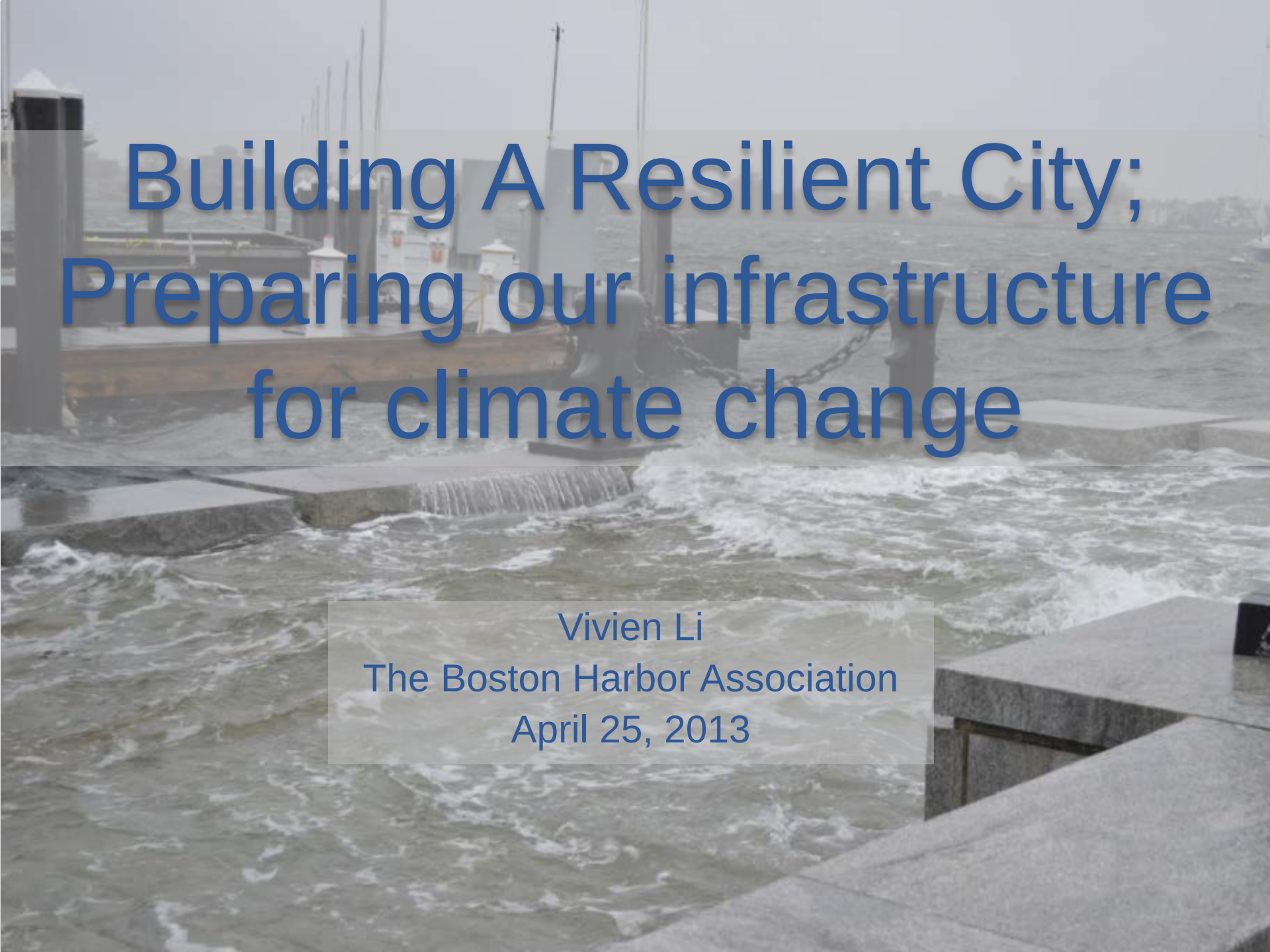
Building A Resilient City: Preparing Our Infrastructure For Climate Change

A Better City
April 25, 2013
Federal Reserve Bank of Boston

Welcome

Michael Cantalupa,

Chair, A Better City & Senior Vice President of Development, Boston Properties

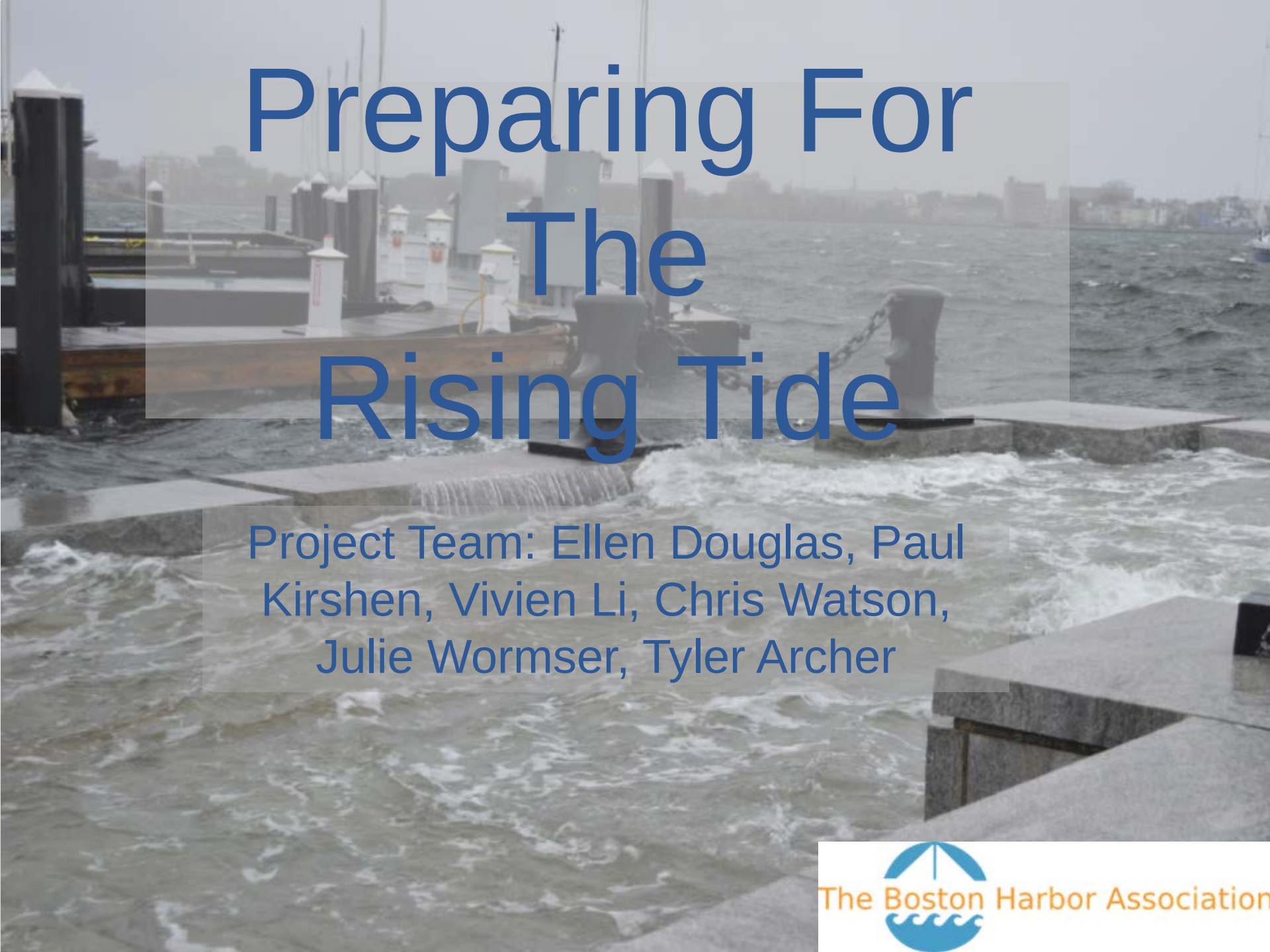


Building A Resilient City; Preparing our infrastructure for climate change

Vivien Li
The Boston Harbor Association
April 25, 2013

Preparing For The Rising Tide

Project Team: Ellen Douglas, Paul Kirshen, Vivien Li, Chris Watson, Julie Wormser, Tyler Archer

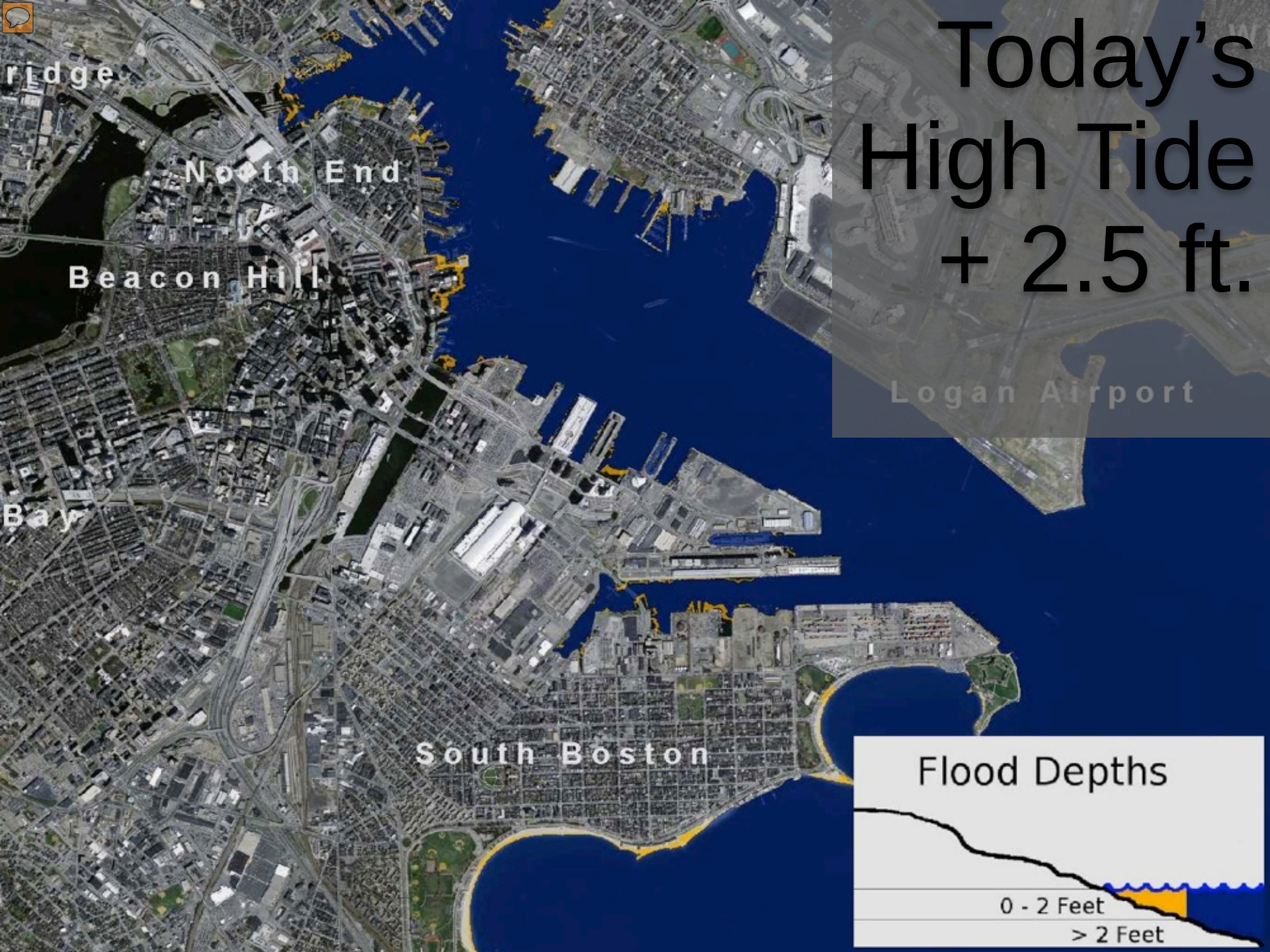


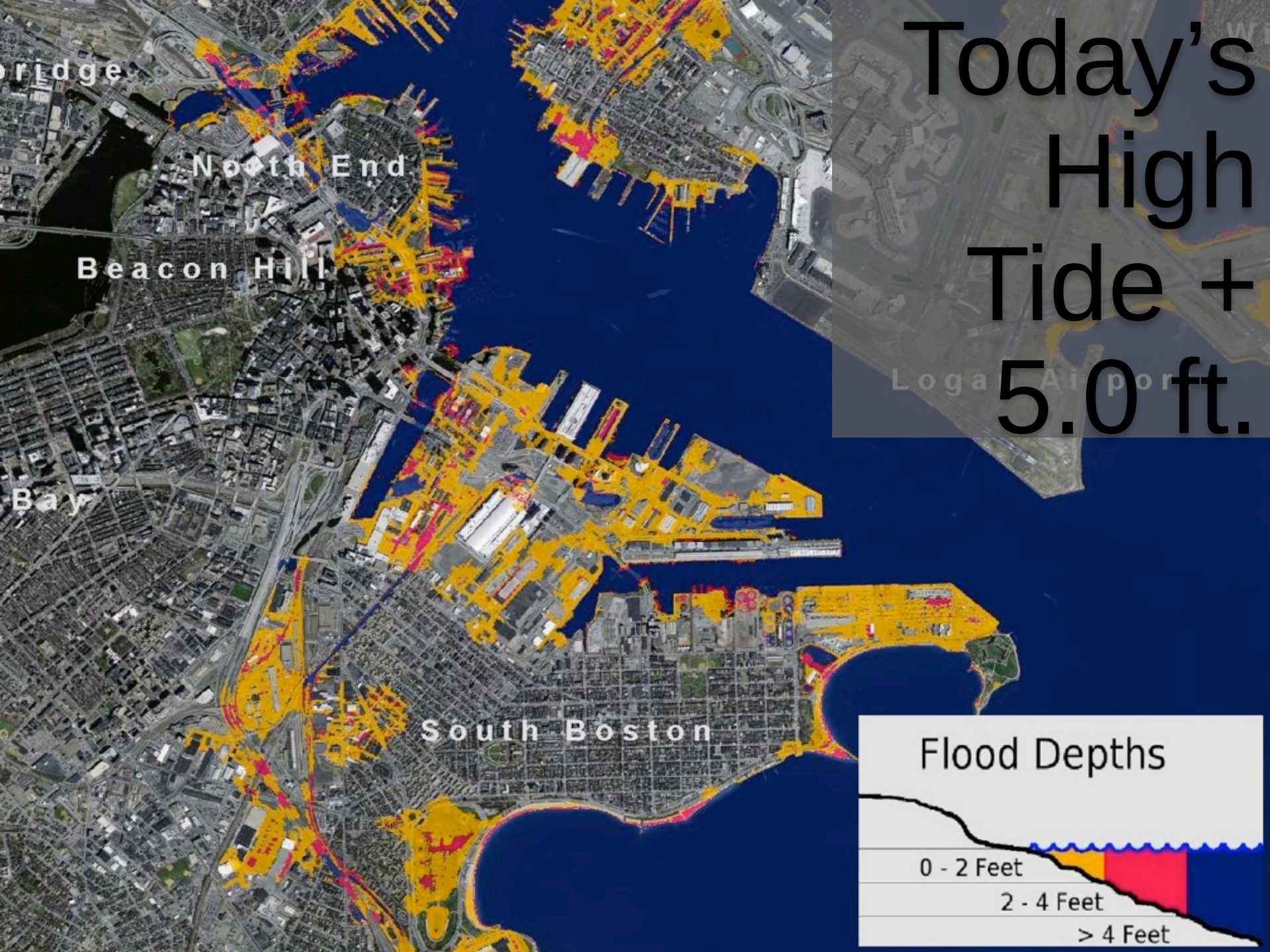
The Boston Harbor Association

Preparing For The Rising Tide

- Identifies Boston's vulnerability to larger storms and higher floods
- Encourages property owners and public agencies to know and decrease risks
- Supports flexible, co-benefit, cost-effective solutions

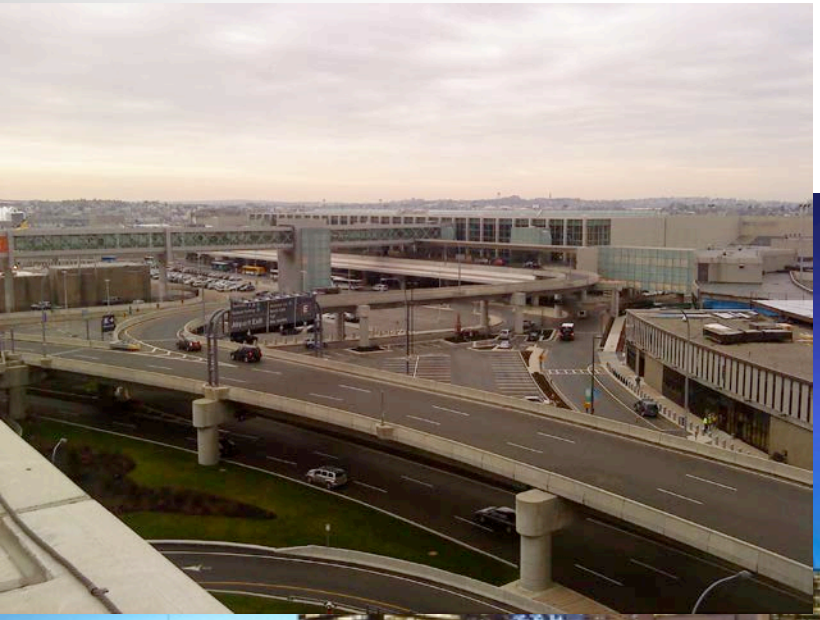
The Boston Harbor Association

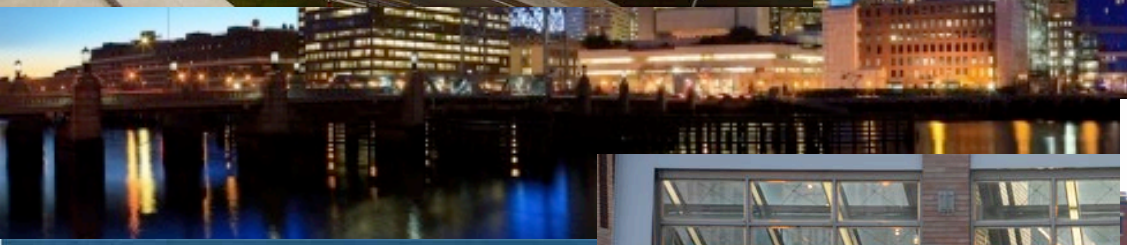

Today's
High Tide
+ 2.5 ft.
ridge
North End
Beacon Hill
Logan Airport
Bay
South Boston
Flood Depths
0 - 2 Feet
> 2 Feet

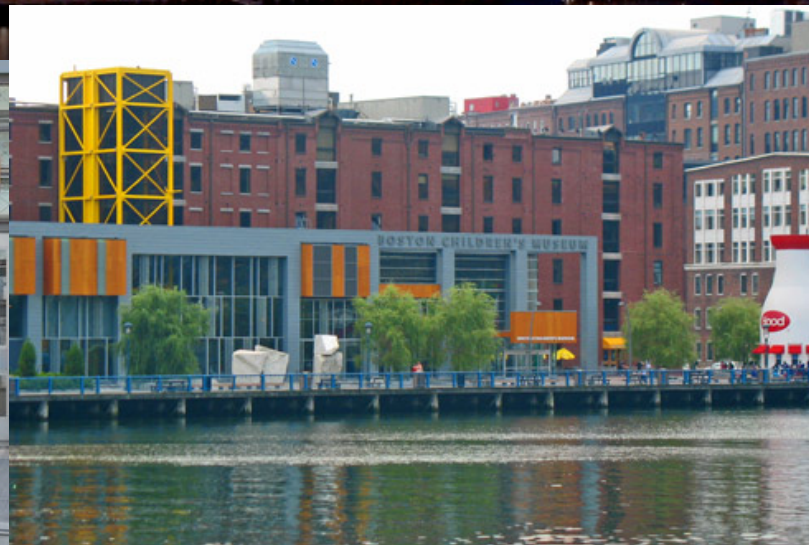

North End
Beacon Hill
Bay
South Boston
Today's High Tide + 5.0 ft.
Flood Depths
0 - 2 Feet
2 - 4 Feet
> 4 Feet

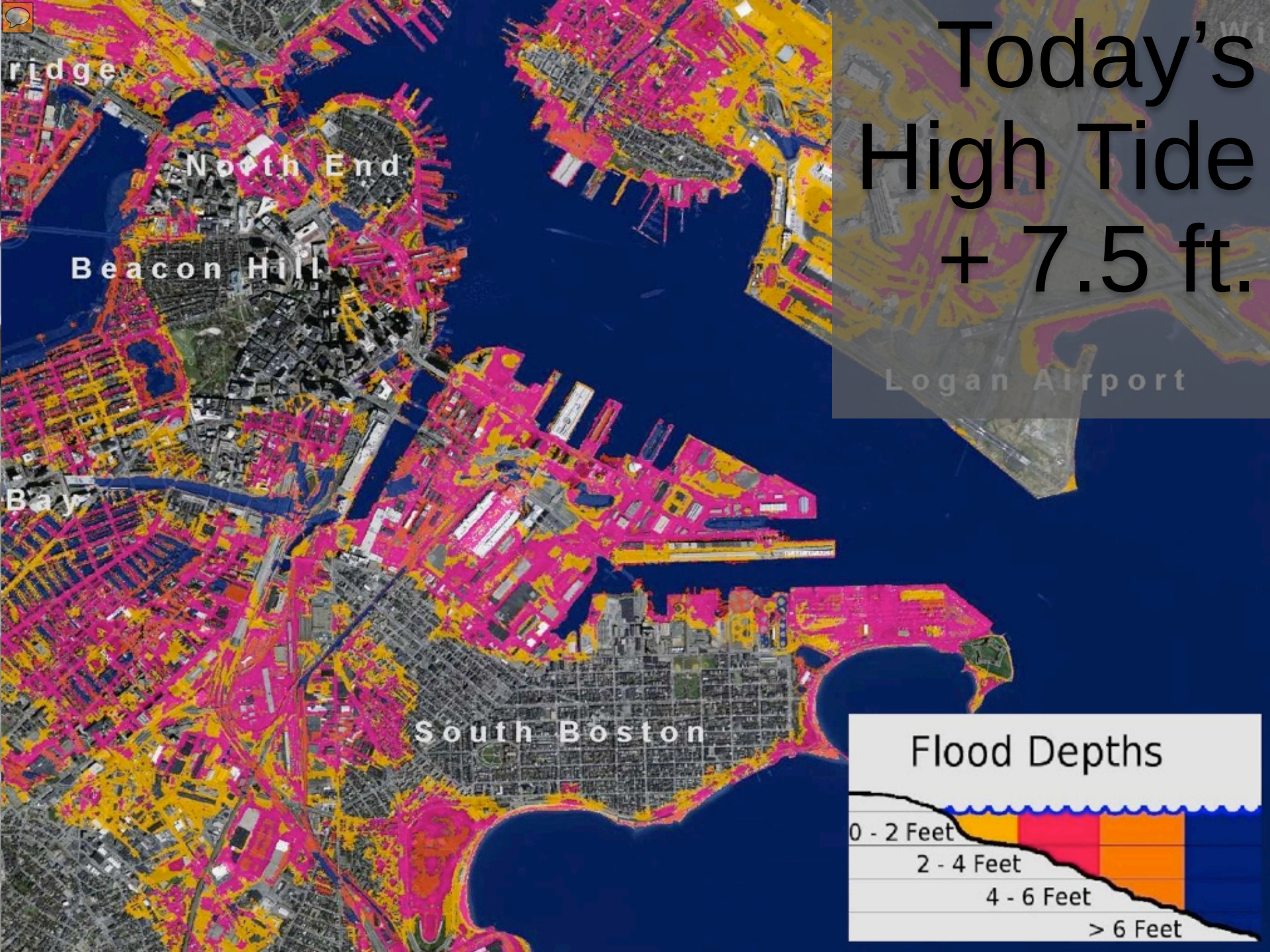

North End
Beacon H
Bay
South Boston
irport
Current
Daily High
Tide by 2100
Annual Flood
100-Year
Flood

Who’s At Risk








ridge
North End
Beacon Hill
Bay
South Boston
Logan Airport
Today's
High Tide
+ 7.5 ft.
Flood Depths
0 - 2 Feet
2 - 4 Feet
4 - 6 Feet
> 6 Feet

Could Flood Annual Flood by 2100

What Would Flood?

What Would Flood?

Table 6. Ownership of ten largest parcels flooded at MHHW+7.5 (12.3 ft NAVD)

Land Use Category	Total Area (in million sq. ft.)	Site Name	Owner	Address
Exempt	101.6	Logan Airport	Massport	Maverick Street
Exempt	7.2	Marine Industrial Park	Economic Development and Industrial Corporation	600 Summer Street
Exempt	4.5	Conley Terminal	Massport	20 Farragut Road
Exempt	2.7	Harvard Stadium	Harvard University	69-79 N. Harvard Street
Residential	1.9	Harbor Point Apartments	Harbor Point Apts. Co Lessee	400-260 Mt Vernon Street
Exempt	1.6	Black Falcon Cruise Terminal	Massport	666R Summer Street
Exempt	1.3	Curley Community Center	City of Boston	William J Day Boulevard
Exempt	1.3	Boston Autoport	Massport	Terminal Street
Exempt	1.2	MBTA Maintenance Facility – Orient Point	MBTA	1023-1081A Bennington Street
Exempt	1.1	Boston Convention and Exhibition Center	Mass. Convention Center Authority	Summer Street

What Can We Do?

...

Public Sector

- Accelerate the implementation of Boston's climate action plan
- Survey preparedness of all public buildings and the MBTA
- Include climate prep as a design component for development
- Increase enforcement of flood proofing standards for property owners

The Boston Harbor Association

Property Owners

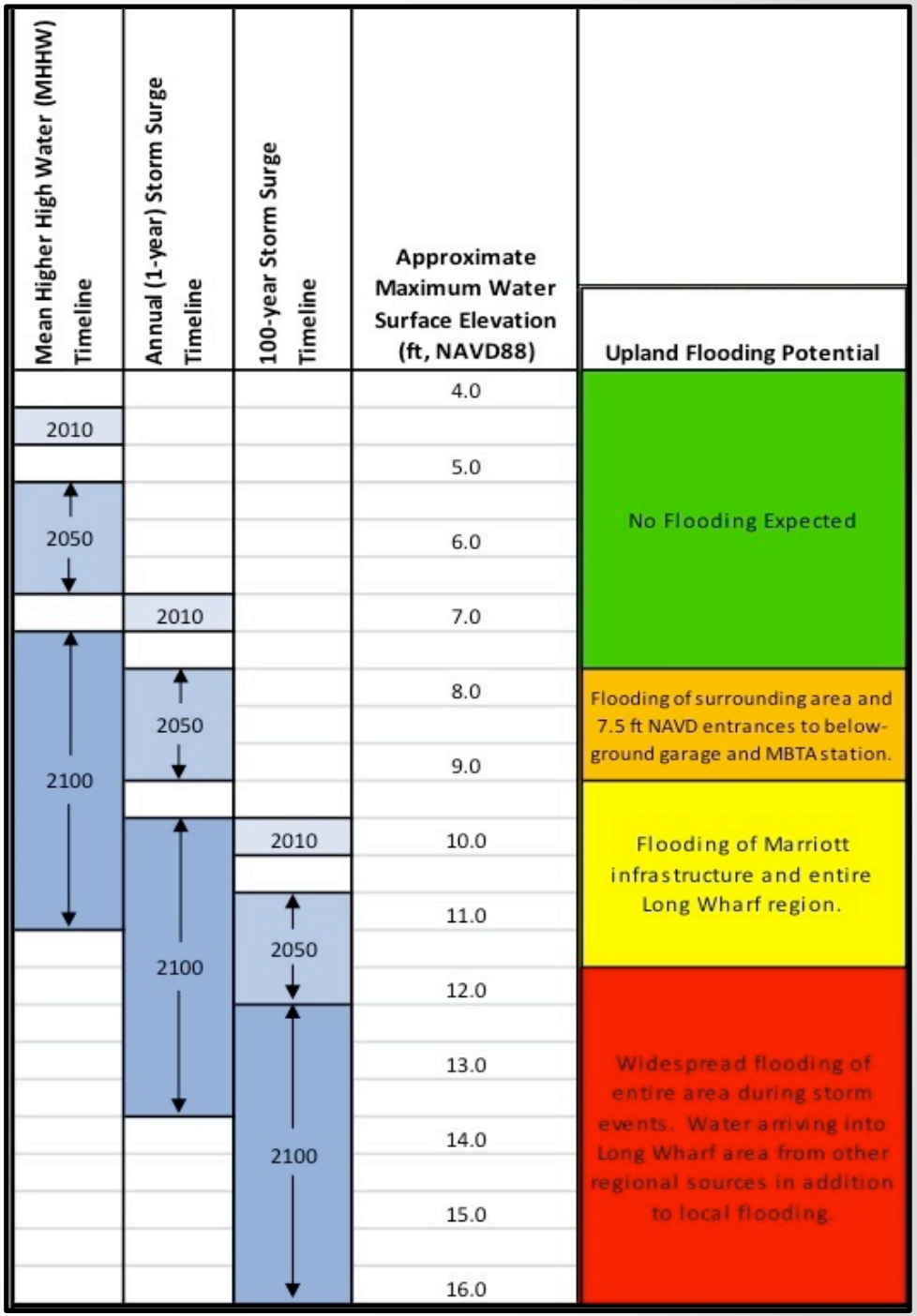
- Identify vulnerable structures and systems on your property
- Understand future flood conditions on and around your property
- Implement cost-effective, flexible adaptation plans

The Boston Harbor Association

Sample Plan

Marriot Hotel/MBTA Aquarium Station

- Three flooding levels projected over time
- What should I care about today?
- When can I expect flooding in the future?



The Boston Harbor Association


AQUARIUM
ELEVATOR
TO TRAINS
AQUARIUM
TO TRAINS
CIN
Imagery ©2013 Google, Sanborn -

What is vulnerable now?

MHHW Timeline	Annual Storm Surge Timeline	100-Year Storm Surge Timeline	Approximate Maximum Water Surface Elevation (ft, NAVD88)	Upland Flooding Potential	Recommended Engineering Adaptations	Estimated Adaption Cost
			4.0	No Flooding Expected	No Action Required	N/A
2010						
			5.0			
2050						
			6.0			
	2010		7.0			
2100						
	2050		8.0	Flooding of surrounding area and 7.5 ft NAVD entrances to below-ground garage and MBTA	Develop alternate access route plans. Minor flood proofing.	Minimal
			9.0			
		2010	10.0	Flooding of Marriott infrastructure and entire Long Wharf region.	See Regional Adaptations (Parapet Wall)	See Regional Adaptations
	2100					
		2050	11.0			
			12.0	Widespread Flooding of entire area during storm event. Water arriving into Long Wharf area from other regional sources in addition to local flooding.	In addition to adaptations above, flood proofing and elevation of critical infrastructure. Evacuate during storm event.	Capital Cost: Estimated $20 per square foot of building for wet flood proofing.
			13.0			
		2100	14.0			
			15.0			
			16.0			

When will there be flooding?

MHHW Timeline	Annual Storm Surge Timeline	100-Year Storm Surge Timeline	Approximate Maximum Water Surface Elevation (ft, NAVD88)	Upland Flooding Potential	Recommended Engineering Adaptations	Estimated Adaption Cost
			4.0	No Flooding Expected	No Action Required	N/A
2010						
			5.0			
2050						
			6.0			
	2010		7.0			
2100						
	2050		8.0	Flooding of surrounding area and 7.5 ft NAVD entrances to below-ground garage and MBTA	Develop alternate access route plans. Minor flood proofing.	Minimal
			9.0			
				Flooding of Marriott infrastructure and entire Long Wharf region.	See Regional Adaptations (Parapet Wall)	See Regional Adaptations
		2010	10.0			
		2050	11.0			
	2100					
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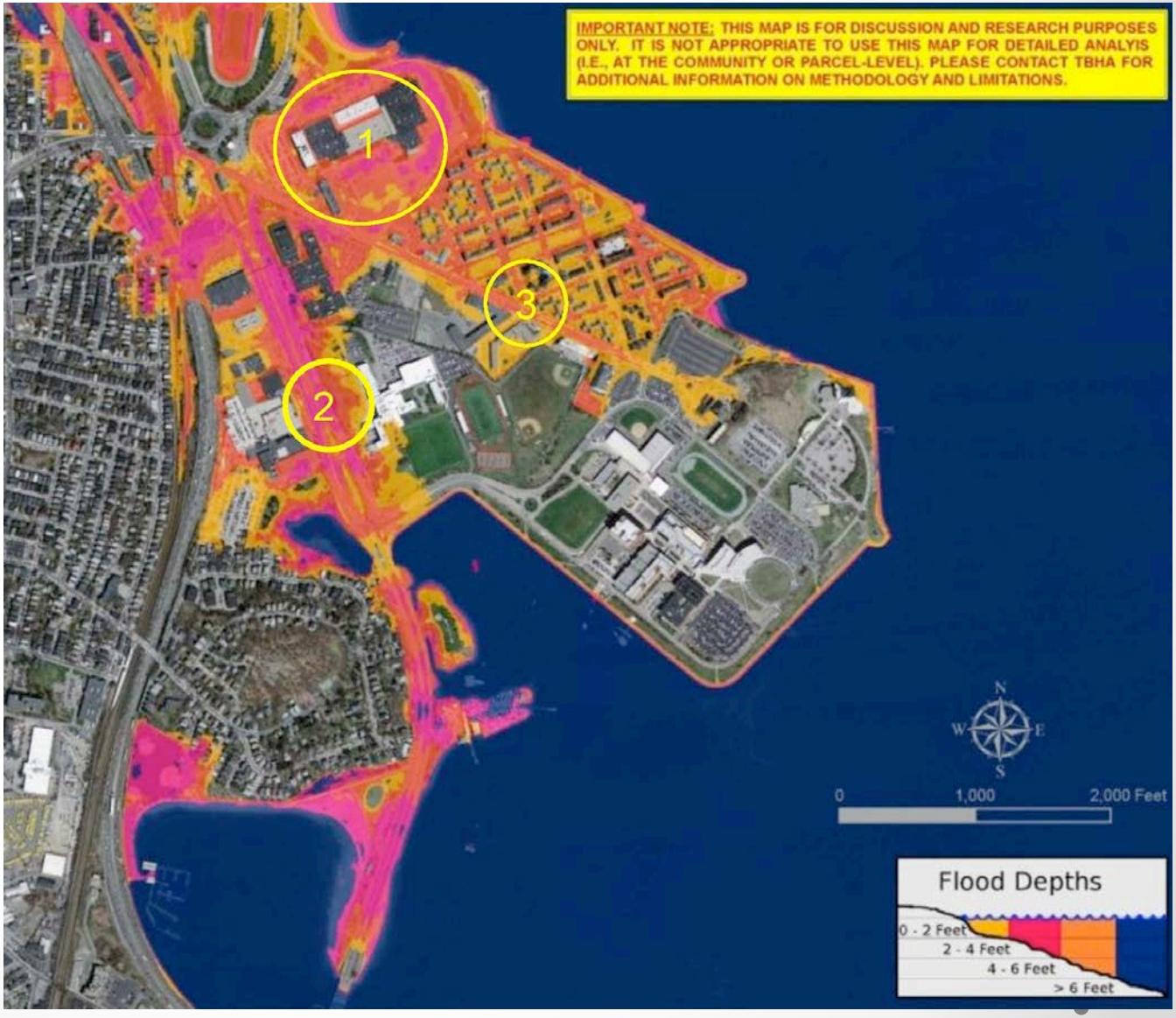
			16.0			

UMass Boston/Columbia Point

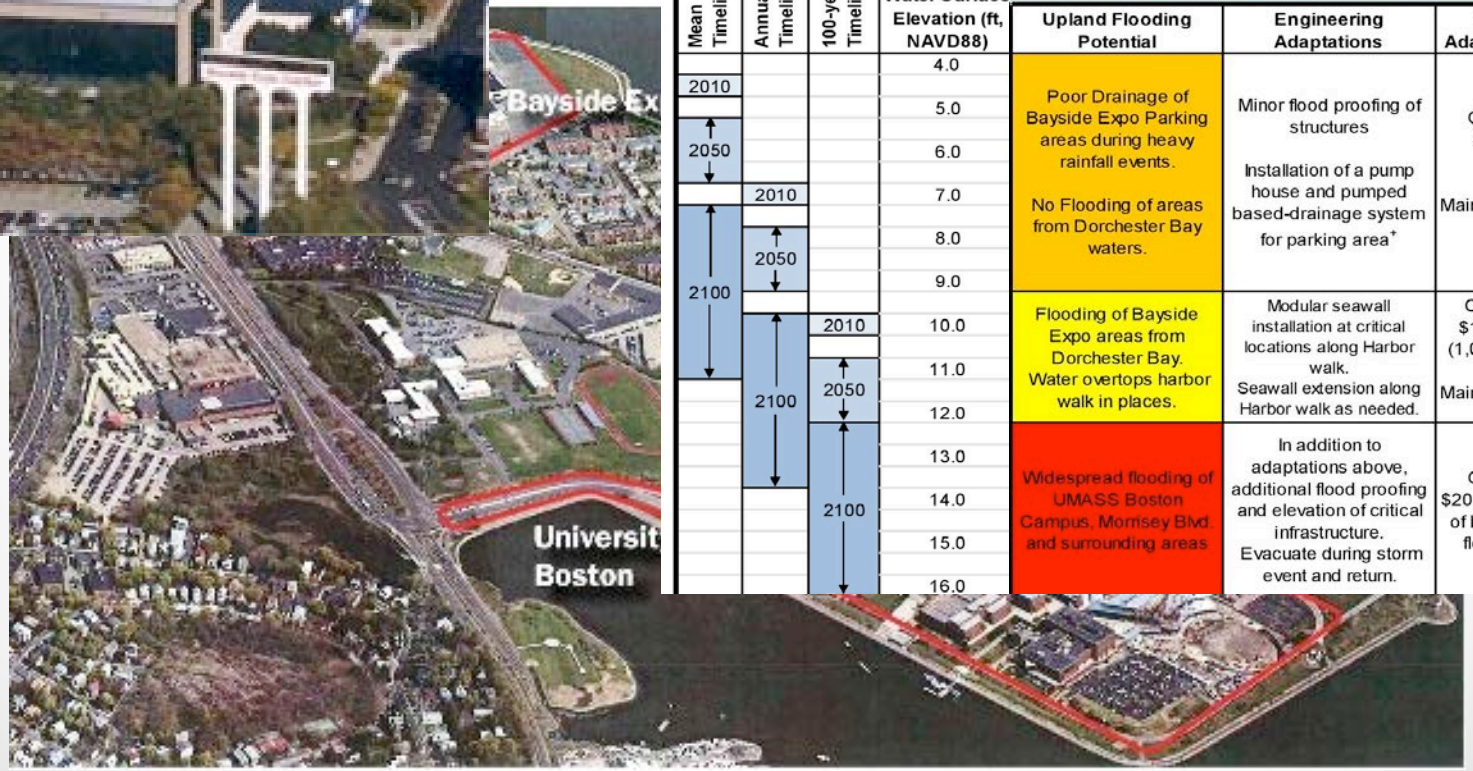
- Bayside Expo

- Current Main Entrance from Morrissey Boulevard

- Proposed 2nd Main Entrance from Mt. Vernon Street

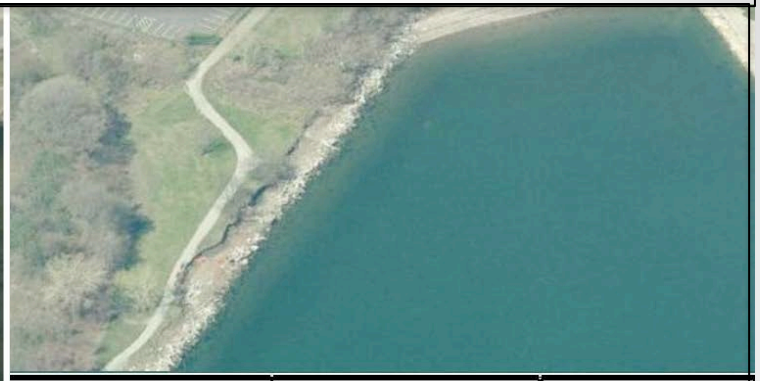


UMass Boston/Columbia Point



Mean Higher High Water (MHHW) Timeline	Annual (1-year) Storm Surge Timeline	100-year Storm Surge Timeline	Approximate Maximum Water Surface Elevation (ft, NAVD88)	Upland Flooding Potential	Engineering Adaptations	Estimated Adaptation Cost*
2010			4.0	Poor Drainage of Bayside Expo Parking areas during heavy rainfall events. No Flooding of areas from Dorchester Bay waters.	Minor flood proofing of structures Installation of a pump house and pumped based-drainage system for parking area+	Capital Cost: $ 2.0 Million Annual Maintenance Costs:: $ 10,000
			5.0			
2050			6.0			
	2010		7.0			
2100	2050		8.0			
			9.0			
	2100	2010	10.0	Flooding of Bayside Expo areas from Dorchester Bay. Water overtops harbor walk in places.	Modular seawall installation at critical locations along Harbor walk. Seawall extension along Harbor walk as needed.	Capital Cost#: $1.0-1.5 million (1,000 foot length) Annual Maintenance Costs:: $15,000
		2050	11.0			
			12.0			
		2100	13.0	Widespread flooding of UMASS Boston Campus, Morrisey Blvd. and surrounding areas	In addition to adaptations above, additional flood proofing and elevation of critical infrastructure. Evacuate during storm event and return.	Capital Cost: $20 per square foot of building for wet flood proofing.
			14.0			
			15.0			
			16.0			

What is vulnerable now?



Mean Higher High Water (MHHW) Timeline	Annual (1-year) Storm Surge Timeline	100-year Storm Surge Timeline	Approximate Maximum Water Surface Elevation (ft, NAVD88)	Morrissey Boulevard: Upland Flooding Potential	Morrissey Boulevard: Engineering Adaptations	Morrissey Boulevard: Estimated Adaptation Cost*	Mt. Vernon Street: Upland Flooding Potential	Mt. Vernon Street: Recommended Engineering Adaptations	Mt. Vernon Street: Estimated Adaptation Cost*
			4.0	No Flooding Expected	No Action Required	N/A	No Flooding Expected.	No Action Required	N/A
2010									
			5.0						
2050			6.0						
	2010		7.0	Flooding of Morrissey Blvd. approx 1/4 mile south of campus entrance. No flooding of campus entrance or facilities			Area has experienced poor storm water drainage. Storm water outfall at 2010 MHHW elevation may not adequately drain in future.	Improve storm water removal and drainage lines. Modify storm water outfall or add pump house.	Capital Cost: $ 250,000 Annual Maintenance Costs: $ 2,000
2100			8.0						
	2050		9.0						
			10.0	Flooding of campus entrance. Initially from Patten's Cove (tidal pond to the west of entrance), and subsequently from Savin Hill Cove.	Tidal control structure at entrance to Patten's Cove. Soft solution (beach nourishment and vegetation enhancement) along Savin Hill Cove.	Capital Cost: $500-750,000 Annual Maintenance Costs: $10,000	Flooding from Dorchester Bay via low-lying pathways to the east of Mt. Vernon Ave.	Provide clean fill in low lying areas or increase storm protection with soft coastal engineering solutions.	Capital: $300-500,000 Annual Maintenance $5,000
		2010							
			11.0						
		2050	12.0						
	2100		13.0	Widespread flooding of UMASS Boston Campus, Morrisey Blvd. and surrounding areas	In addition to adaptations above, additional flood proofing and elevation of critical infrastructure. Evacuate during storm event and return.	Capital Cost: $20 per square foot of building for wet flood proofing.	Widespread flooding of UMASS Boston Campus, Morrisey Blvd. and surrounding areas.	In addition to adaptations above, additional flood proofing and elevation of critical infrastructure. Evacuate during storm event and return.	Capital Cost: $20 per square foot of building for wet flood proofing.
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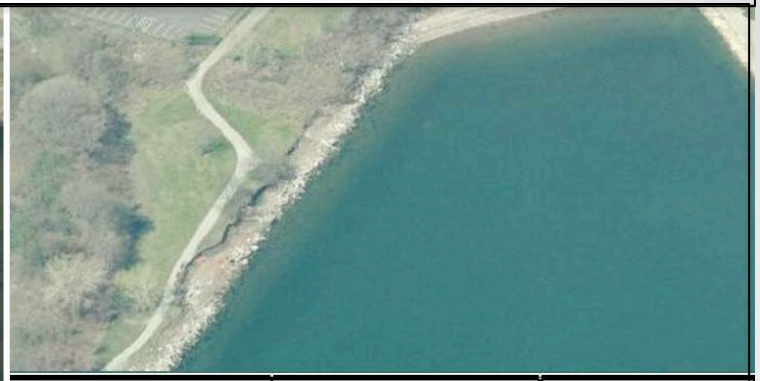
		2100	15.0						
			16.0						

When will there be flooding?



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			14.0						
		2100	15.0						
			16.0						

Essentials for the Future

- Balance “robustness” with “flexibility”
- Include “no-regret” and “co-benefit” solutions
- Favor “resilience” over “resistance”

The Boston Harbor Association

Summary of Findings

- Today's 100-year flood could be 2050's annual flood and 2100's high tide.
- Private sector can and should develop building-specific preparedness plan
- Vulnerability assessments should integrate resilient adaptation methods
- Public sector should help property owners overcome barriers, step in when private action is insufficient
- No-Regret, Co-Benefit, Flexible and Robust

The Boston Harbor Association

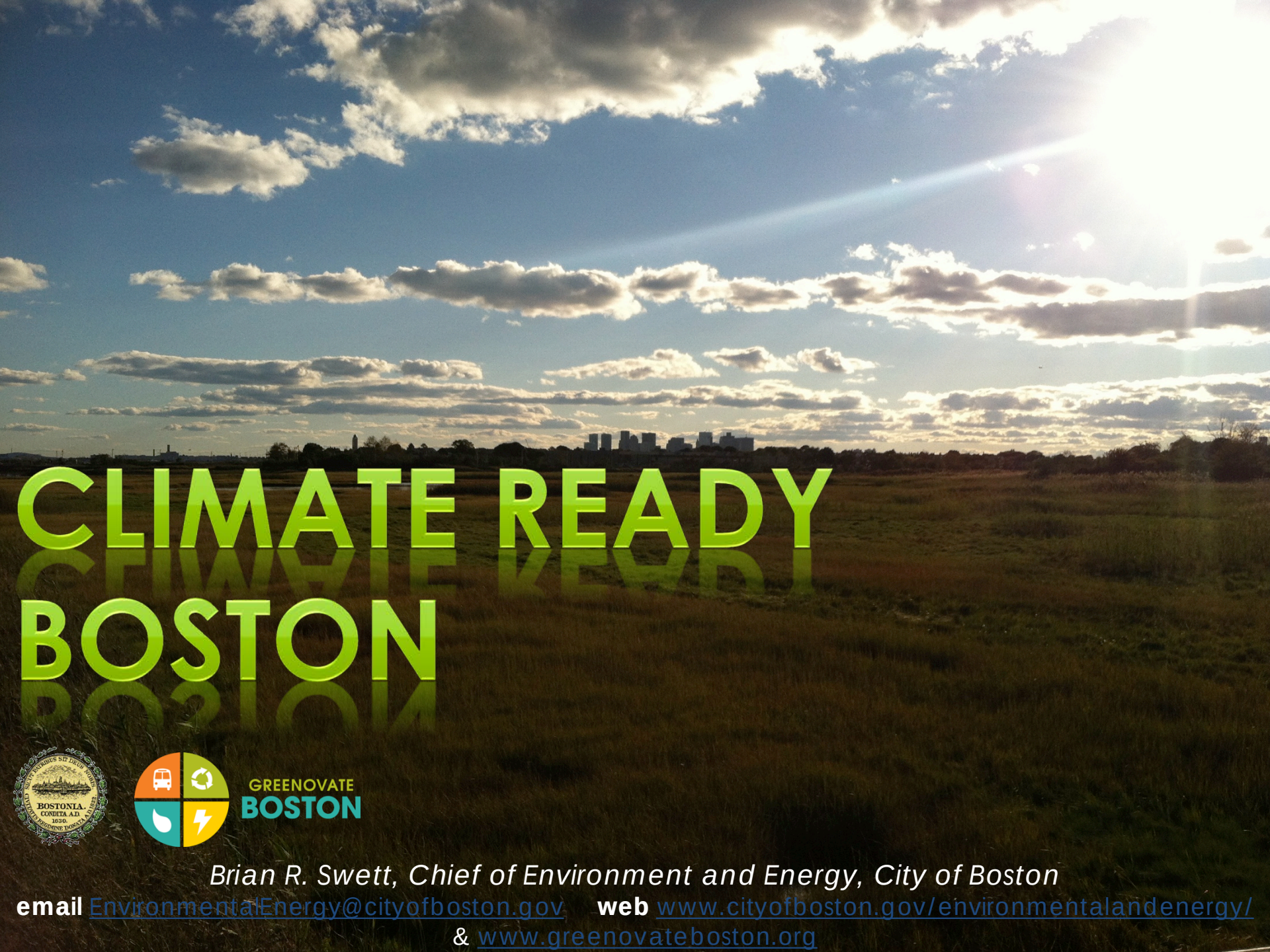

Thank You
tbha.org/preparing-rising-tide-report
The Boston Harbor Association

PANEL

Moderator:

Bud Ris,

President/CEO, New England Aquarium

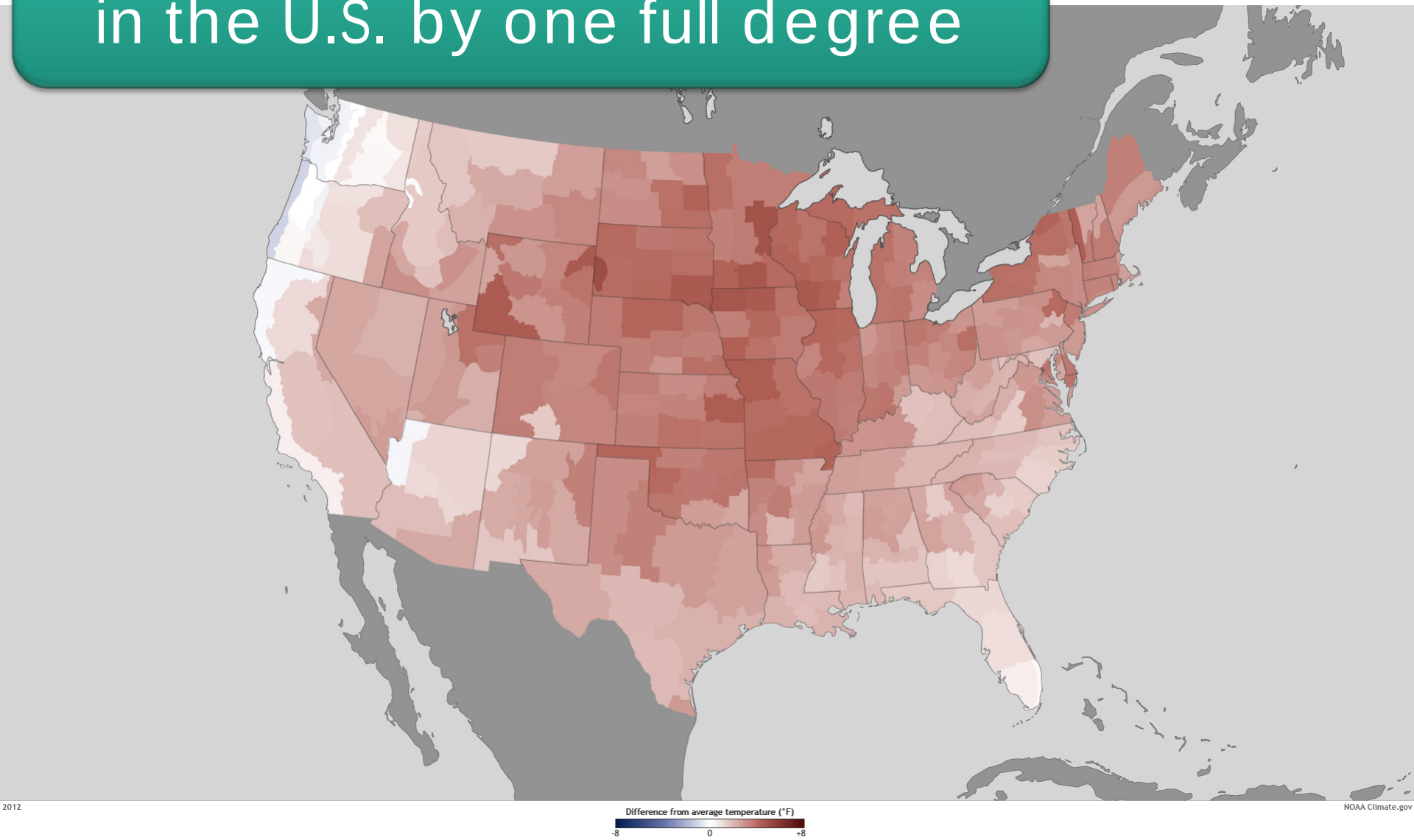


Brian R. Swett, Chief of Environment and Energy, City of Boston

email EnvironmentalEnergy@cityofboston.gov **web** www.cityofboston.gov/environmentalandenergy/

& www.greenovateboston.org

2012: Warmest Year on Record in the U.S. by one full degree



-8 **Difference from the average temperature (ºF)** +8

City of Boston has been focused on Climate Preparedness since 2007

Infrastructure

- BWSC 25-year Asset Management Plan
- Local Energy Assurance Planning
- Complete Streets
- Internal Adaptation Working Group

Neighborhoods

- Tree Planting
- Hazard Mitigation Plan Update
- TBHA Sea Level Rise Forum and Community Meetings

Buildings

- Climate Adaptation Questionnaire

Solar Powered Fueling Stations for Emergency Vehicles at 400 Frontage Road 120 kW

Deer Island Constructed to Withstand 2 Feet of Sea Level Rise

Solar Powered Traffic Signals Along Evacuation Route

Boston Complete Streets

Multimodal

Green

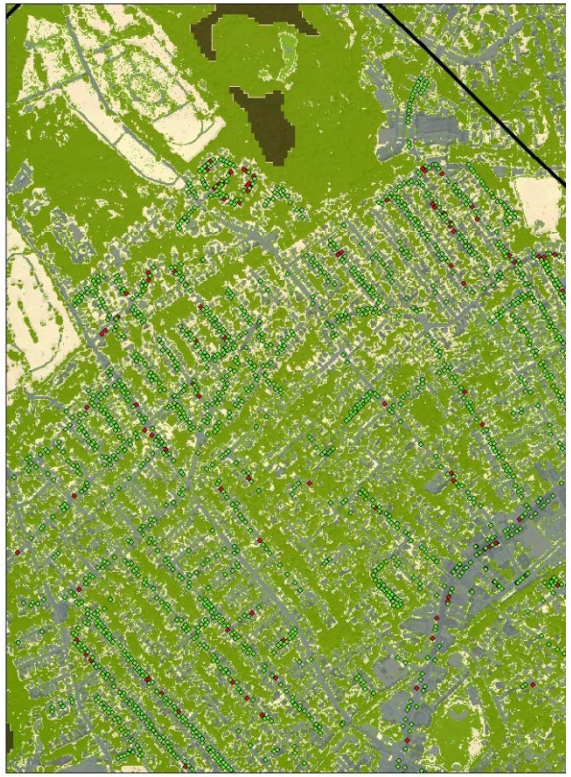
Smart

Growing Boston Greener

100,000 New Trees By 2020

East Boston

Roxbury



West Roxbury

Increase Tree Canopy to 35% by 2020

Climate Ready Boston

#ClimateReadyBos

Planning

- Climate Preparedness Task Force in City Hall
- Green Ribbon Commission working group focused on climate adaptation

Existing Buildings

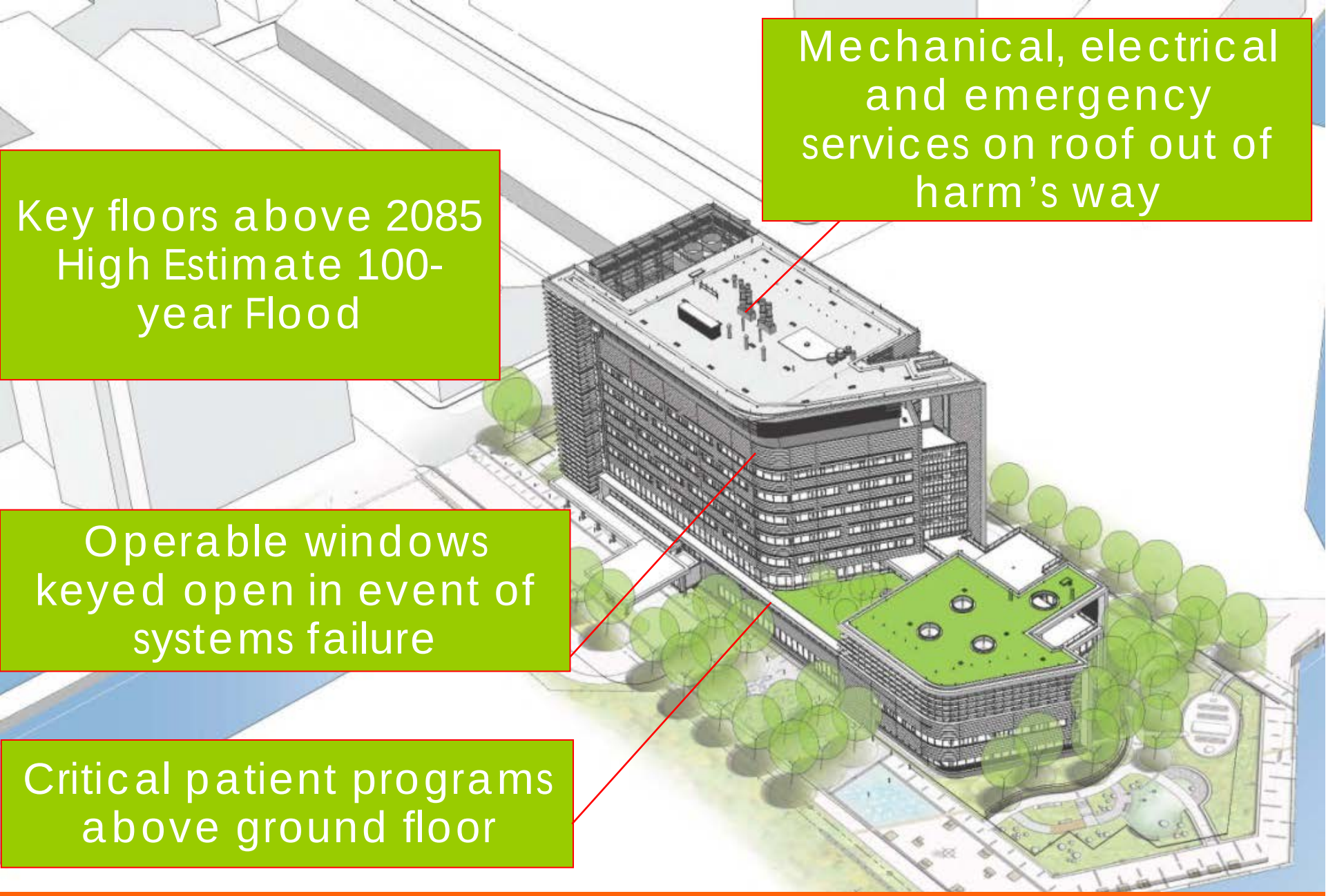
- Assess vulnerabilities of buildings and infrastructure through BRA survey
- Better enforcement of flood proofing building standards

New Buildings

- Incorporate climate change adaptation guidelines into Article 80
- Wetlands Ordinance and new floodplain maps

Emergency Response

- Review emergency operation planning



Spaulding Rehabilitation Hospital

Emergency Response

Thank You

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Greenovate Boston

@GreenovateBos

Building a Resilient City: Preparing Our Infrastructure for Climate Change

A Resilient Water and Sewer System

Frederick A. Laskey
Executive Director

April 25, 2013

MWRA Service Area

- MWRA provides wholesale water and wastewater services to over 2.5 million customers in 61 communities
- On average, MWRA delivers about 200 million gallons per day to its water customers
- MWRA collects and treats an average of 350 million gallons of wastewater per day, with a peak capacity of 1.2 billion gallons

Hurricane Sandy Impacts On NY/NJ Water Utilities

- Many water utilities lost power due to lack of generators
- NYC water was safe to drink, but surrounding counties in NY and NJ had do not use advisories, or boil water notices
- Passaic Valley was forced to release billions of gallons of raw or partially treated sewage into New York Bay over several weeks

Drinking Water System Is In Good Shape

- Quabbin Reservoir, Belchertown
  - 65 miles west of Boston
  - Elevation 528 feet
- Wachusett Reservoir, Clinton
  - 35 miles west of Boston
  - Elevation 395 feet
- Water treatment plant is in Marlborough
- 85% of water delivered by gravity
- Lowest elevation of a water tank is 192 feet above sea level

Adaptation For Sea Level Rise In The Design of Deer Island

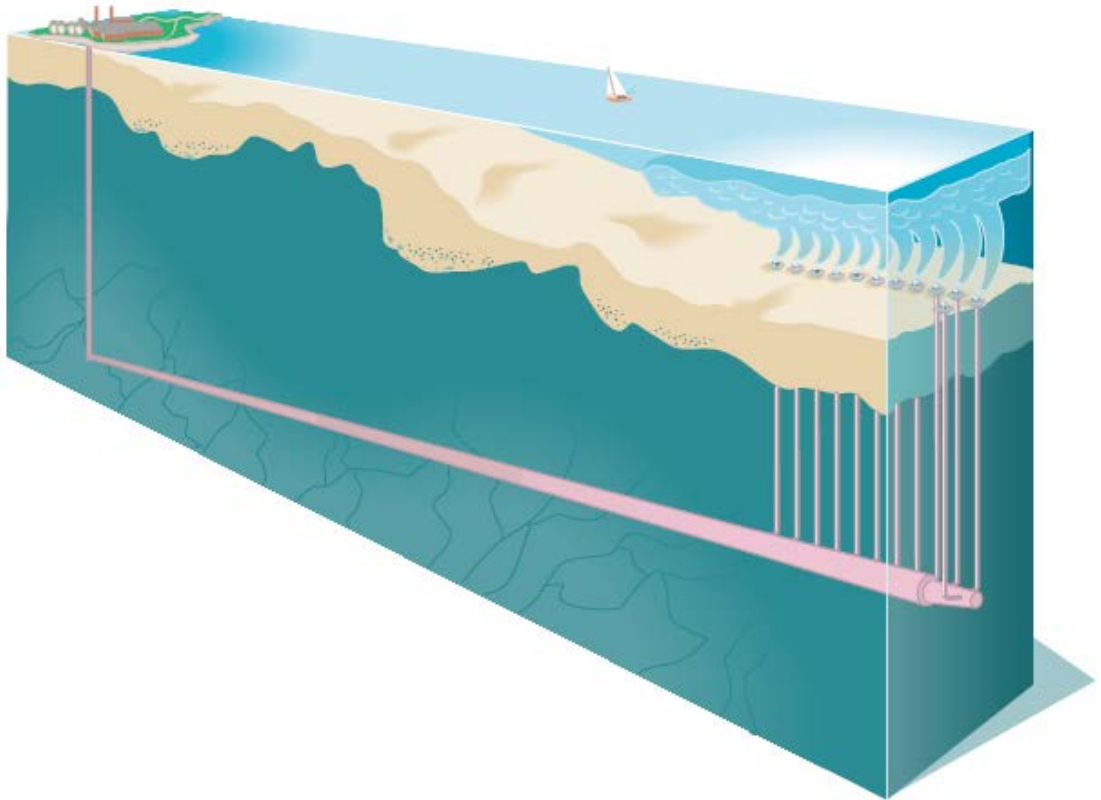
- Deer Island plant fully protected
  - 100-year flood
  - 1.9-foot sea level rise
  - Wave runup of 14 feet on east side and 2 feet on west side

- On-site power plant ensures uninterrupted power supply

- Nut Island headworks in Quincy similarly designed for sea level rise

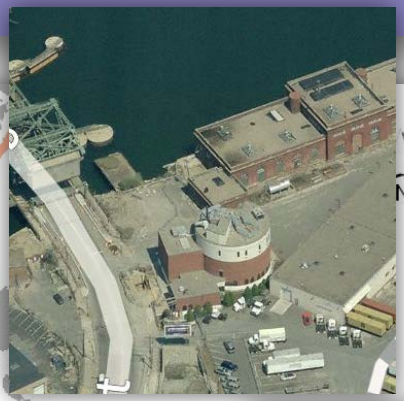
A Rising Sea Impacts The Hydraulics Of The Outfall Tunnel

- The effluent from the sewage treatment plant is discharged through a gravity fed downhill pipe
- To maintain hydraulic capacity, tunnel diameter was up-sized from 24 feet to 24.25 feet



21 Of MWRA Coastal Sewer Facilities Are Within 15 Feet Of Mean Sea Level

Areas Potenti By Loss Of Coastal Pump Stations



Past Practice

- Low-lying facilities are protected with sandbags and pumps
- Mobile generators are deployed in advance of storms
- Increased staffing

Created SOPs To Redeploy Staff And Equipment To Higher Ground

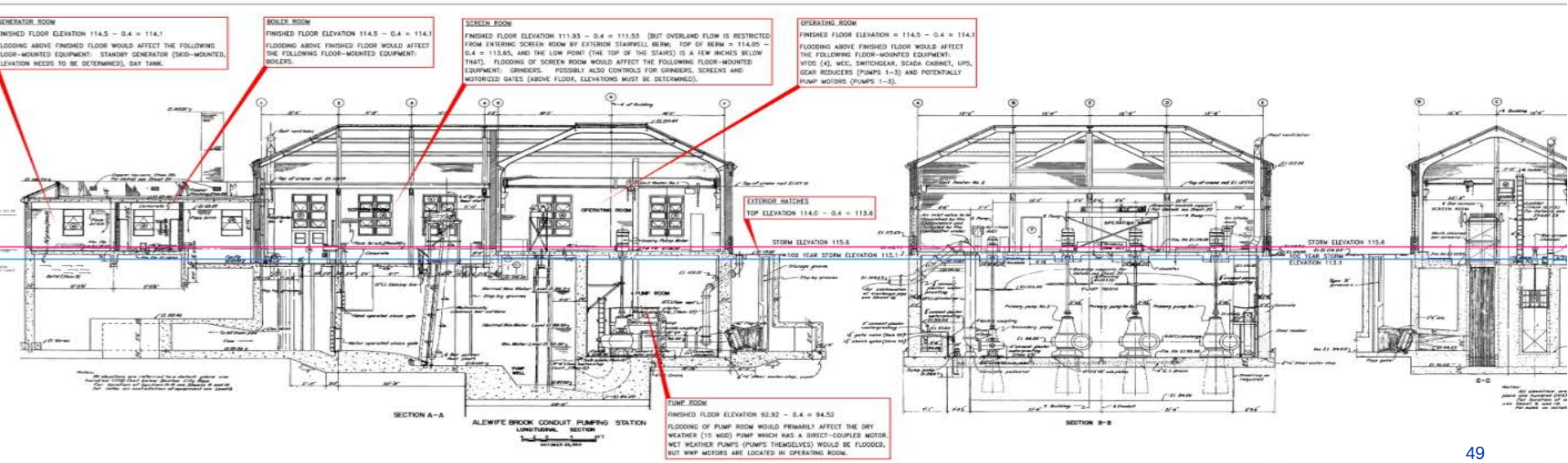
- Staff and equipment redeployed to pre-determined locations in advance of storms

- Back-up emergency operations center created at Carroll Treatment Plant in Marlborough

Going Forward

- Short-term
  - At-risk buildings may be fitted with temporary flood barriers

- Long-term
  - Future rehabilitation contracts will take sea level rise into account
  - Consider moving important equipment to higher elevations



capitalprograms and environmentalaffairs massport

Building A Resilient City: Preparing Our Infrastructure for Climate Change

Brenda L. Enos, CHMM, REM
Assistant Director, Capital Programs
& Environmental Management

A Better City

April 25, 2013

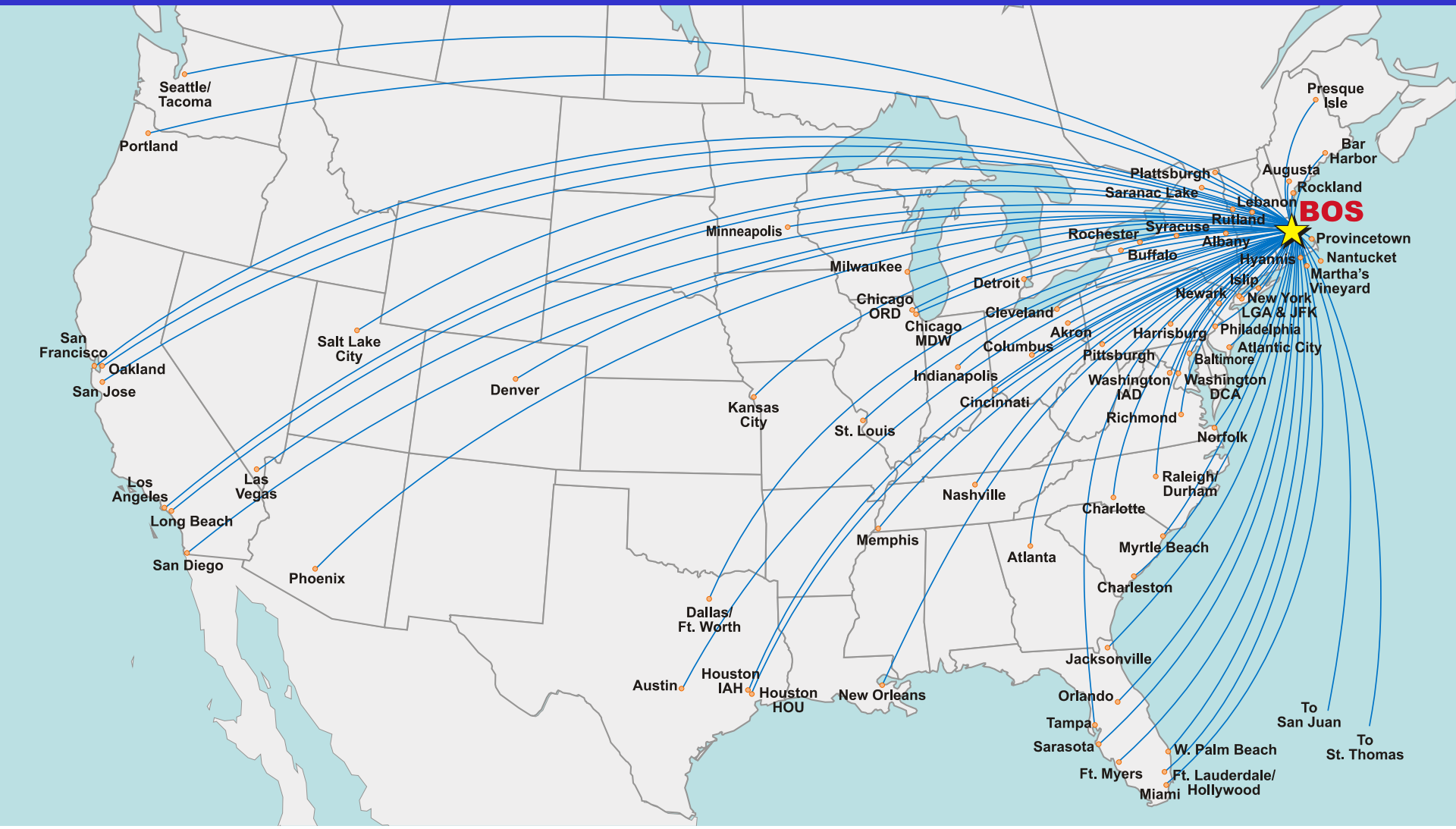
Definition of Massport

- Massport is an independent authority governed by a board of directors, appointed by the state's governor
- Massport owns and operates
  - Boston-Logan International Airport
  - Hanscom Field, Bedford, MA
  - Worcester Airport
  - Conley Container Terminal
  - Black Falcon Cruiseport
  - Various real estate assets

Importance of Air Transportation Facilities to the Region

- In any disaster airports are the first to receive methods of relief efforts.
- Airport has to remain open.
- Our obligation is to make sure we can receive National aid.

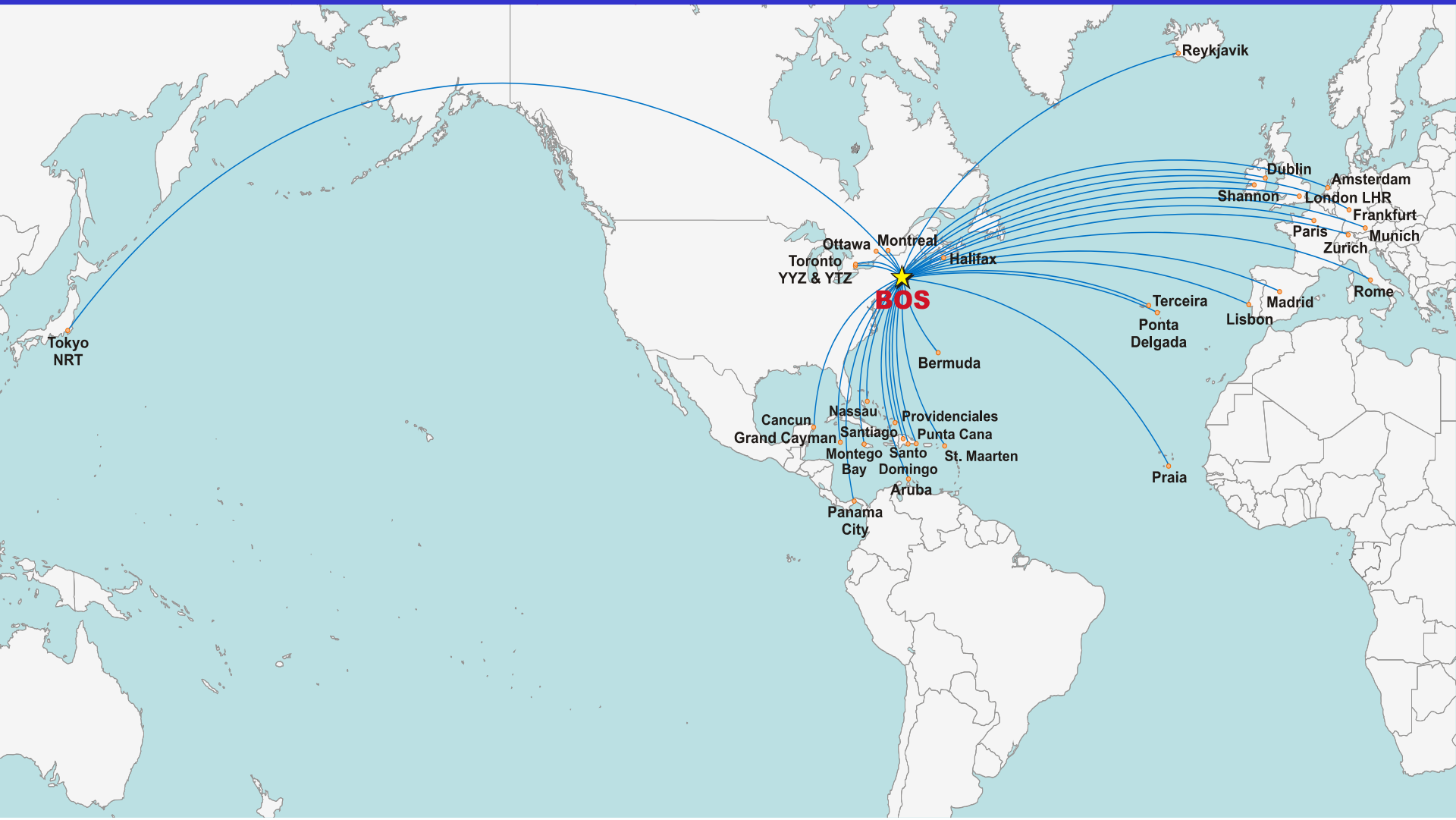
Climate Change Is No Longer A Local/Regional Issue



massport

Boston Logan has Nonstop Domestic Service to 75 Destinations

Climate Change Is No Longer A Local/Regional Issue



Boston Logan has Nonstop International Service to 33 Destinations

CLIMATE CHANGE SCENARIOS
1M SEA LEVEL RISE AT LOGAN INTERNATIONAL AIRPORT- BOSTON, MA

LEGEND

1 m sea level rise

- Sea level (1m)
- High tide (2m)
- 1 yr tidal flood (3m)

0 0.25 0.5 Miles

SOURCE: MASSGIS, ARMY CORP OF ENGINEERS
NEW ENGLAND COASTLINE TIDAL FLOOD SURVEY.
NOTE: ALL TIDAL FLOODS OCCUR DURING HIGH TIDE.
FLOODING DOES NOT TAKE INTO ACCOUNT STORM-WATER DRAINAGE SYSTEM.

CDM

Climate Change Impacts

- Extreme Events (more storms, increased severity)
  - Damage to infrastructure (terminals, navigation aids, etc.)
  - Pressure on cargo storage if cargo cannot leave site.
- Temperature Change (more hot days)
  - Limits on payloads
  - Use greater thrust, leading to more noise, increased fuel use and greenhouse gas emissions
  - Decrease utility of pavement
  - Increase demand for longer runways

Sandy Impacts

- Aviation
  - 8,000 flights were cancelled on October 30th at LaGuardia, Newark and JFK
  - Flights diverted to Boston
- Cruise Port
  - 5 diversions
  - 3 remained over night
- Container Port
  - Closed for 30 hours
  - 1 ship arrived a day early
  - 1 ship altered it's route to discharge cargo early to Boston

Massport Approach

Strategy

- Modeling of storm surge for 25 years
- Identification of critical infrastructure for resiliency planning
- Implement Short and Long Term Programs

Program Elements

- Planning
- Existing Buildings and Infrastructure
- New Buildings
- Emergency Response

Selected

Prime: Kleinfelder

Team Members

- Northeastern University
- University of New Hampshire
- U Mass Boston
- Atmos Research & Consulting
- Catalysis Adaptation Partners
- VJ Associates of New England
- Architectural Engineers, Inc.

Challenges & Risks

- Challenges
  - Come up with a Program that:
    - Is Actionable
    - Is Measurable
    - Is Financially Feasible
    - Involves both Infrastructure Upgrades & Operational Changes
    - Allows us to Carry the Philosophy Through all New Buildings & Third-Party Development as a Standard
- Risks
  - Model is not consistent with other models being used
  - Program must be scalable

THANK YOU

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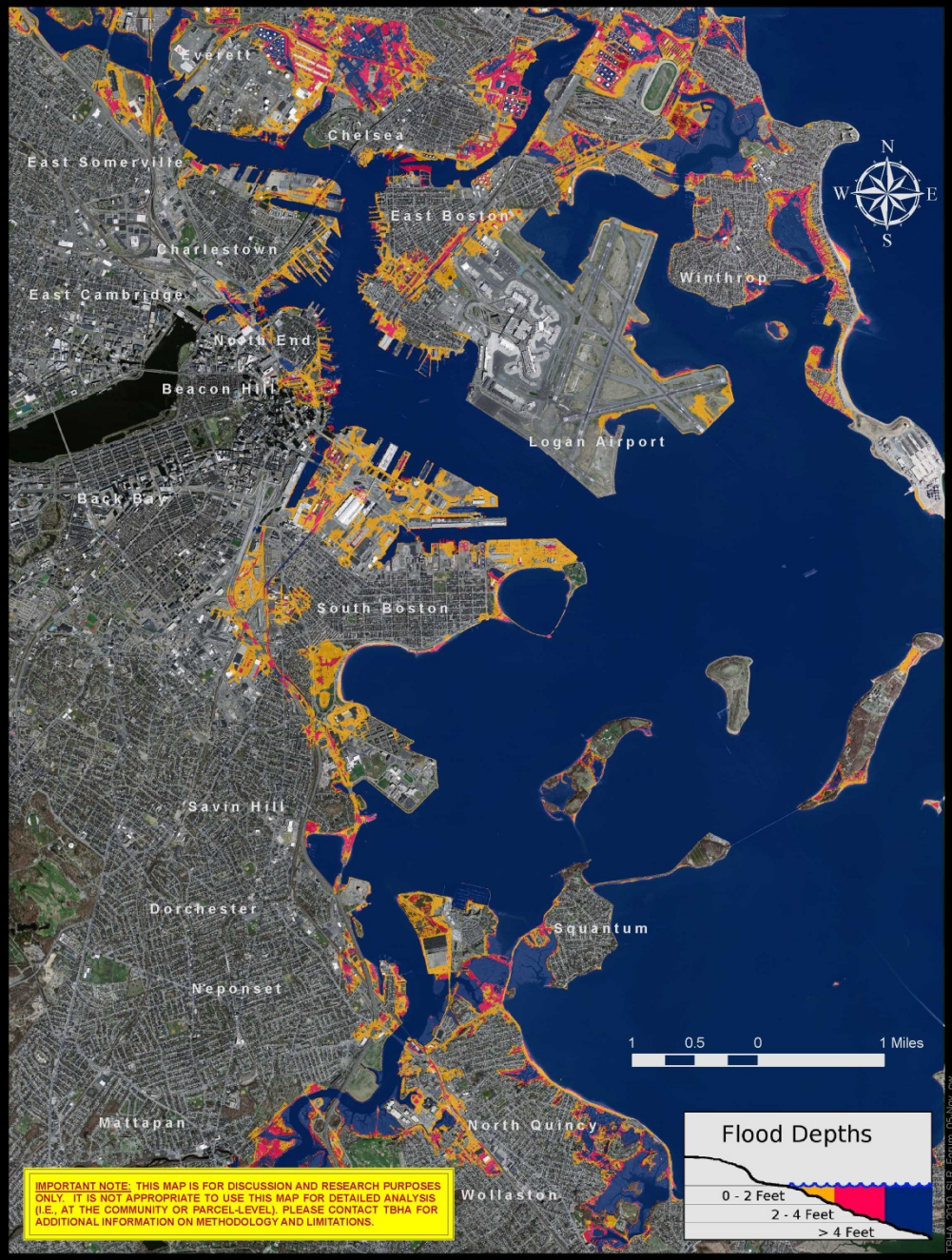
MassDOT Climate Preparedness

Frank DePaola, Highway Administrator, MassDOT



Boston Harbor and Vicinity
Mean Higher High Water Plus 5 Feet
Sources: MassGIS, NOAA, USGS

Map Development:
Chris Watson,Ellen Douglas - UMass Boston
Paul Kirshen - Battelle

MassDOT-FHWA Pilot Project

- **MassDOT proposal selected by FHWA (1 of 19 nationally)**
- **The project will examine the Central Artery for climate change/extreme weather vulnerabilities and evaluate adaptation options and is based on the initial work produced by The Boston Harbor Association**
- **Initially we will focus on the Sumner and Callahan Toll Plaza in East Boston, the Greenway, Ted Williams Tunnel boat section in South Boston, the MBTA Aquarium Station, and the Silver Line Way and Red Line in South Boston (see next slide).**

FHWA Pilot Project
Central Artery Overlay with Proposed Study Areas
Figure 2

Boston Inner Harbor
Mean Higher High Water Plus 5 Feet
Sources: MassGIS, NOAA, USGS

Map Development:
Chris Watson, Ellen Douglas - UMass Boston
Paul Kirshen - Battelle

Legend

Central Artery Facilities

Facility Type
- Administration Building
- Air Intake
- Electrical Substation
- Emergency Response Station
- Fan Chamber
- Low Point Pump
- Maintenance
- Operations Center
- Storm Water Pump
- Tunnel Drainage
- Vent Building
- D Street Facility

MHS Roads Boston Area

Facility Type
- Mainline
- Tunnel
- Viaduct

CAD Feature
- Facility
- Buildings

Other Feature
- Study Area

Data Sources:
Roads: 1:5,000 Massachusetts Road Inventory Centerline File, January 2013. Rails: 1:5,000 Massachusetts Rail Inventory Centerline File, January 2013. Transportation assets: Planning maintained files. Boundary layers: MassGIS 1:5,000 maintained files. Ponds, streams and other environmental layers: MassGIS 1:5,000 maintained files.
Note:
This map was produced by the Office of Transportation Planning. The Federal Highway Administration provided funding for the production of this map through the State Planning and Research Program. The location of the boundaries and features shown on this map are approximate and are intended for planning purposes only. This map is not intended to be used for survey, engineering or legal purposes.
For more information call: (617) 973-7313
File: MHS_Flood_StudyArea - Boston
Date: January 28, 2013

massDOT
Massachusetts Department of Transportation
Office of Transportation Planning

MassDOT-FHWA Pilot Project

- **The first of its kind for Boston Harbor, the project will simulate storm surge behavior using a hydrodynamic model of Boston Harbor circulation patterns and water levels during a storm**
- **The project includes using the Advanced Circulation Model for Oceanic, Coastal, and Estuarine Waters (ADCIRC) for present conditions and SLR for 2030, 2070, and 2100**
- **MassDOT has issued a Notice-to-Proceed to UMass-Boston to complete the work in 18 months**
- **Results will be peer reviewed by Woods Hole Oceanographic Institution, US Geological Survey Coastal and Maine Geology Program, US Army Corps of Engineers and, the US EPA**
- **Although this study focuses on the Central Artery, the Boston Harbor modeling will be made available for all to use with their own vulnerability and adaptation planning.**

Questions

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Thank you

Rick Dimino

President & CEO, A Better City