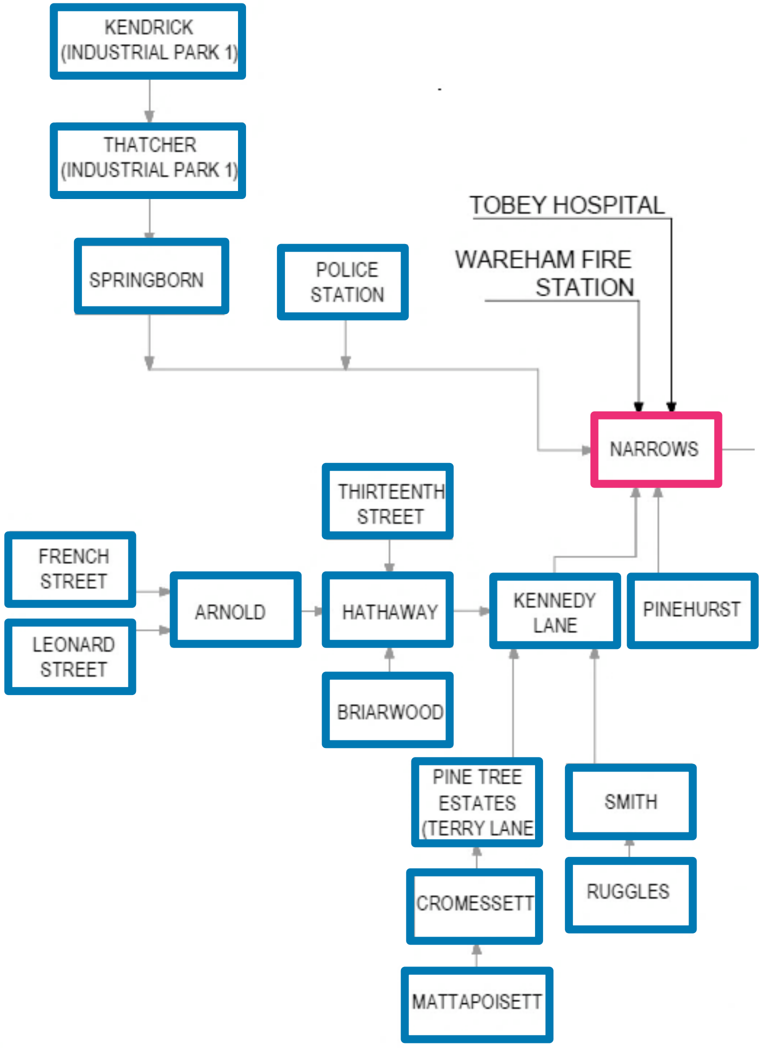
- No dependent pumping stations
- Minimal equipment damage
- Submersible pumps
- No ASCE 24-14 Flood Design Class 4 Infrastructure (hospitals, fire dept, police dept etc) in sewershed

Total Losses

- Minimal equipment damage

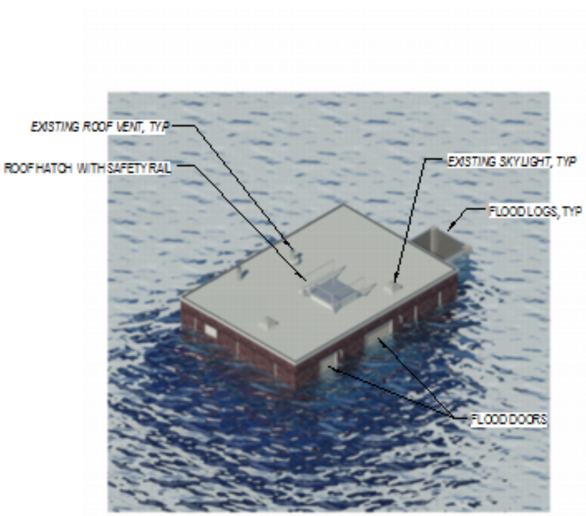
Coastal Resilience Design Phase

- **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

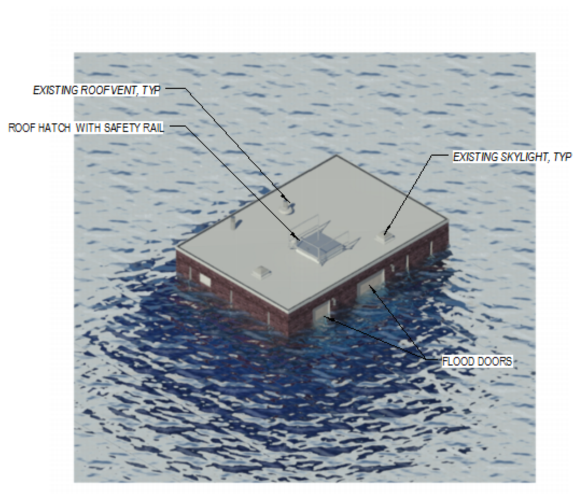


Priority Pump Stations

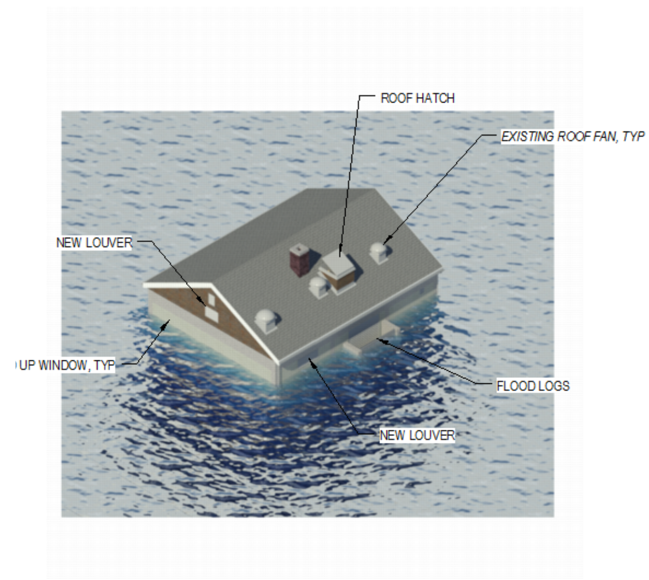
Narrows



Hynes Field

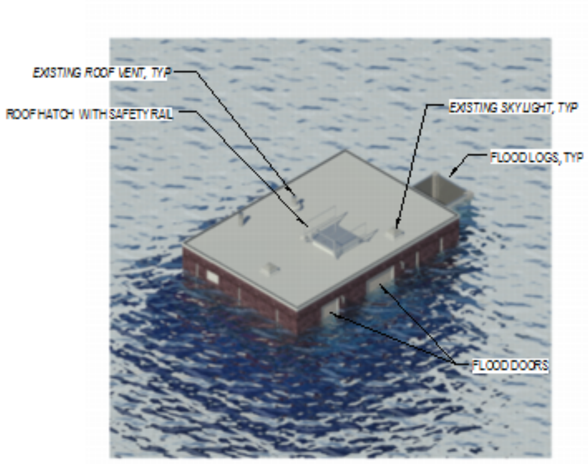


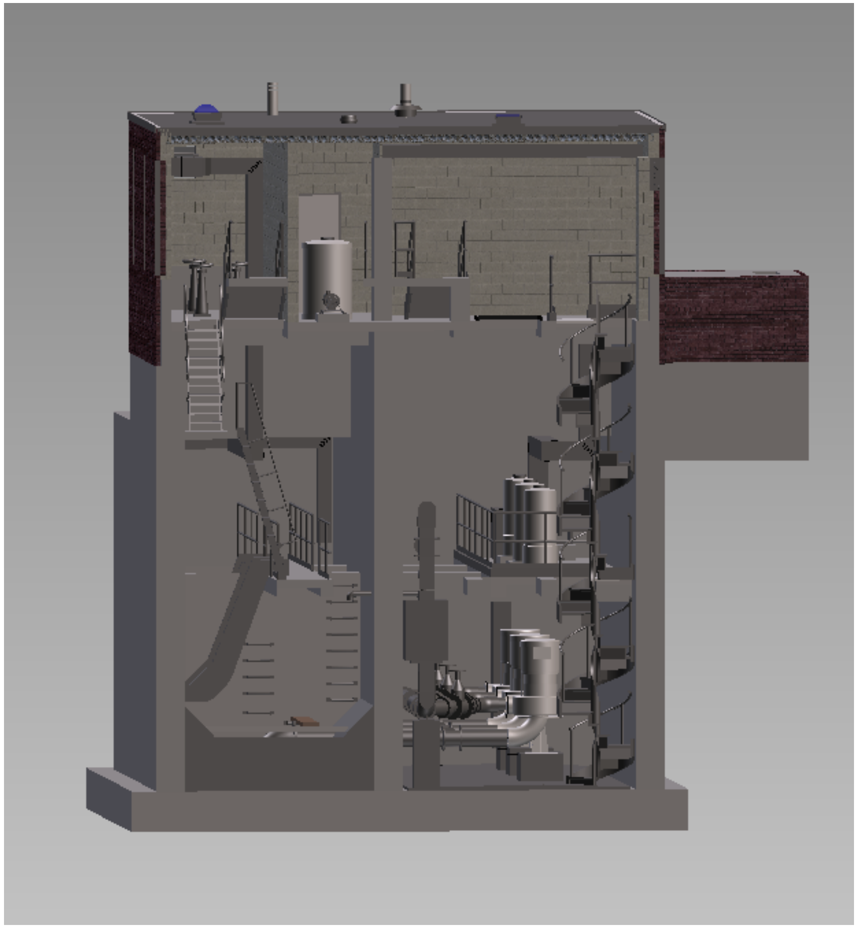
Cohasset Narrows



Priority Pump Stations

- Existing equipment not waterproof
  - Equipment damage
  - Electrical damage
- Potential structure collapse
- Dry flood proofing



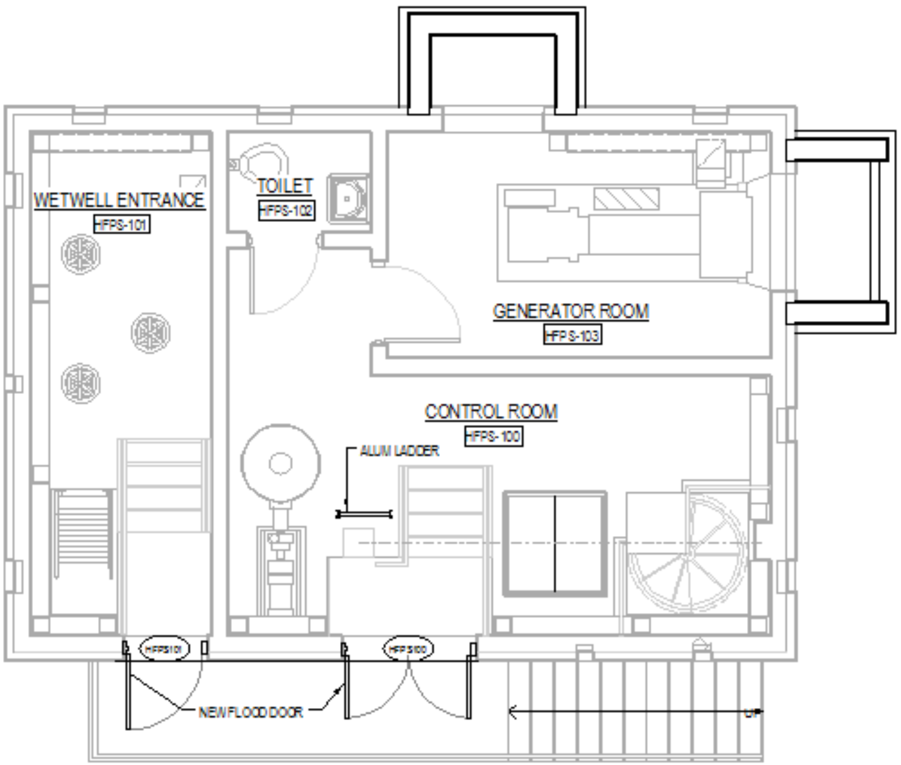


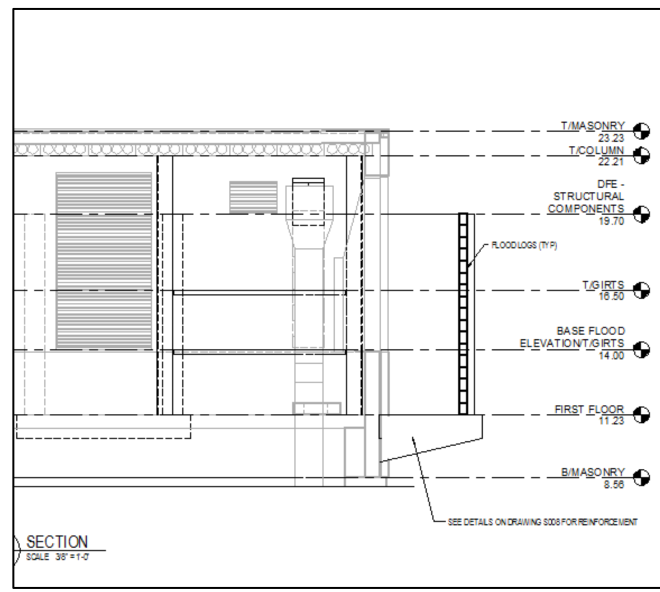
Flood Proof Doors

Pedestrian Flood Door (Single)

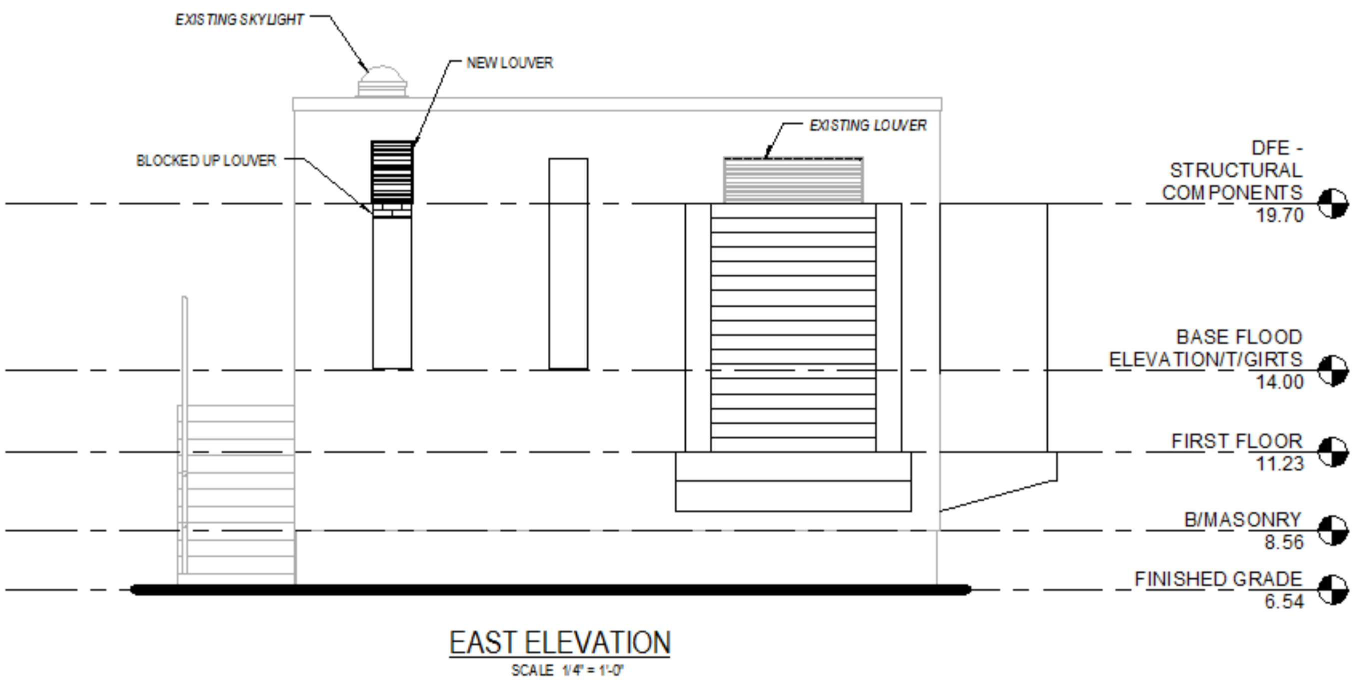
Pedestrian Flood Door (Paired)

Flood Planks

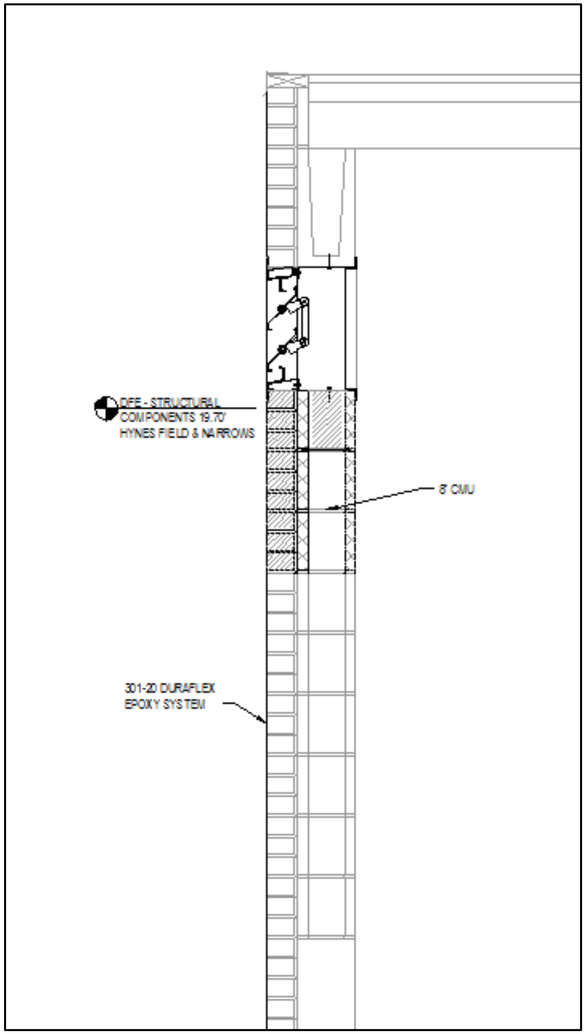




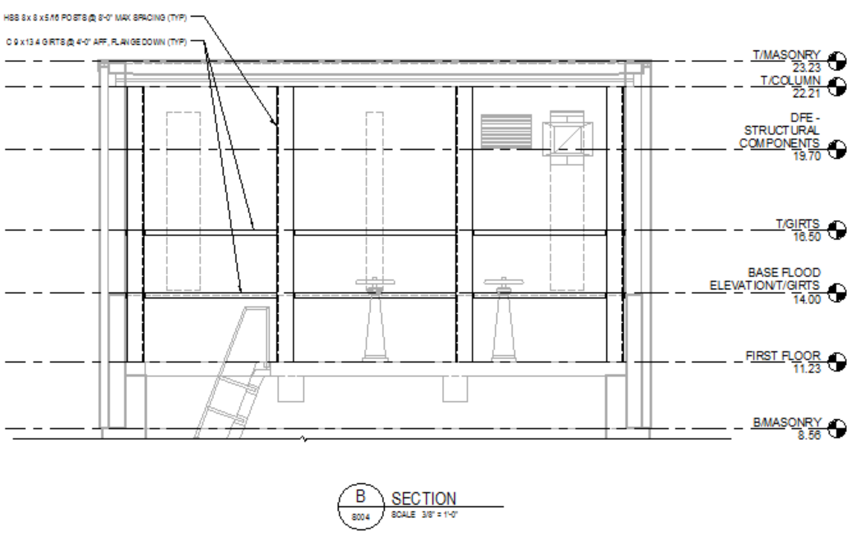
Sealing Potential Entry Points



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

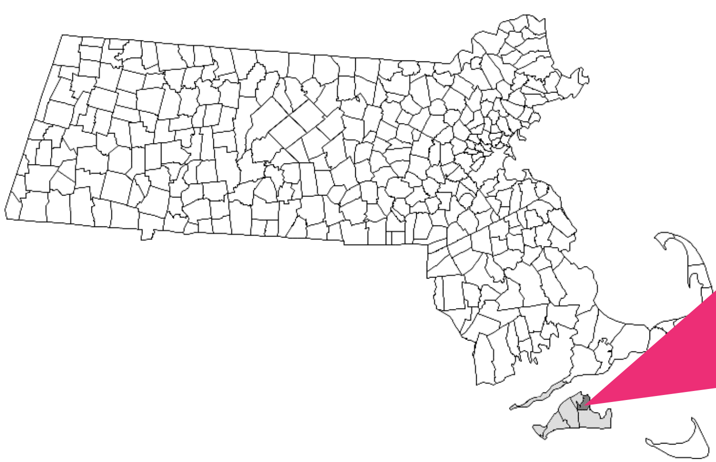
Next Steps

Apply for funding for:

- Final design of priority pump stations
- Construction of emergency bypass

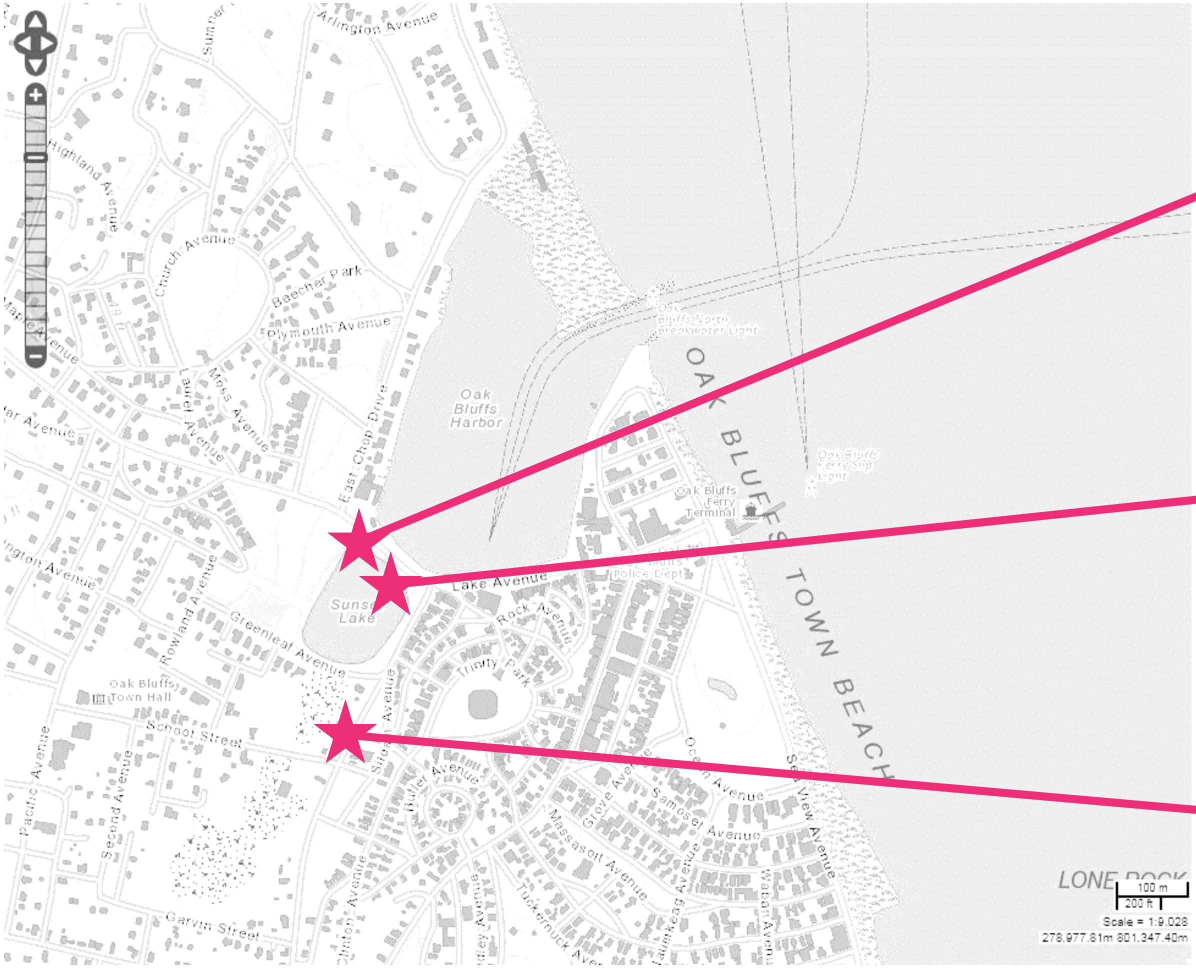
Case Study 2 | Town of Oak Bluffs

- Northern part of Martha's Vineyard
- **3** pump stations in vulnerable locations and **1** wastewater treatment plant



Town of Oak Bluffs

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

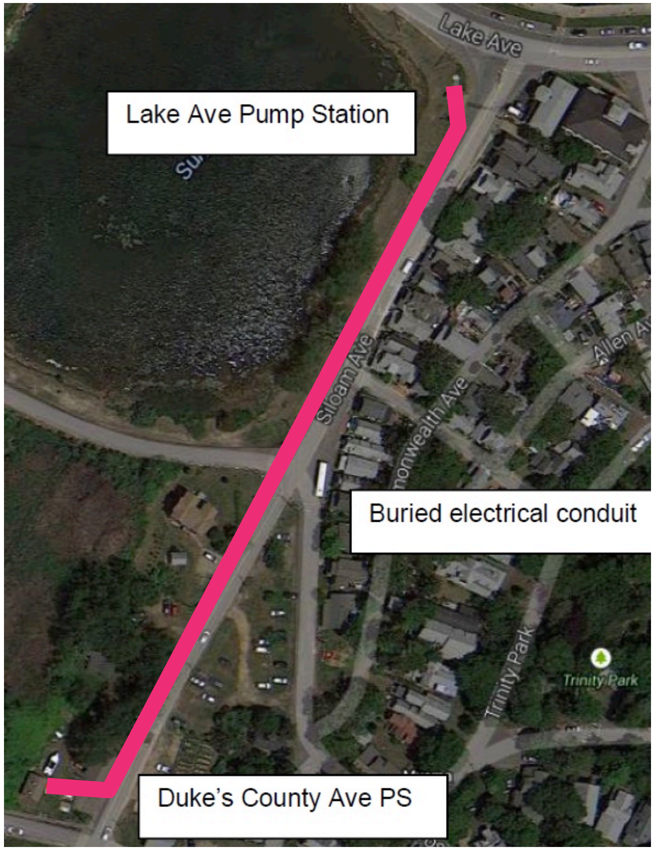
Problems

- Generator connection point inaccessible during flood (Town has portable generator)

Lake Avenue Pump Station

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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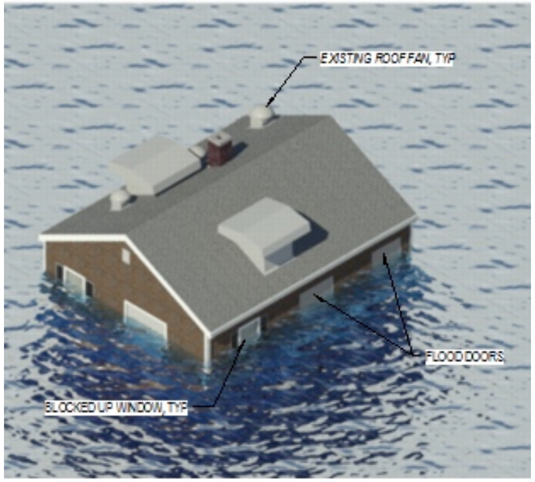
Coastal Resilience Measures

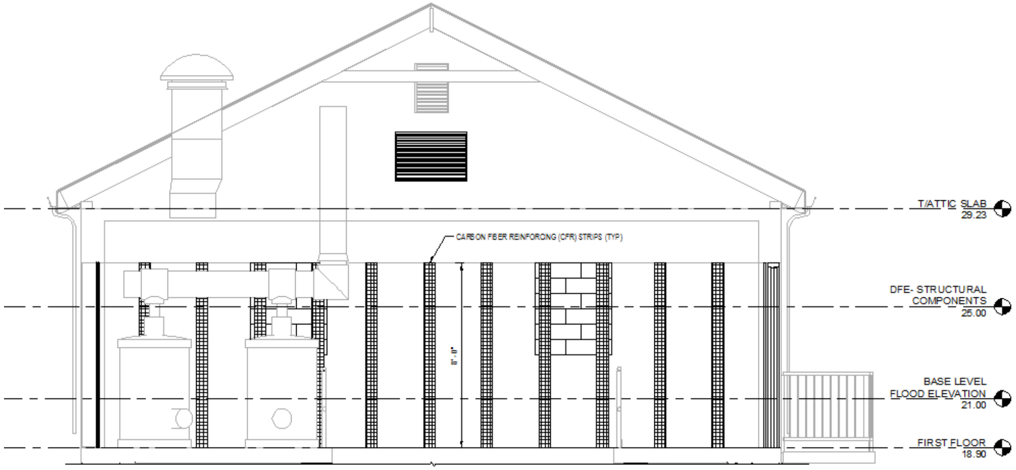
Dry Flood Proof Stations

- 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

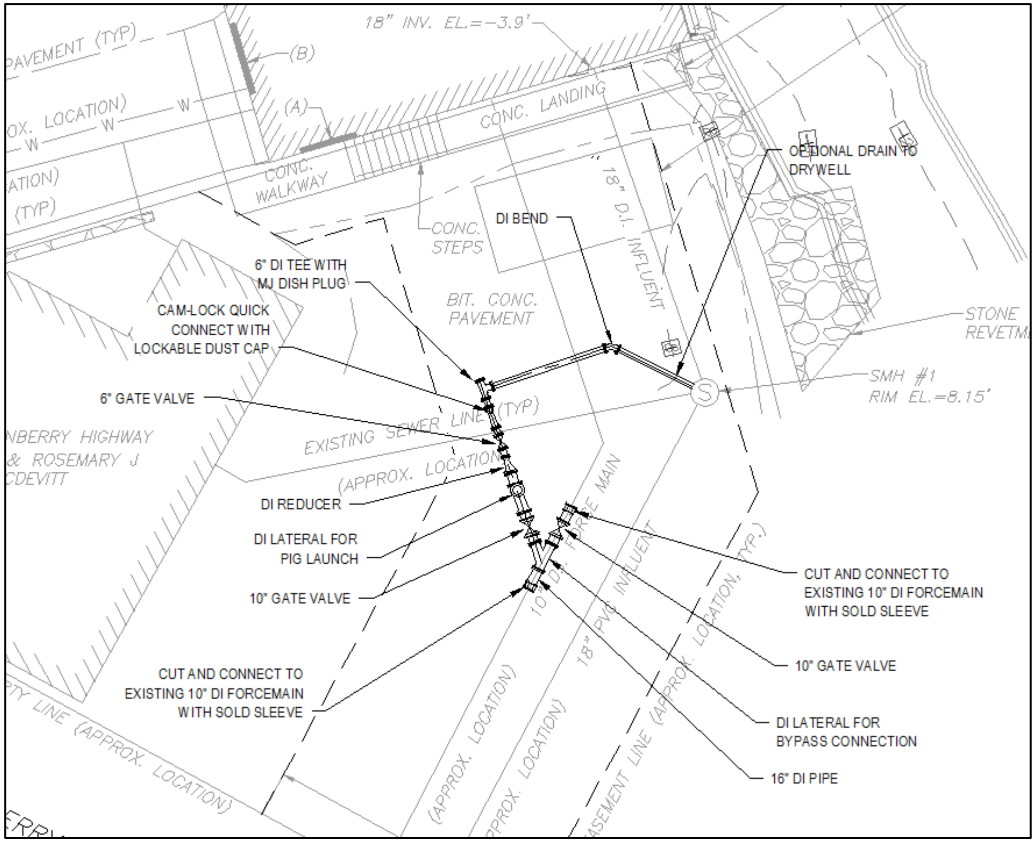


Structural Reinforcement

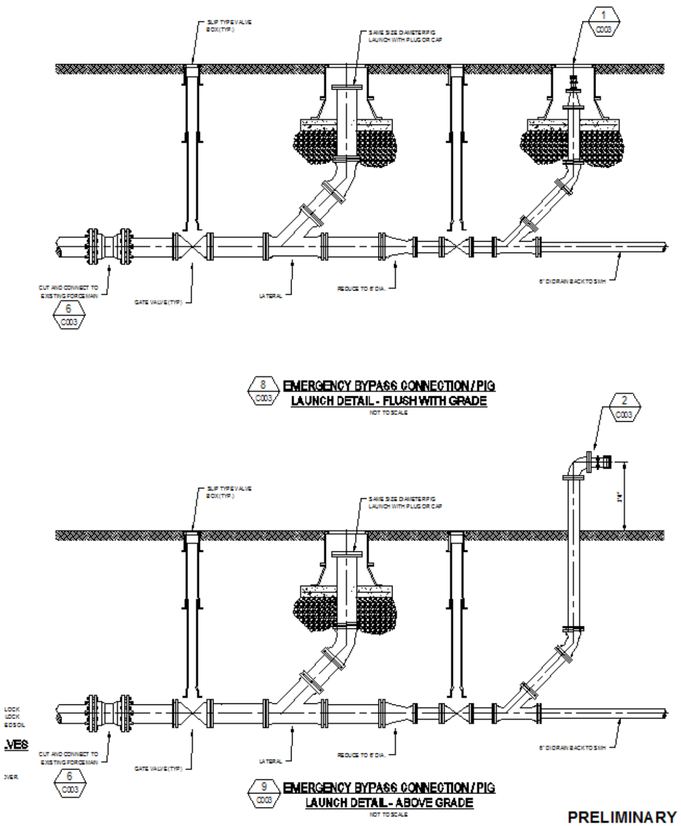
- Cohasset Narrows
  - Reinforced masonry walls
  - Carbon Reinforcing Strips



Returning to Operation if Station Goes Down



Emergency Bypass Connection



PRELIMINARY