Adaptation for City Infrastructure; A Case Study of East Boston, MA

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with support from
Kirk Bosma, Wood Hole Group

EMF, July 22, 2014

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"Climate Change and Environmental Justice Communities"

Topics

Characteristics of Infrastructure Adaptation

East Boston Adaptation Planning

Changing the Scale

All human and natural systems are sensitive to climate: thus as climate changes, their services will change. Therefore we must consider how we will adjust to the changes, the process of **adaptation**

"A mix of local and regional actions taken over space and time by public and private organizations…"

Infrastructure Adaptation to Climate Change

- Do Nothing
- Accommodate
- Protect
- Retreat

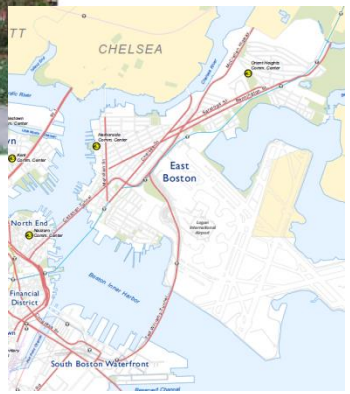
Address Uncertainty with Strategies

that:

- Consider a range of future conditions
- Are robust, and/or flexible and adjustable
- Include no-regrets and co-benefit solutions
- Are integrated with mitigation, regional and sustainability planning
- Recognizes Adaptive Capacity (economic, social, and natural resources, institutions, technology)
- Evaluated with Multiple Criteria
- Are stakeholder driven
- Combine “here and now” and “prepare and monitor” actions

Example of Staged Strategy

Present to 2050 – Local Solutions



2050 to 2100– Regional Solutions

Figure 15. Example of parapet wall

Retreat

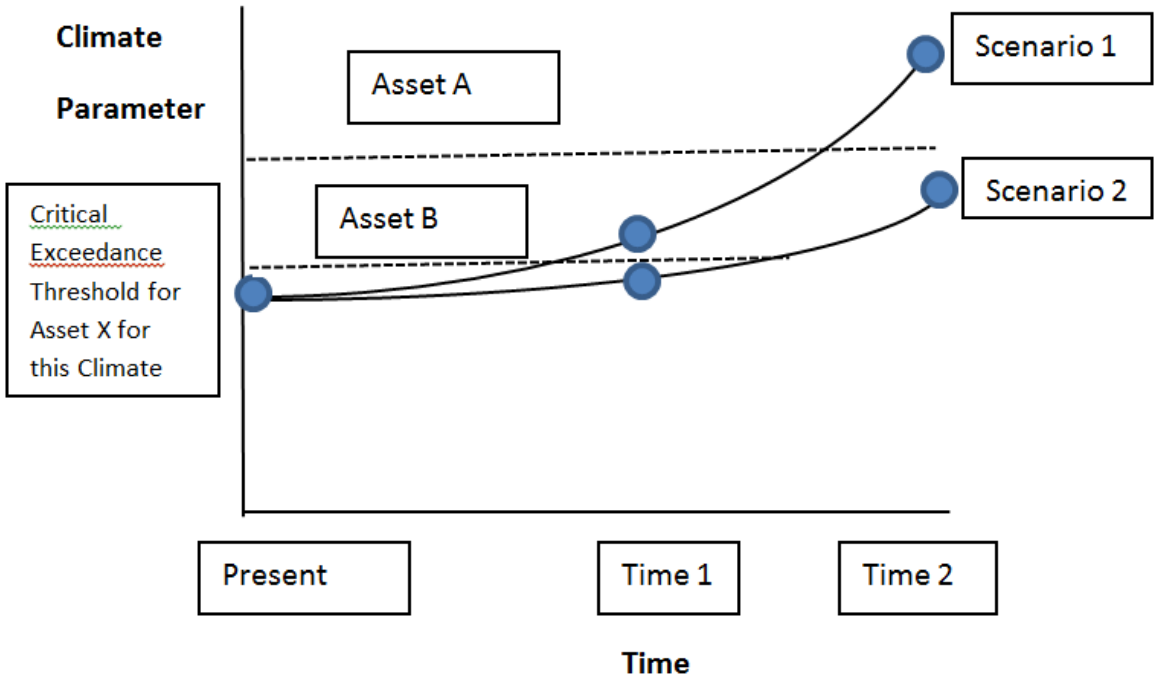
Example Infrastructure Climate Change Impacts

- Direct damage costs to buildings/infrastructure
- Lost wages/tourism/business disruption
- Loss of neighborhoods
- Health consequences

Corollaries

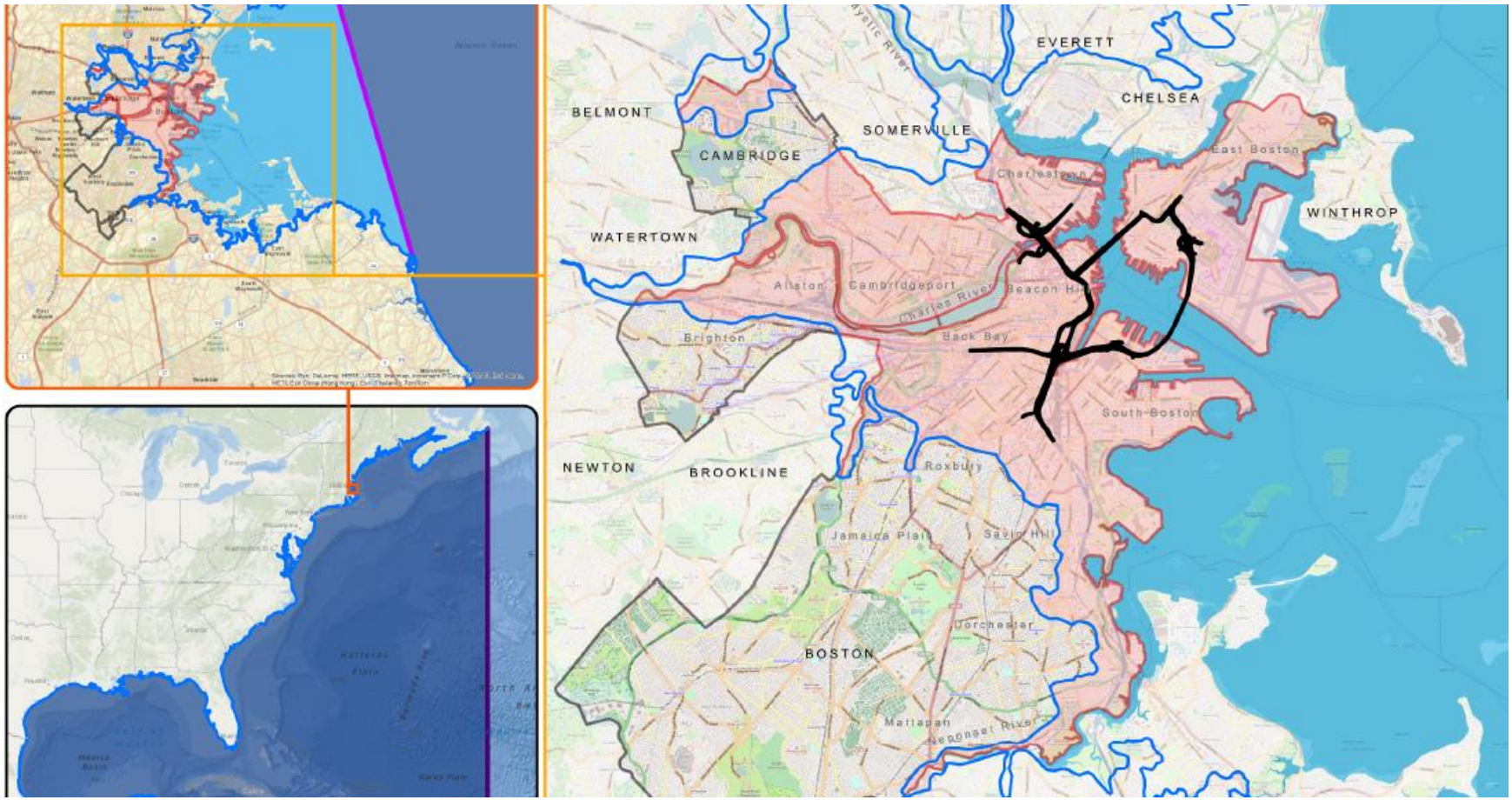
- Safe to Fail, not Fail Safe
- Design with Nature

Scenario Planning



Assume we have high and low climate change scenarios for each climate parameter and determine the critical threshold for each asset. Eg, an asset is flooded at 15 ft NAVD . The scenarios are defined by the blue points above for present and the time periods of Time 1 and Time 2 (eg 2014, 2040, 2070). Thus we can say Asset B could fail some time in between present to Time 1 or as late as between Time 1 and Time 2. Asset A will not fail at the earliest until between Time 1 and Time 2; thus from a time perspective, less need to take action here, but need to plan to in the future. PHK 1 5 13

East Boston Case Study




Tank Farm
Underground Water, Sewer, Gas & Electric
Highways
Commercial
Industrial
Drainage and CSOs
Recreation
Subsatation
Subway
Tunnels
Housing
Airport

East Boston

- **Population is just over 50 percent minority**

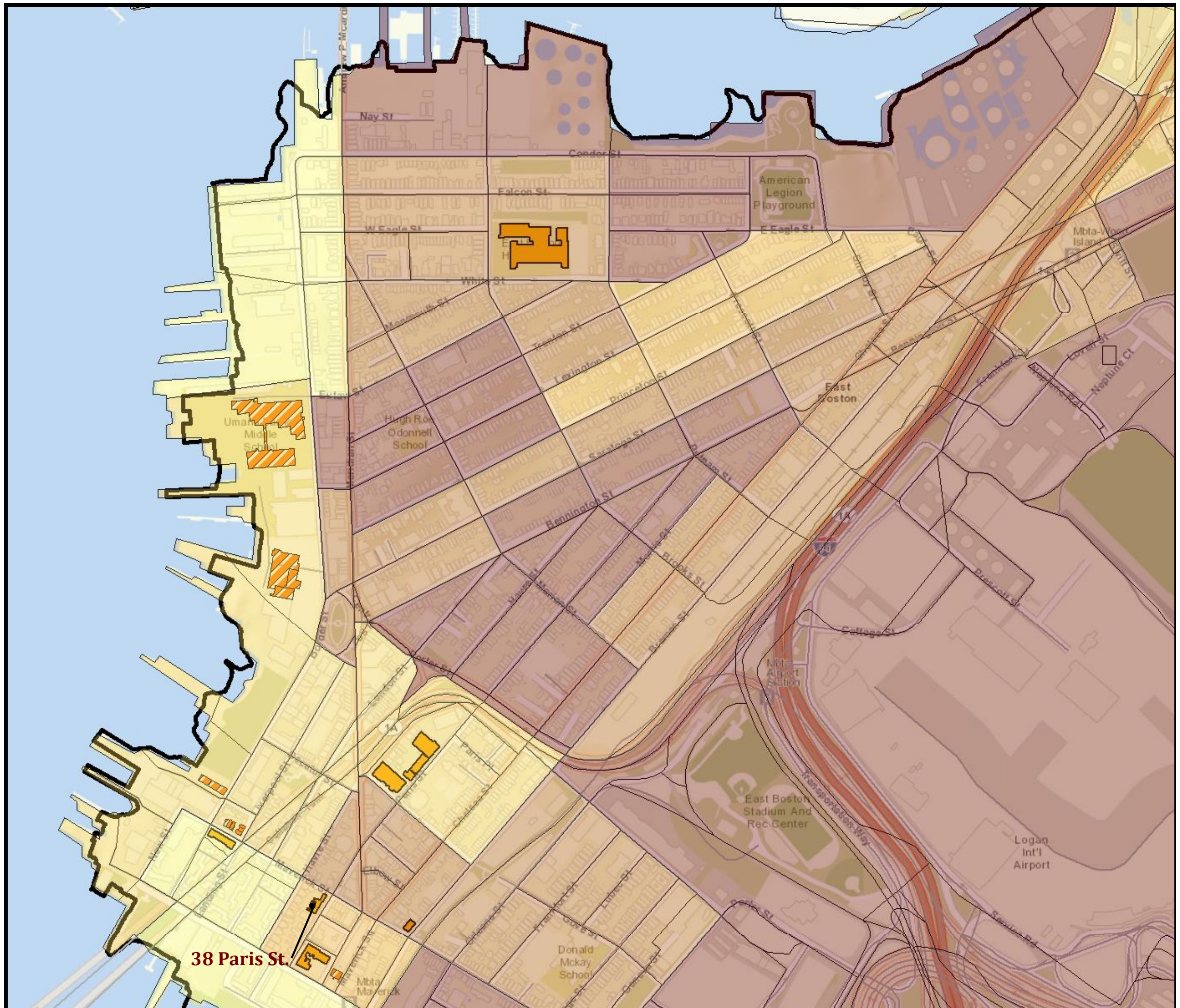
- **The neighborhood's median household income is about $31,311 or 57 percent of the regional (metropolitan Boston) average**

- **42% of residents are foreign-born, and some 60% of these have entered the United States after 1990**

- **Nearly 40% of the population speaks only Spanish at home; and approximately 23% of the population is considered to be linguistically isolated**

- **Over 20% of families in East Boston live below the poverty level**

Vulnerability of Human Capital



Median household income (US$)

- 12891 - 20000
- 20001 - 30000
- 30001 - 40000
- 40001 - 50000
- 50001 - 80000
- Census 2010 Blocks
- Community Mapping
- Impt Community Function

Step 1 –Vulnerability Assessment What Happens if No Adaptation

Climate Change Adaptation in East Boston; Workshop I, Understanding the Issues

May 13, 2014

Objective: The objective is an exchange of the values and points of view of neighborhood and agency stakeholders in creating an East Boston that is resilient to the present and future impacts of sea level rise, coastal storms, and extreme precipitation.

Agency	Group (Neighborhoods (N), Planning (P) and Infrastructure(I))
Boston Environmental Services	N
Northeast Utilities	I
Boston Redevelopment Authority	P
Boston Housing Authority	N
National Grid	I
MassDOT	P
MassPORT	P
Boston Public Health Division	N
Boston Water & Sewer Commission	I
MAPC	P
MBTA	I
Boston Emergency Management	N
Boston Neighborhood Services	N
The Boston Harbor Association	P
MA CZM	P
Other	

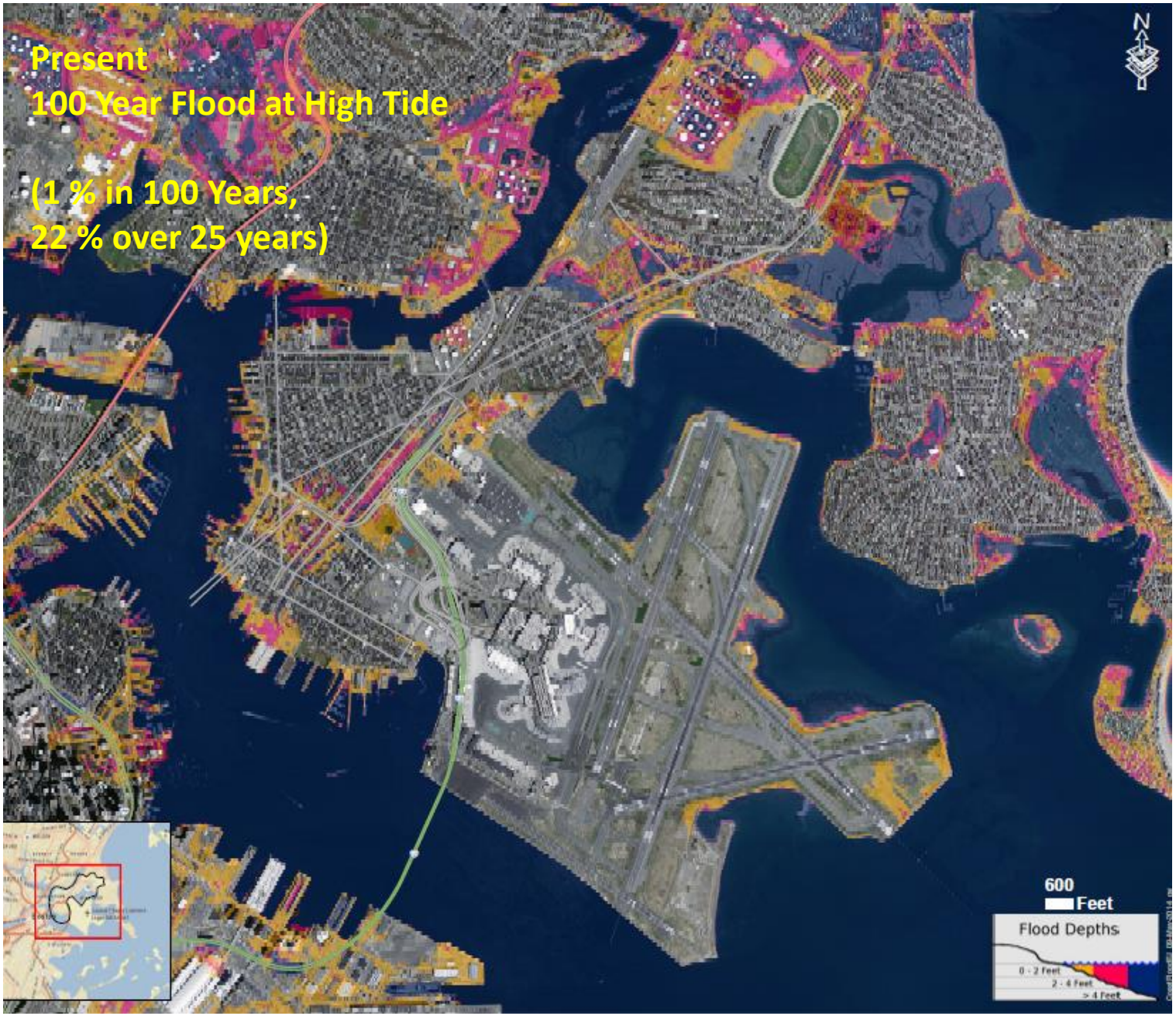
Neighborhood Group
Orient Heights/Star of the Sea,
Eagle Hill and Central Square
Maverick/Jeffries Point

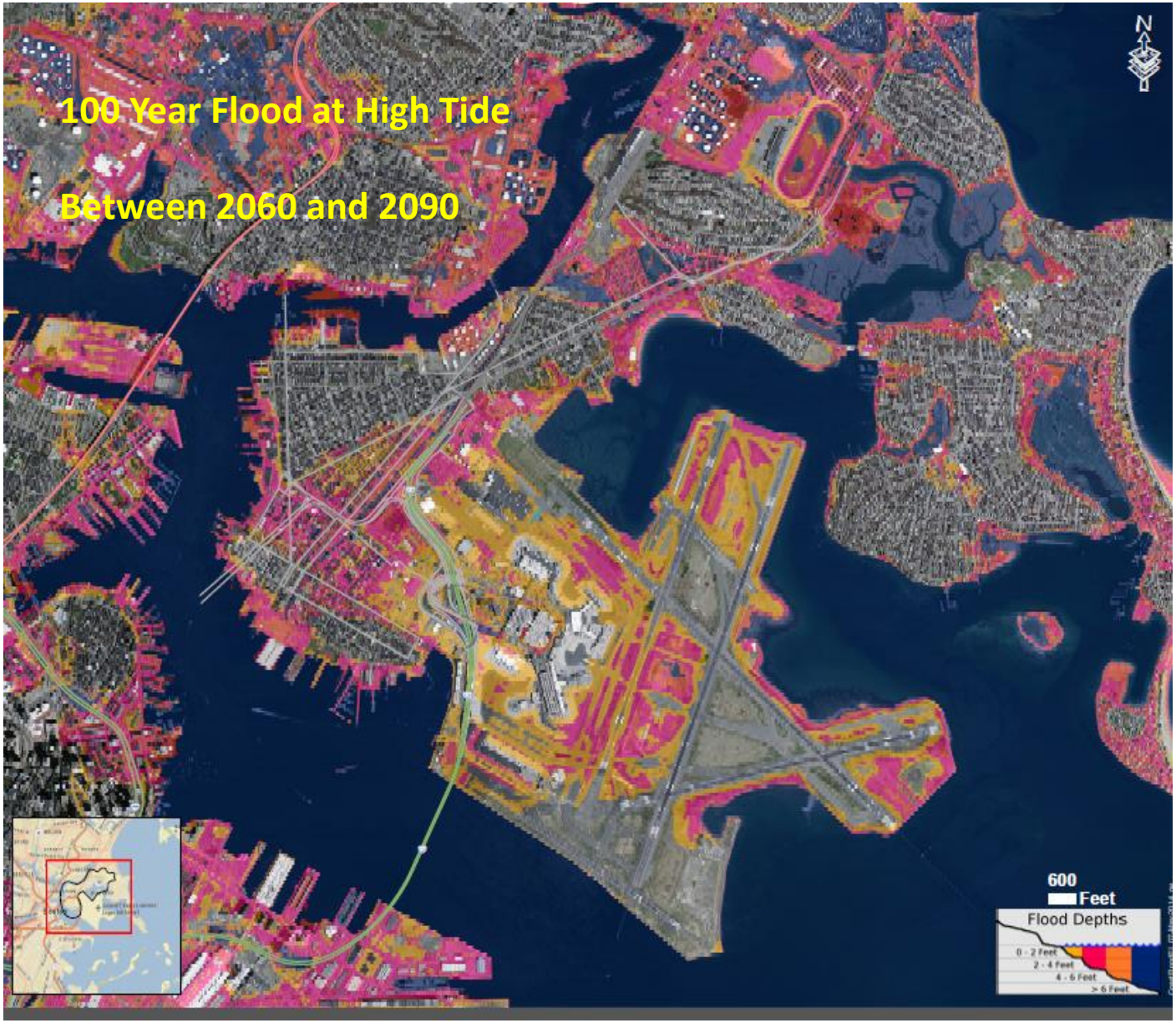
Future Climate and Sea Level Rise

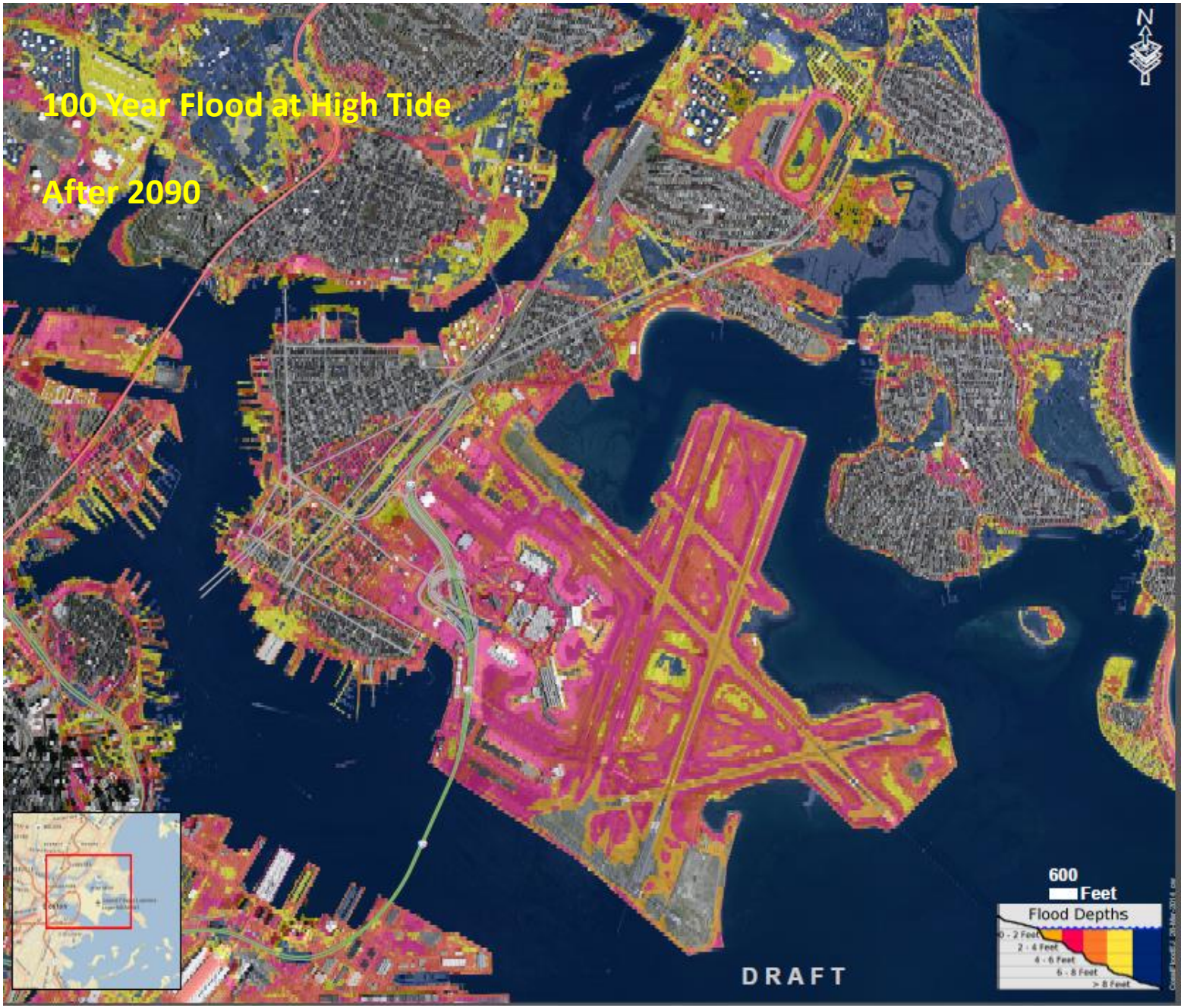
SLR – 1 to 2 feet by 2050, 3 to 6 feet by 2100

Extreme Rainfall - 2 to 20 % increase by 2050, 8 % to 25 % by 2100

EMPHASIS ON COASTAL FLOODING


Present
100 Year Flood at High Tide
(1 % in 100 Years,
22 % over 25 years)
N
600
Feet
Flood Depths
0 - 2 Feet
2 - 4 Feet
> 4 Feet


100 Year Flood at High Tide
Between 2060 and 2090
N
600
Feet
Flood Depths
0 - 2 Feet
2 - 4 Feet
4 - 6 Feet
> 6 Feet


100 Year Flood at High Tide
After 2090
N
600
Feet
Flood Depths
0 - 2 Feet
2 - 4 Feet
4 - 6 Feet
6 - 8 Feet
> 8 Feet
DRAFT

What is Important to Protect?

1. Protecting Family

2. Specific Activities, Locations, Facilities

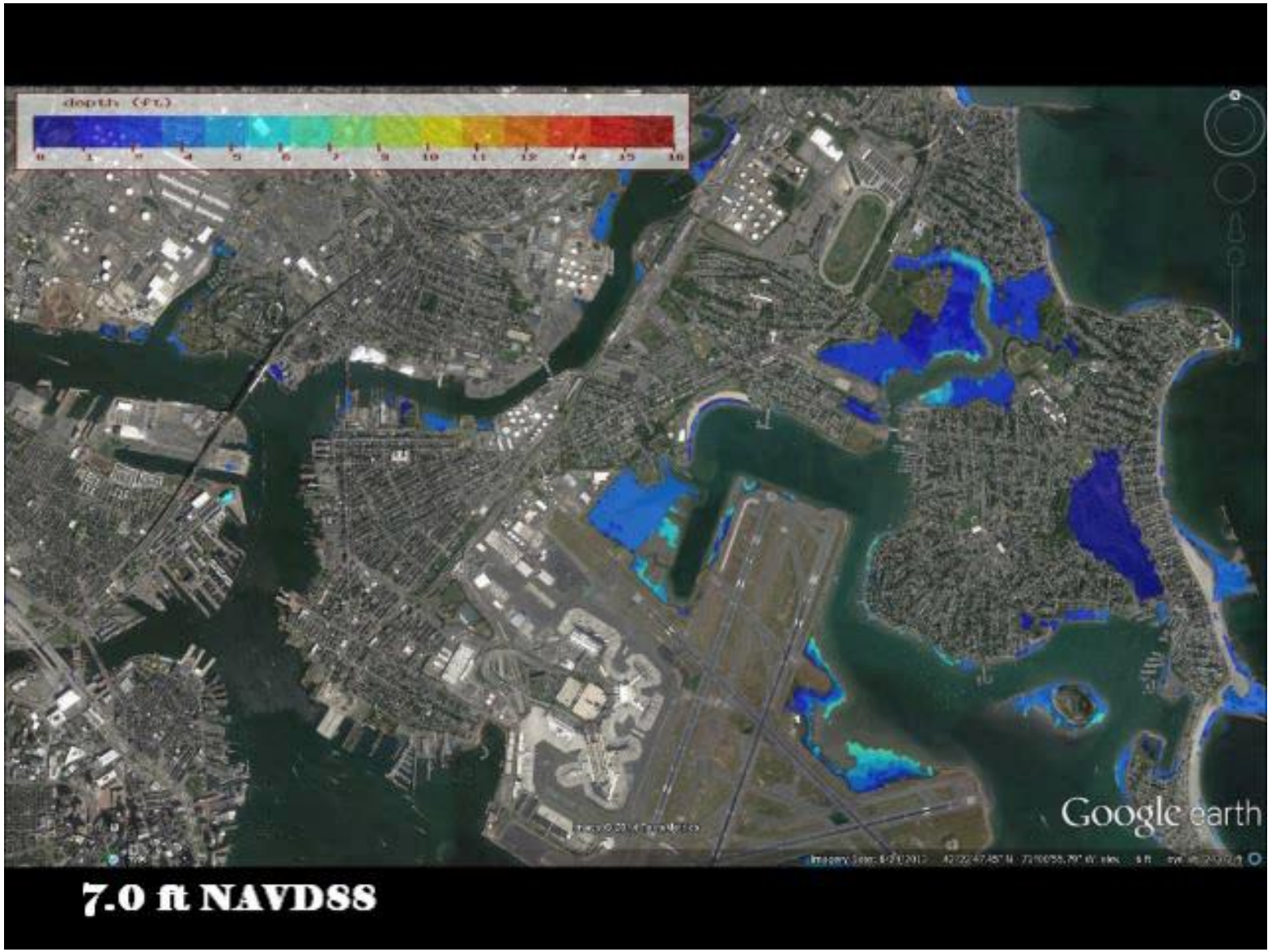

E - C5
O - I2
O - N2
O - C12
M - N5
O - P1
M - P3
O - P3
O - N1
M - C8
O - P1
E - N2
O - C4
E - C2
M - N3
O - C13
O - C3
M - C9
O - C1
O - C8
O - C9
O - N3
M - C4
E - C3
O - I1
M - C9
O - C12
O - C16
O - C14
O - C4
M - C6
M - N1
E - C4
O - I3
M - P2
O - P2
E - N3
O - C10
O - C5
O - C11
O - C1
O - C7
M - C5
E - C7
O - C6
O - C15
E - C4
E - C10
O - C4
E - C1
E - C8
M - I1
E - P2
M - P1
M - C1
E - N1
M - N4
M - P1
M - N2
M - C2
Legend
Label format N-Yx
where N = Neighborhood,
Y = C, P, N or I, and x = 1, 2, 3 ...
Community
Eagle Hill
Maverick
Orient
Planning
Eagle Hill
Maverick
Orient
Neighborhood
Eagle Hill
Maverick
Orient
Infrastructure
Eagle Hill
Maverick
Orient
600
Feet

Climate Change Adaptation in East Boston; Workshop 2, Managing Present and Future Coastal Flooding Risks

June 25, 2014

In this workshop, the study team will present alternative plans to help East Boston adapt to the impacts that reflect the values expressed at the workshop. Using the alternative plans as starting points, this workshop will then discuss the pros and cons of each plan

How Water Gets In to Flood



Flood Management Options

Flood Walls

Accommodation

Types of Flood Protection

- Conventional Flood Wall/Levee
- Tide Gates/Surge Barriers
- Greener Solutions
- Articulating structures/gates
- Temporary

Monolithic Structures

Viewing Sections

Roads Through Floodwall

Tide Gate/Surge Barrier

Fox Point Hurricane Barrier, Providence, RI

(http://en.wikipedia.org/wiki/File:Barrier-Providence.jpg)

Greener Solutions

Enhanced Natural Dunes and Vegetation

Landscaped Flood Berm

Tulsa Park, Brooklyn, NH

Terracing

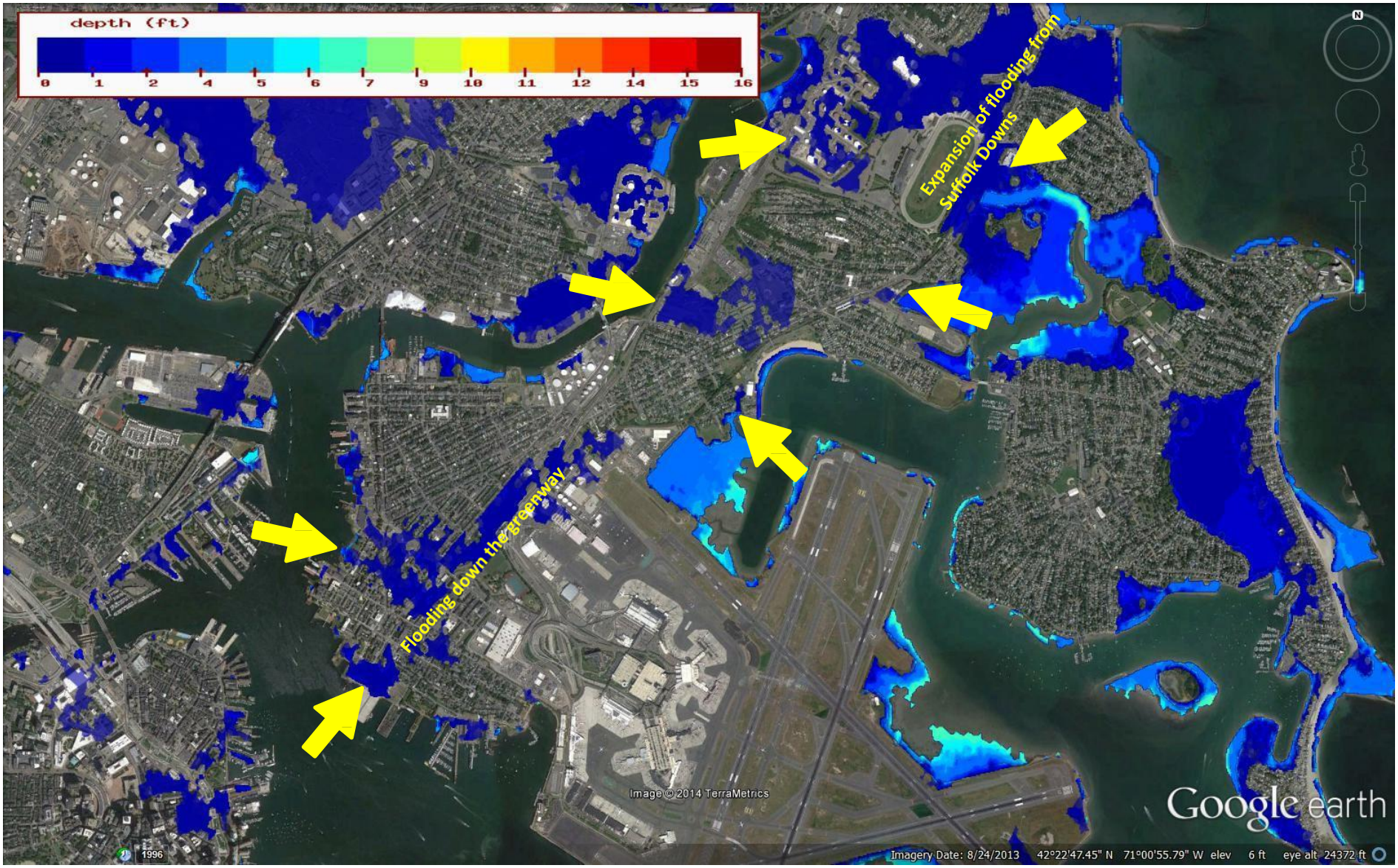
Removable Flood Wall

Local Solution - Aquarium MTBA Station

Articulating Floodwall

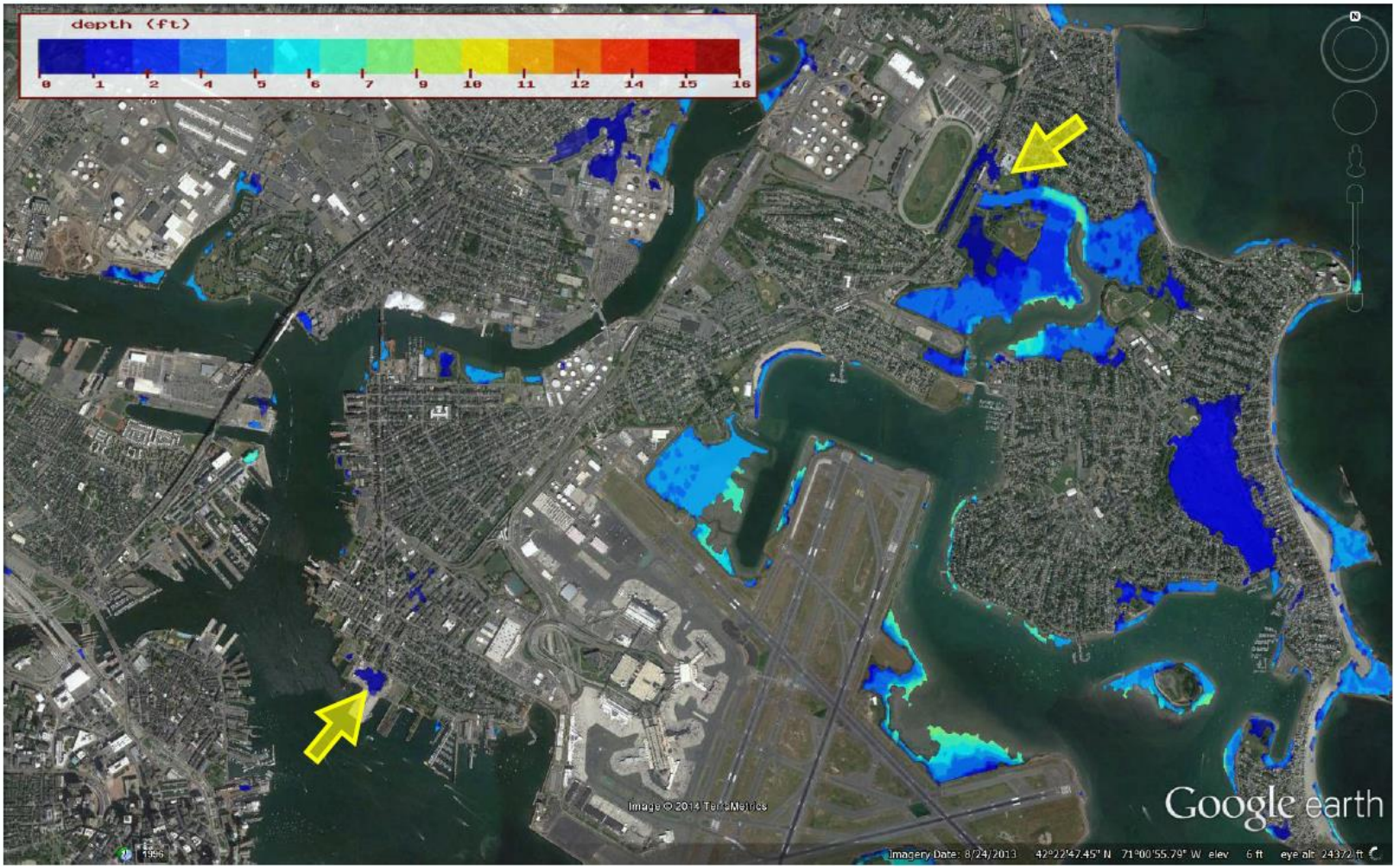
Conceptual Modular Seawall at Uman School/Harborside Community Center

100-year Water Level Threat Today - Water Surface Elevation of 9.8 feet NAVD88

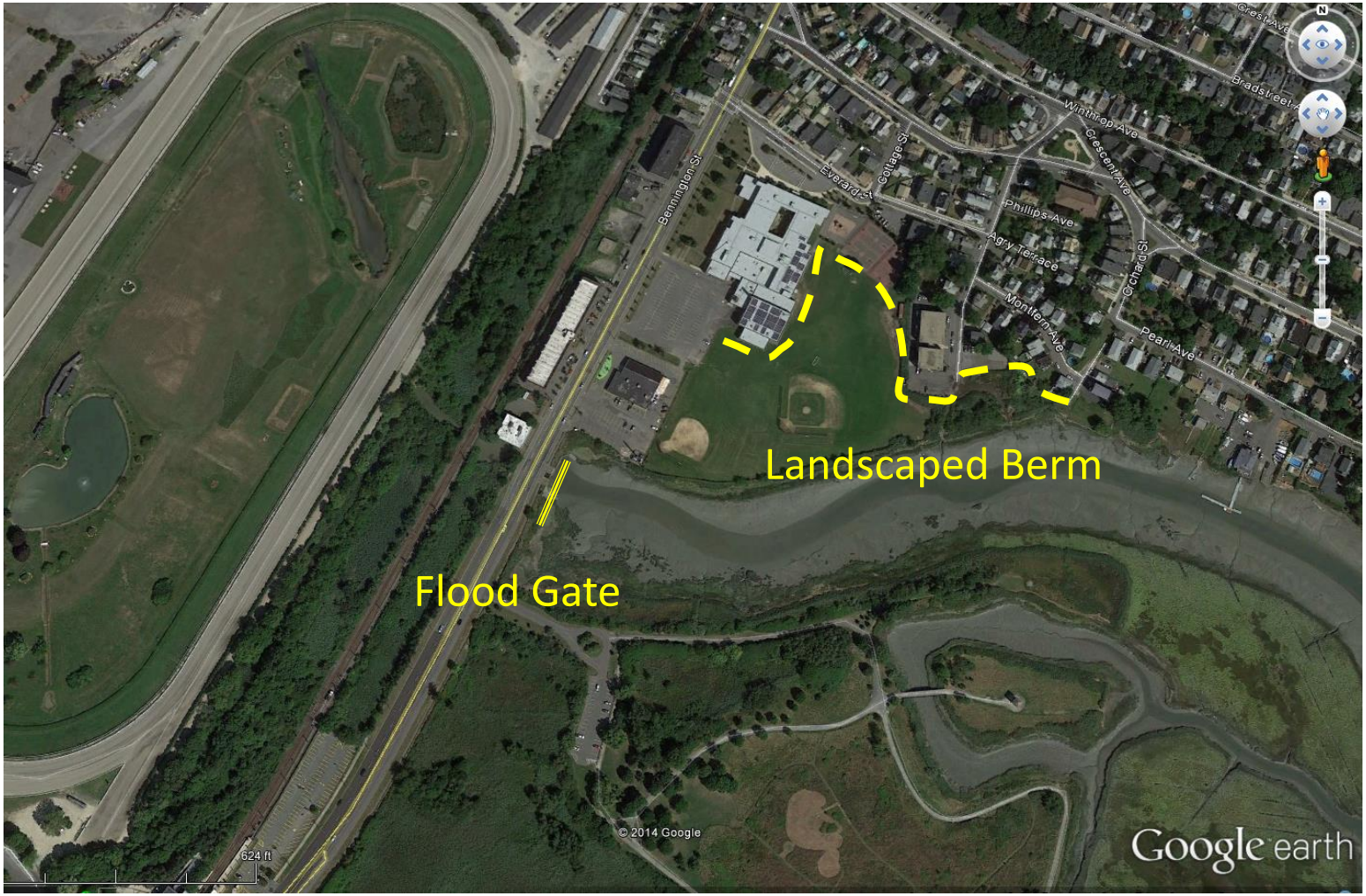


Sites 1N and 1S

Water Surface Elevation of 7.8 feet NAVD88



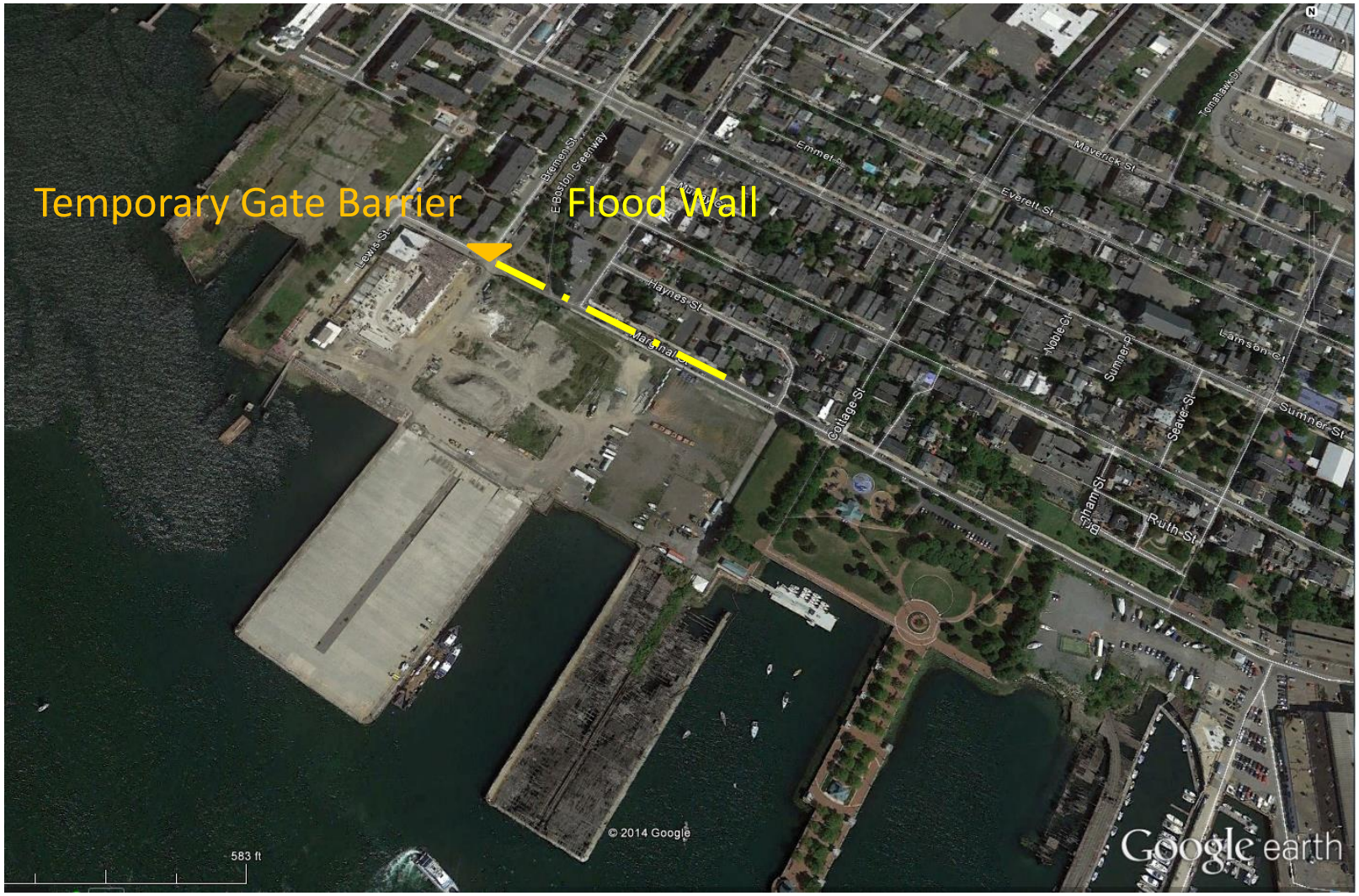
Site 1N – Fredericks Park, Bennington Street and Belle Isle Inlet



Fredericks Park Flood Wall

Year	Maximum Height (feet)	Top Elevation (NAVD)
2020	5	10
2060 - 2080	8	13

Site 1S – Marginal Street



Greenway Across Street

Temporary Gate Barrier

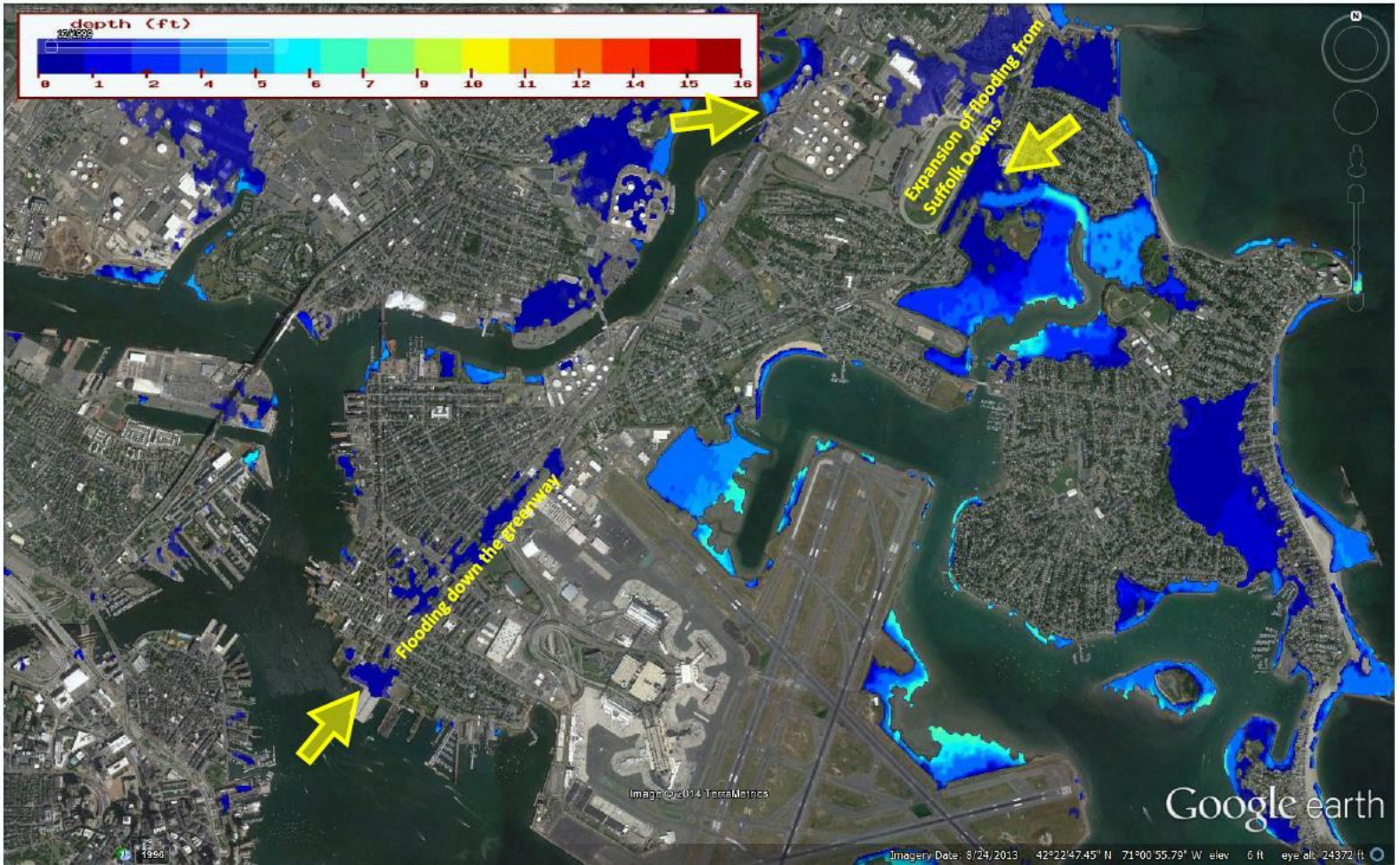
Marginal Street Flood Wall

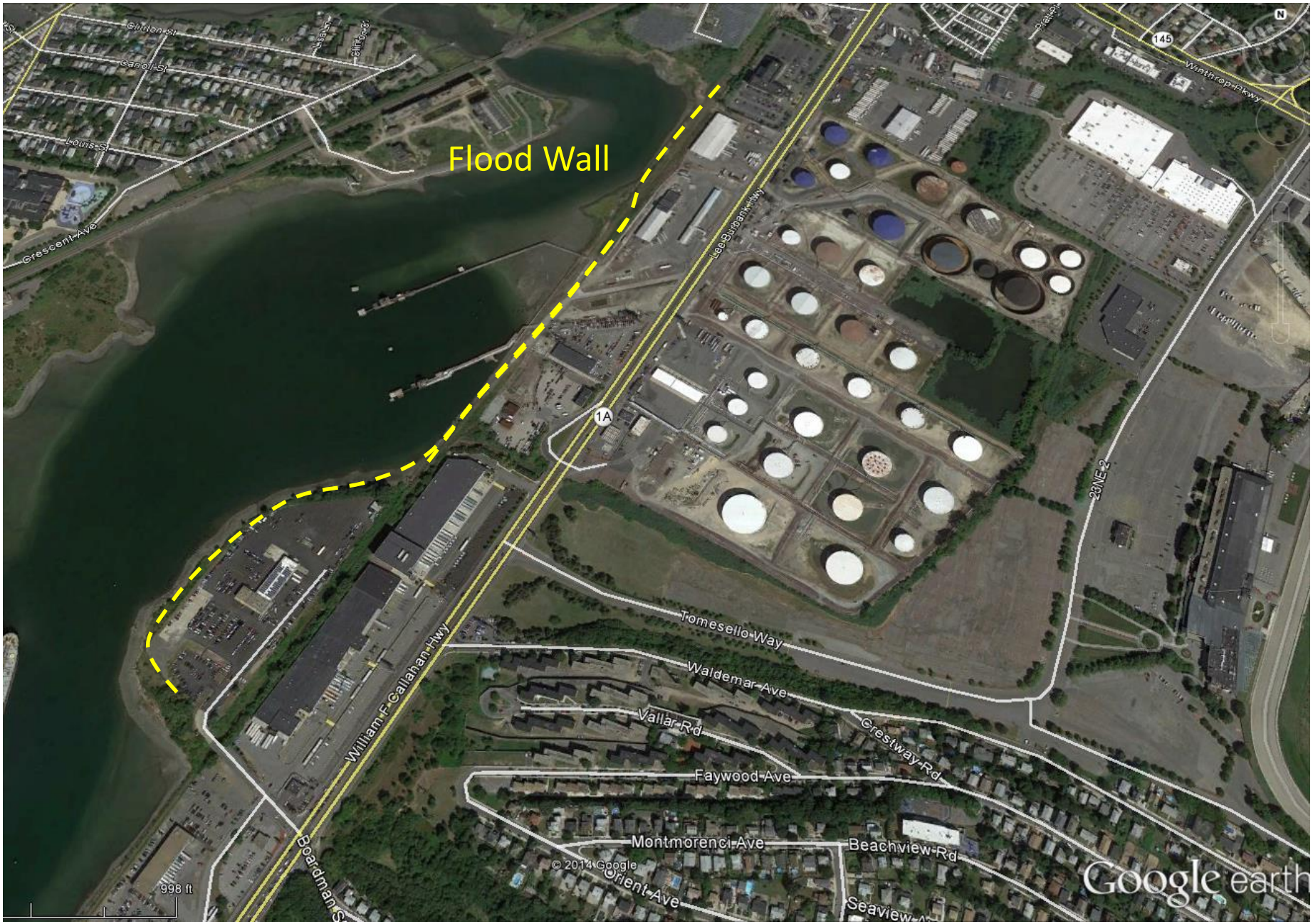
Marginal Street Flood Wall

Year	Maximum Height (feet)	Top Elevation (NAVD)
2020	3	10
2060 - 2080	6	13

Site 2 – Irving Oil Terminal

Water Surface Elevation of 9.0 feet NAVD88



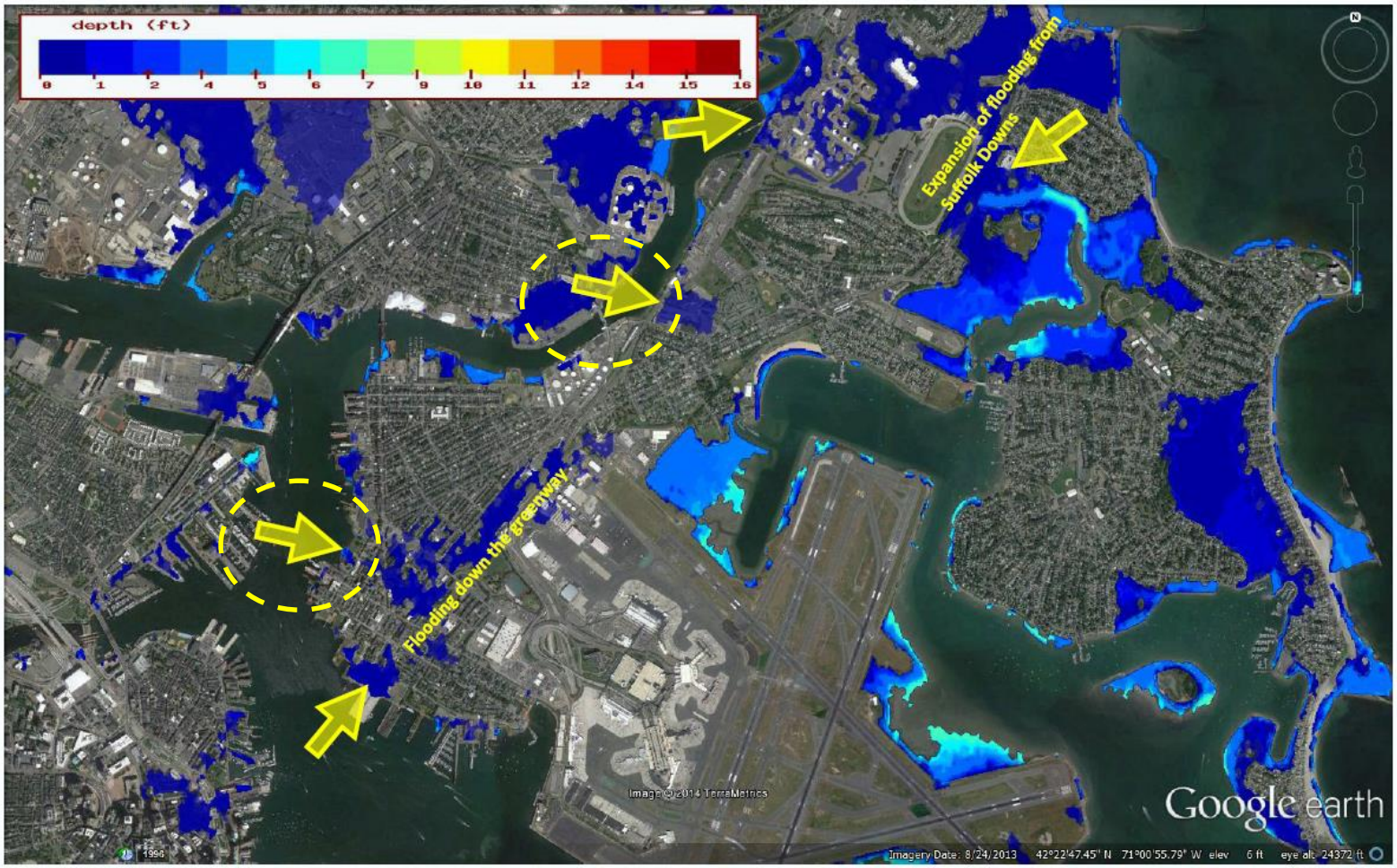

Flood Wall
Crescent Ave
Louis St
Carroll St
Gladen St
Lee Burbank Hwy
1A
145
Winthrop Pkwy
23NE-2
Tomesello Way
Waldemar Ave
Vallar Rd
Crestway Rd
Faywood Ave
Montmorenci Ave
Beachview Rd
Orient Ave
Seaview
William F Callahan Hwy
Boardman St
998 ft
© 2014 Google
Google earth

Irving Oil Terminal Flood Wall

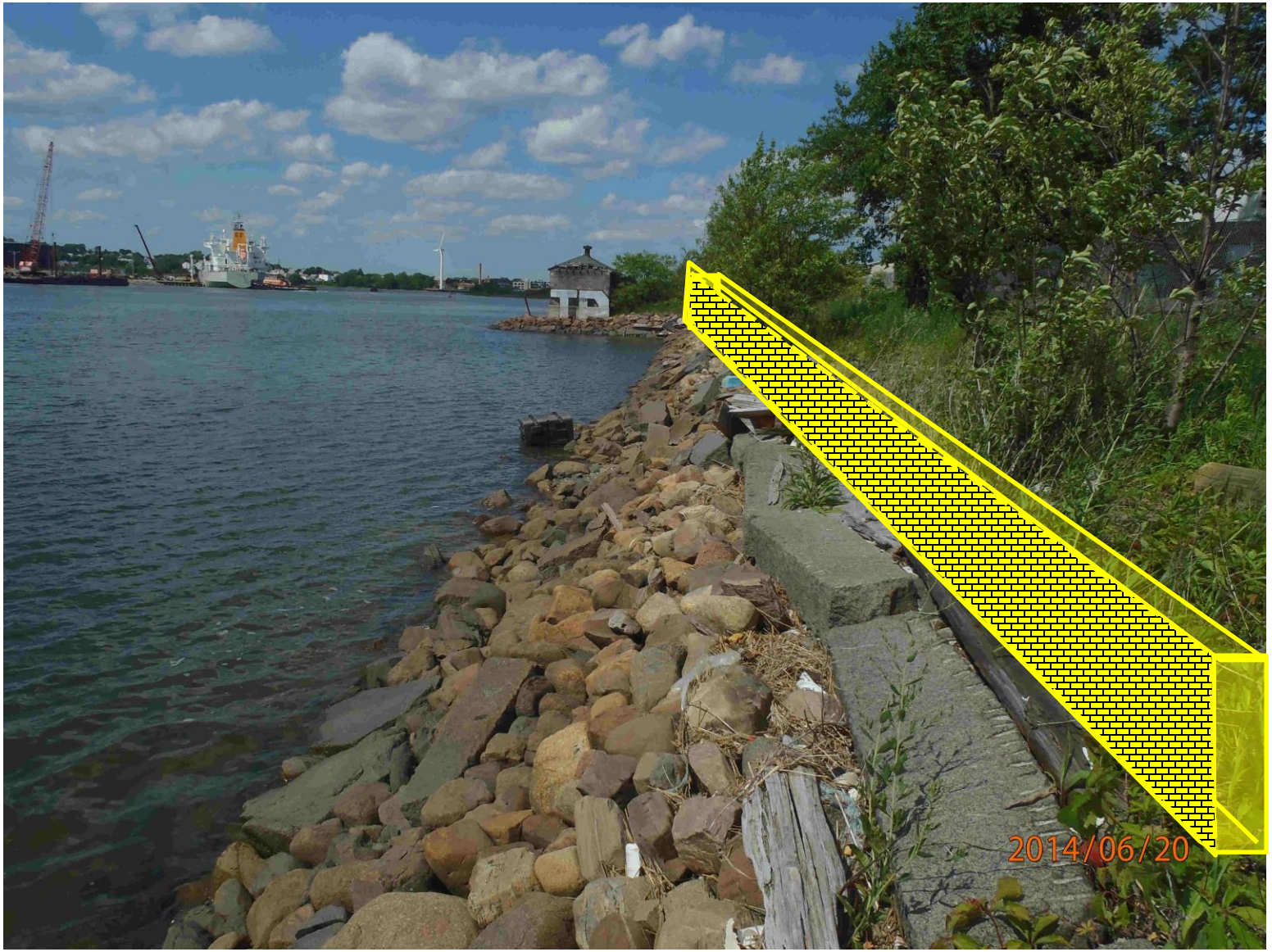
Year	Maximum Height (feet)	Top Elevation (NAVD)
2020	2	10
2060 - 2080	5	13

Sites 3N and 3S – do by 2020

Water Surface Elevation of 9.6 feet NAVD88

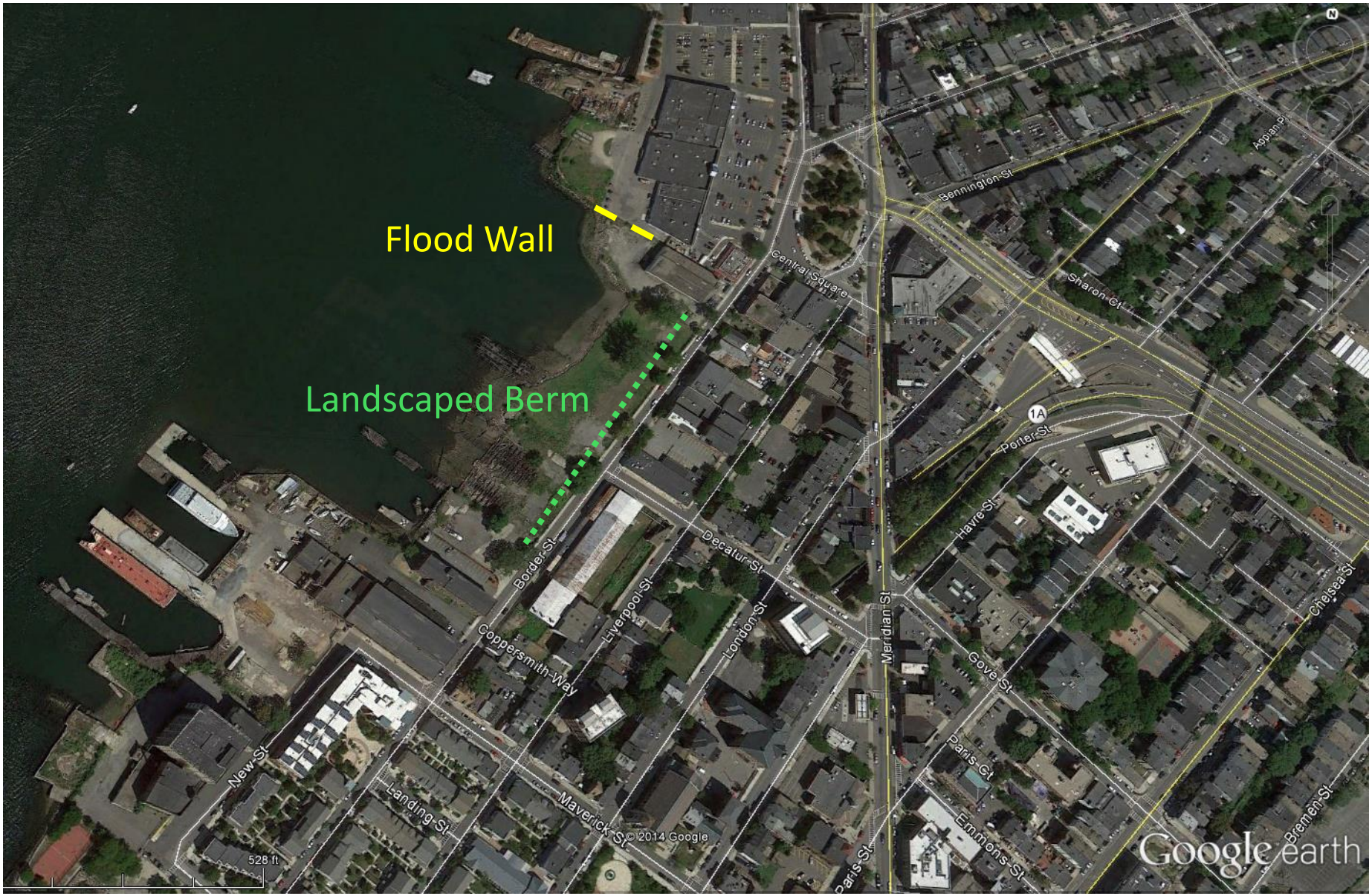


Site 3N– Route 1A


2014/06/20

Site 3N - Route 1A Flood Wall

Year	Maximum Height (feet)	Top Elevation (NAVD)
2050	1	10
2060 - 2080	4	13


Flood Wall
Landscaped Berm
Central Square
Bennington St
Sharon Ct
Porter St
Havre St
Border St
Decatur St
Liverpool St
London St
Coppersmith Way
Meridian St
Gove St
Paris Ct
Emmons St
Chelsea St
Bremen St
New St
Landing St
Maverick St
Paris St
528 ft
© 2014 Google
Google earth

Border Street Green Space

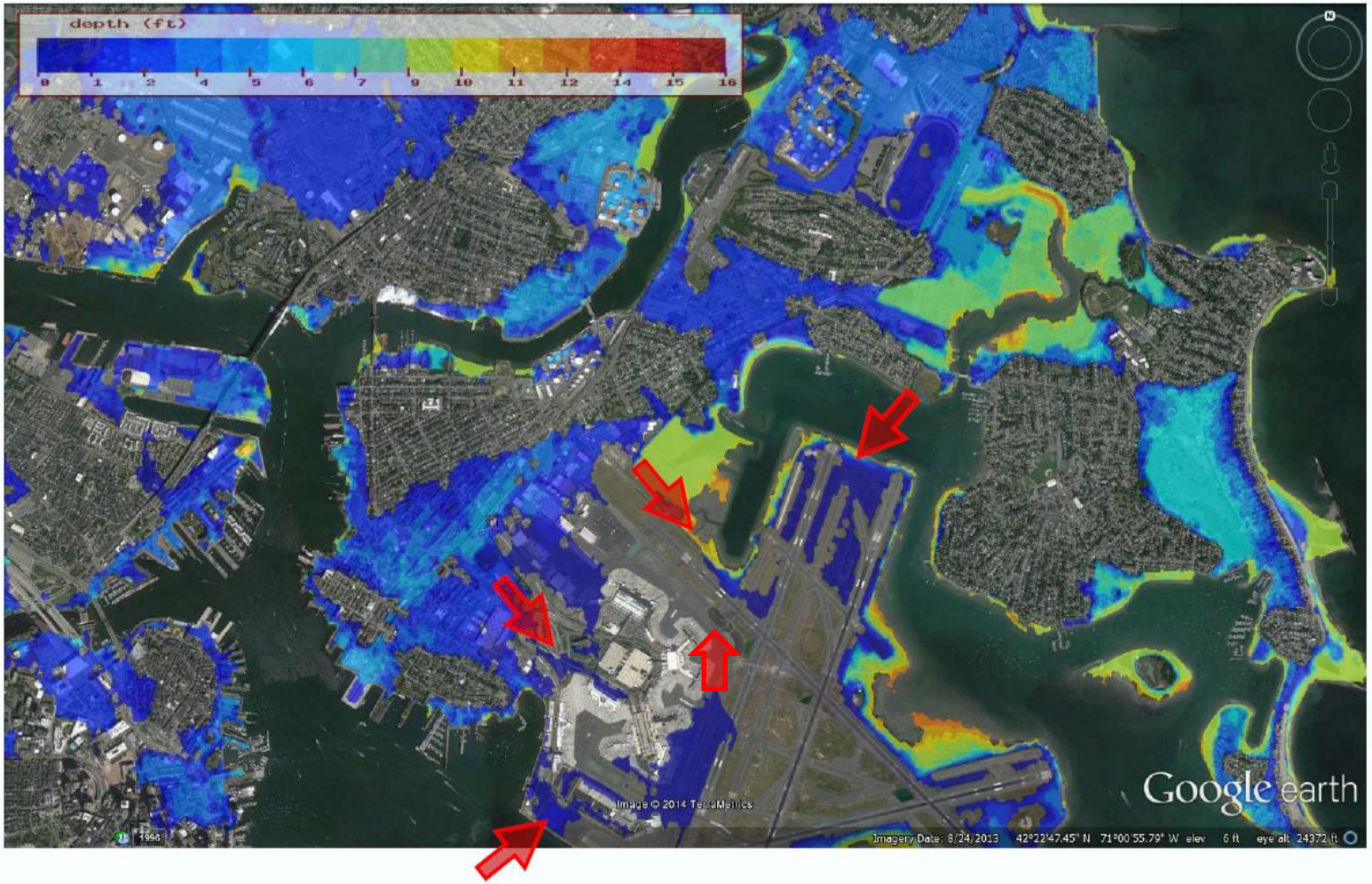
Potential for Border Street Flood Protection

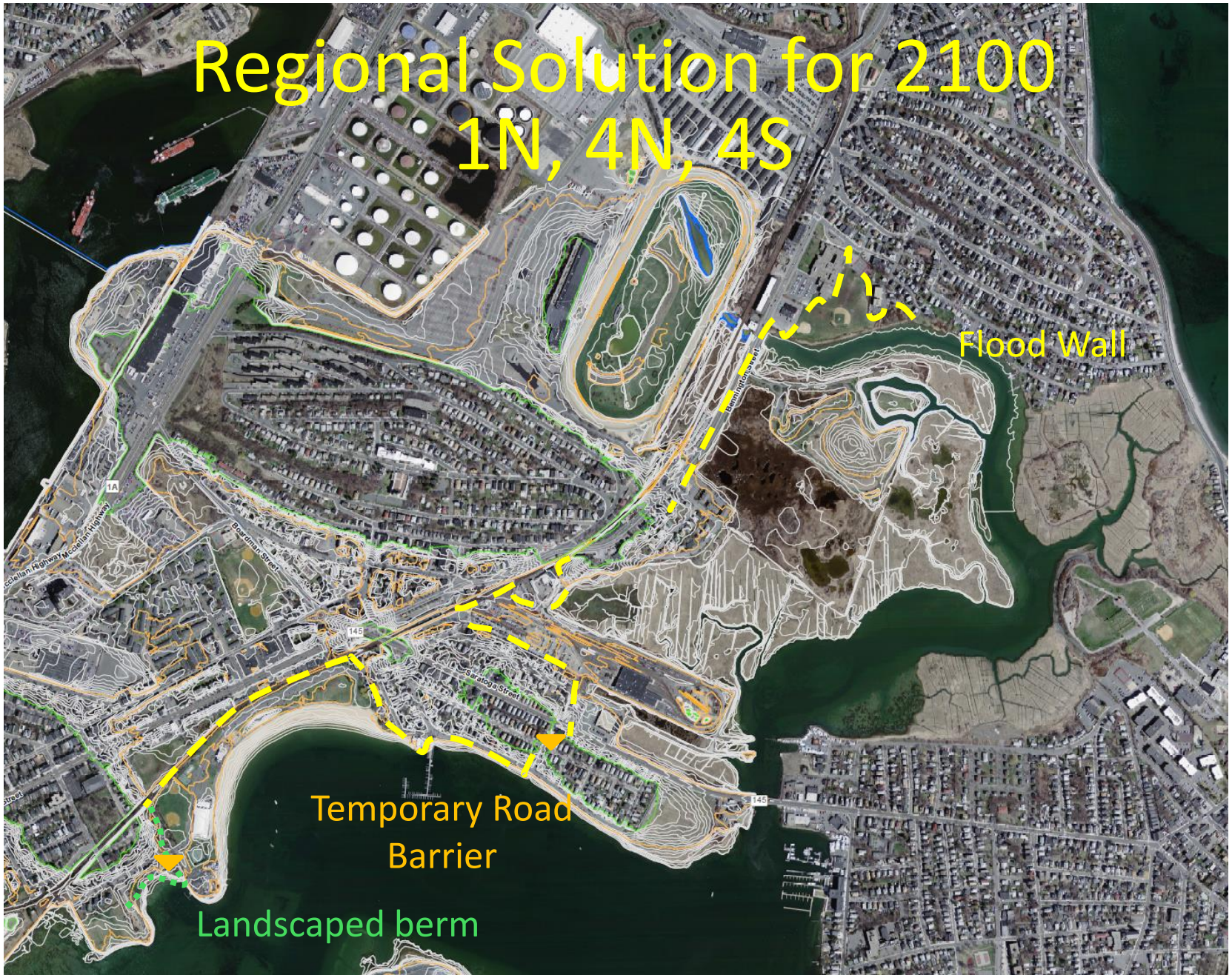
Site 3S – Border Street Flood Wall

Year	Maximum Height (feet)	Top Elevation (NAVD)
2020	1	10
2060-2080	4	13

Sites to Protect 2060- 2080

Water Surface Elevation of 12.6 feet NAVD88



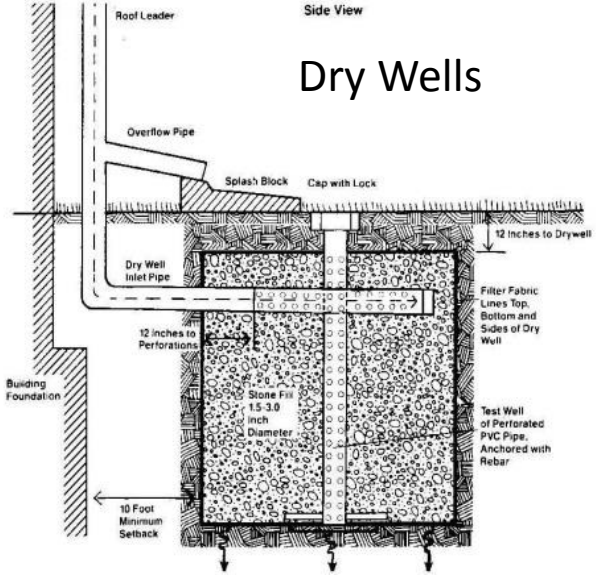

Regional Solution for 2100
1N, 4N, 4S
Flood Wall
Temporary Road Barrier
Landscaped berm


Regional Solution after 2100
Surge Barrier

Stormwater Pumping Stations Will be Necessary on Dry Side of Flood Walls and Berms

MA DOT

Dry Wells



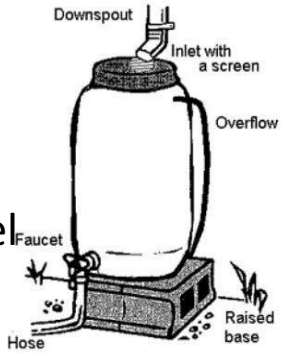
"Low Impact Development"

Blue Roof

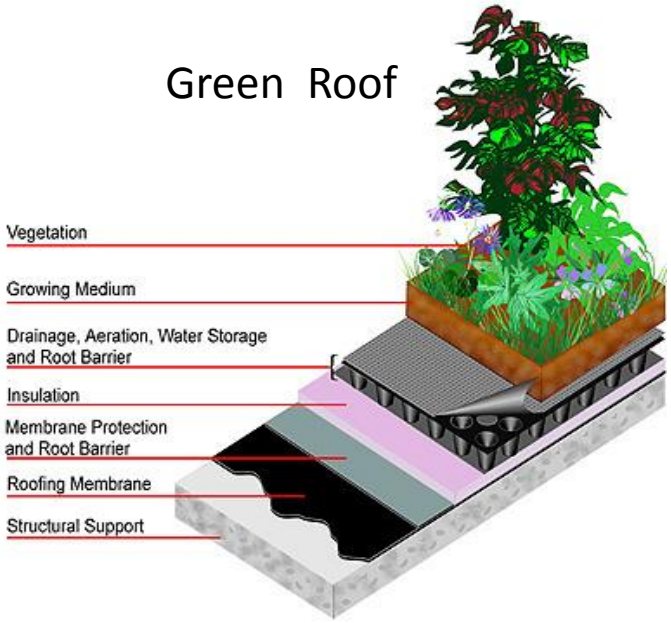
Bioretention

Porous Pavement

Rain Barrel

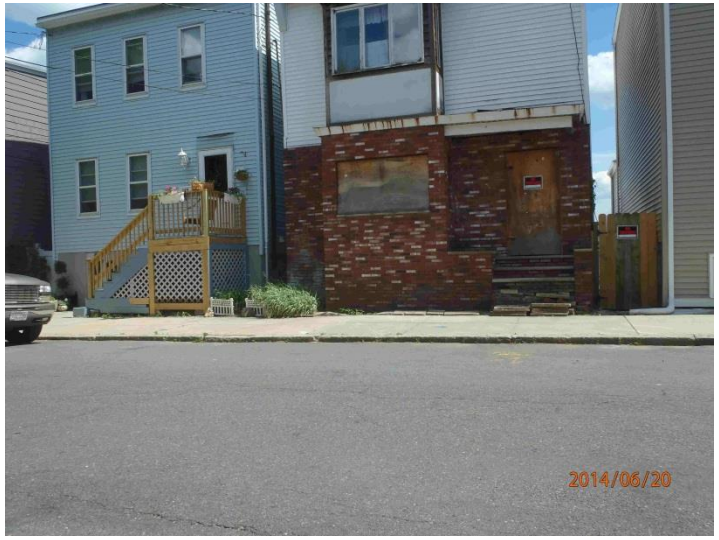


Green Roof

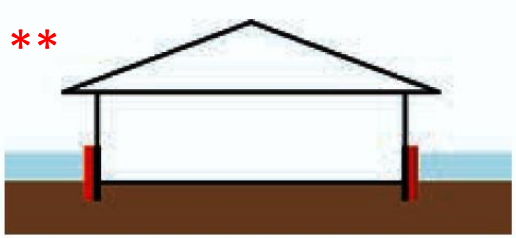



Approximate Locations of Areas
Not Protected by Walls up to
2065 – 2085 (13 ft NAVD)
N

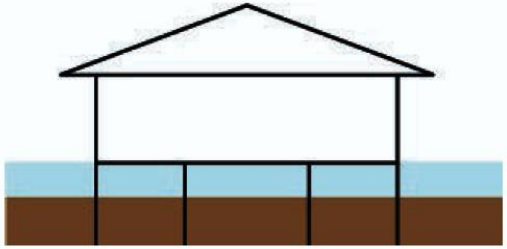
Building Floodproofing



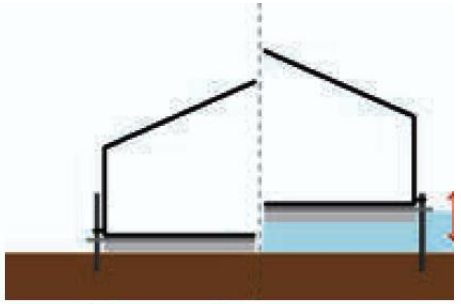
Site Strategies



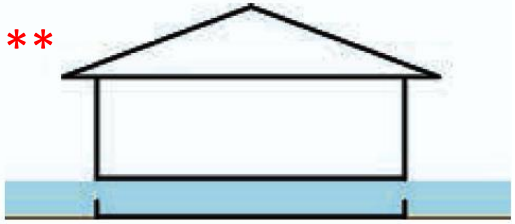
Dry Floodproofing



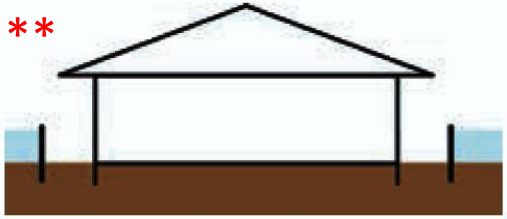
Elevate on Piles



Amphibious Structures

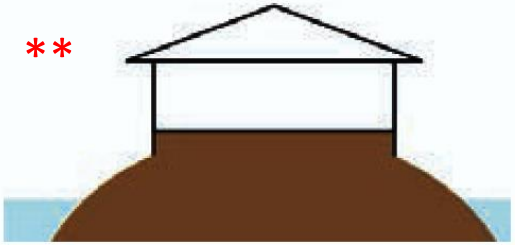


Wet Floodproofing

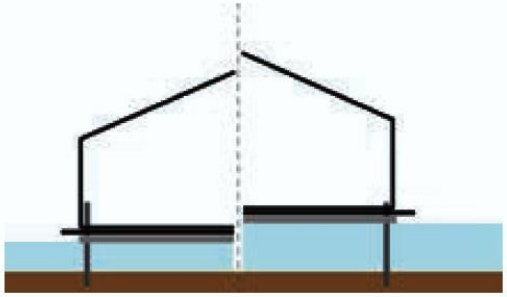


Site Protection

Building System Protection



Elevate on Fill or Mound



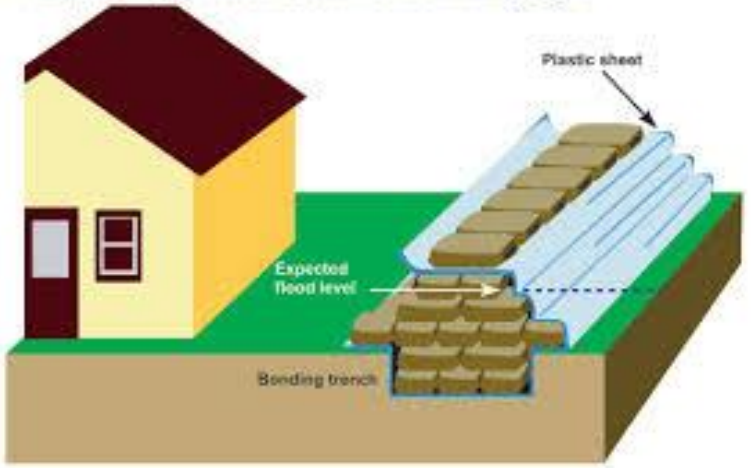
Floating Structures

**Require pumping systems in basement

Dry Floodproofing

FEMA does not allow for residential structures

Floodproofing – cross-section of a sandbag dyke



Dry Floodproofed building in HafenCity, Hamburg, Germany

From:NYC, Urban Waterfront Adaptive Strategies, June 2013

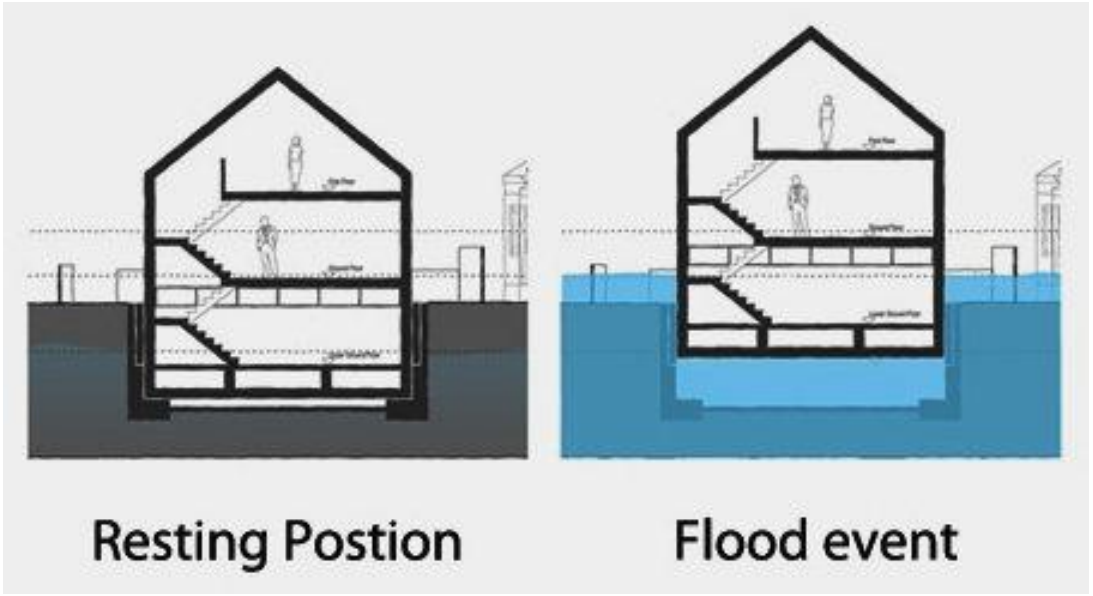
Wet Floodproofing

Elevate Structure

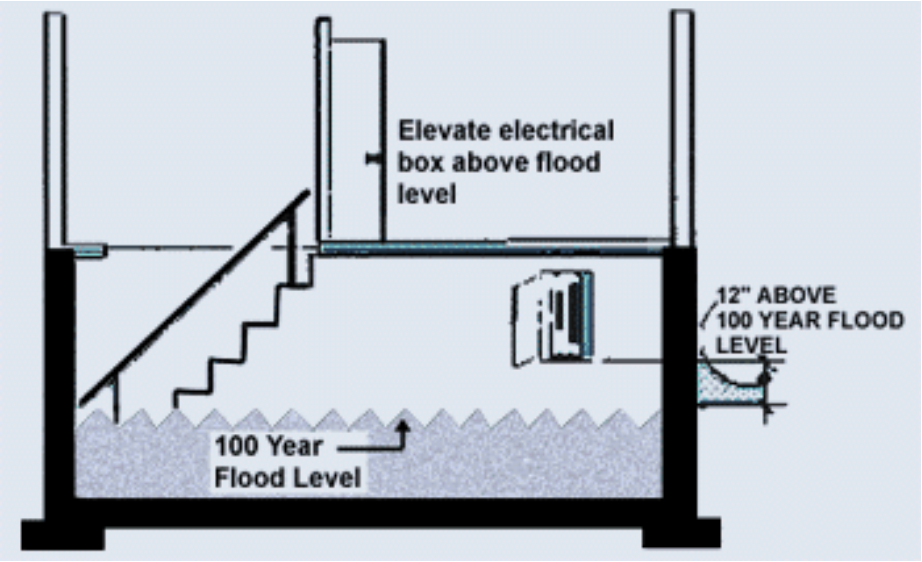
Site Protection

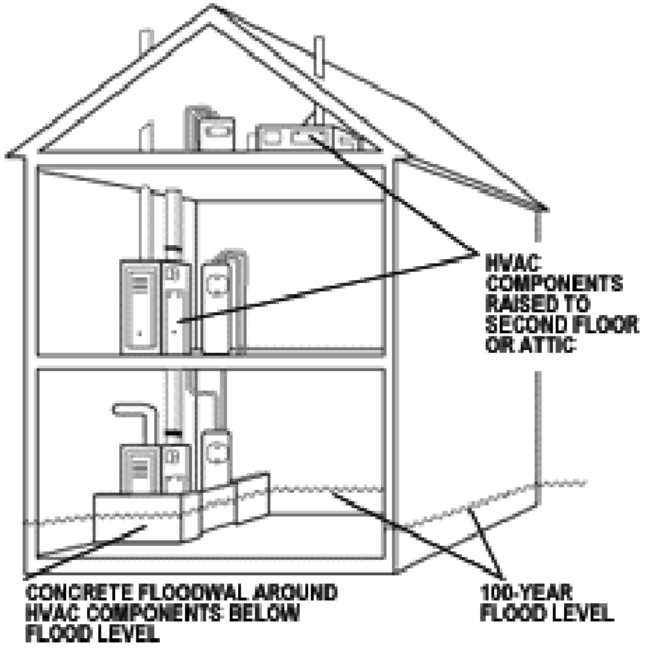
Floating Structures

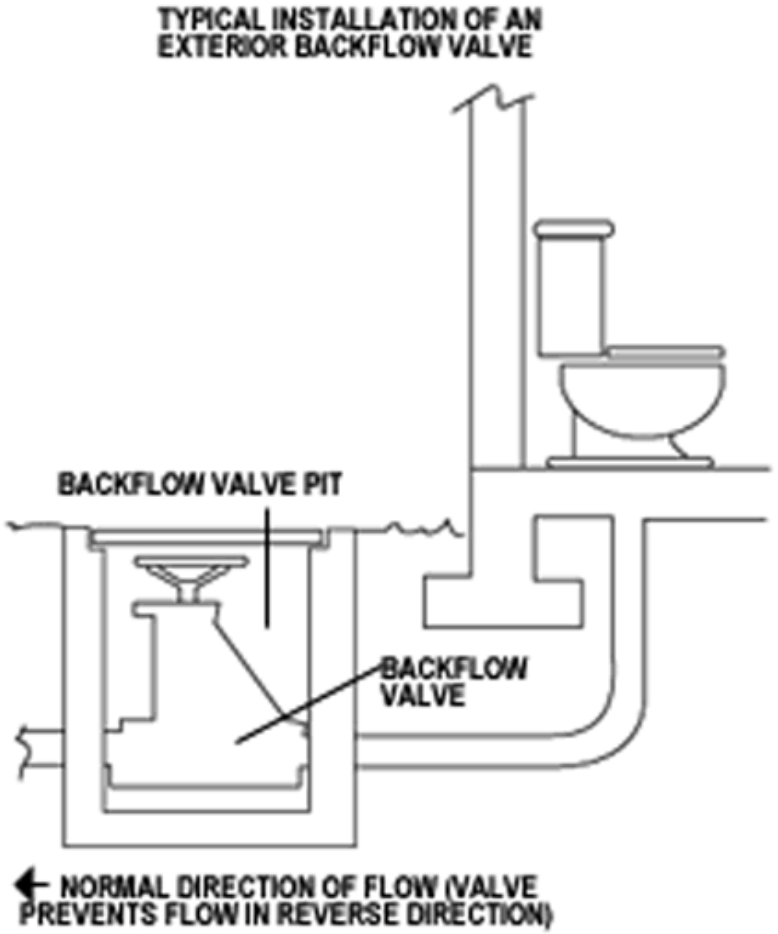
Amphibious Structure



Building System Protection







Possible Next Steps

-Review of Social, Economic &, Environmental Consequences

-More detailed flood modeling

-More Adaptation Options

Example Economic Consequences

-Building damages from Depth-Damage Curves

-Regional consequences using regional modeling such as IMPLAN

-Benefit-Cost Analysis using damages avoided by an adaptation strategy as the benefit (generally very high B:C ratios)

Example Social Consequences

-Flooding by social group

-Isolated neighborhoods

-Loss of Emergency Services

Example Environmental Consequences

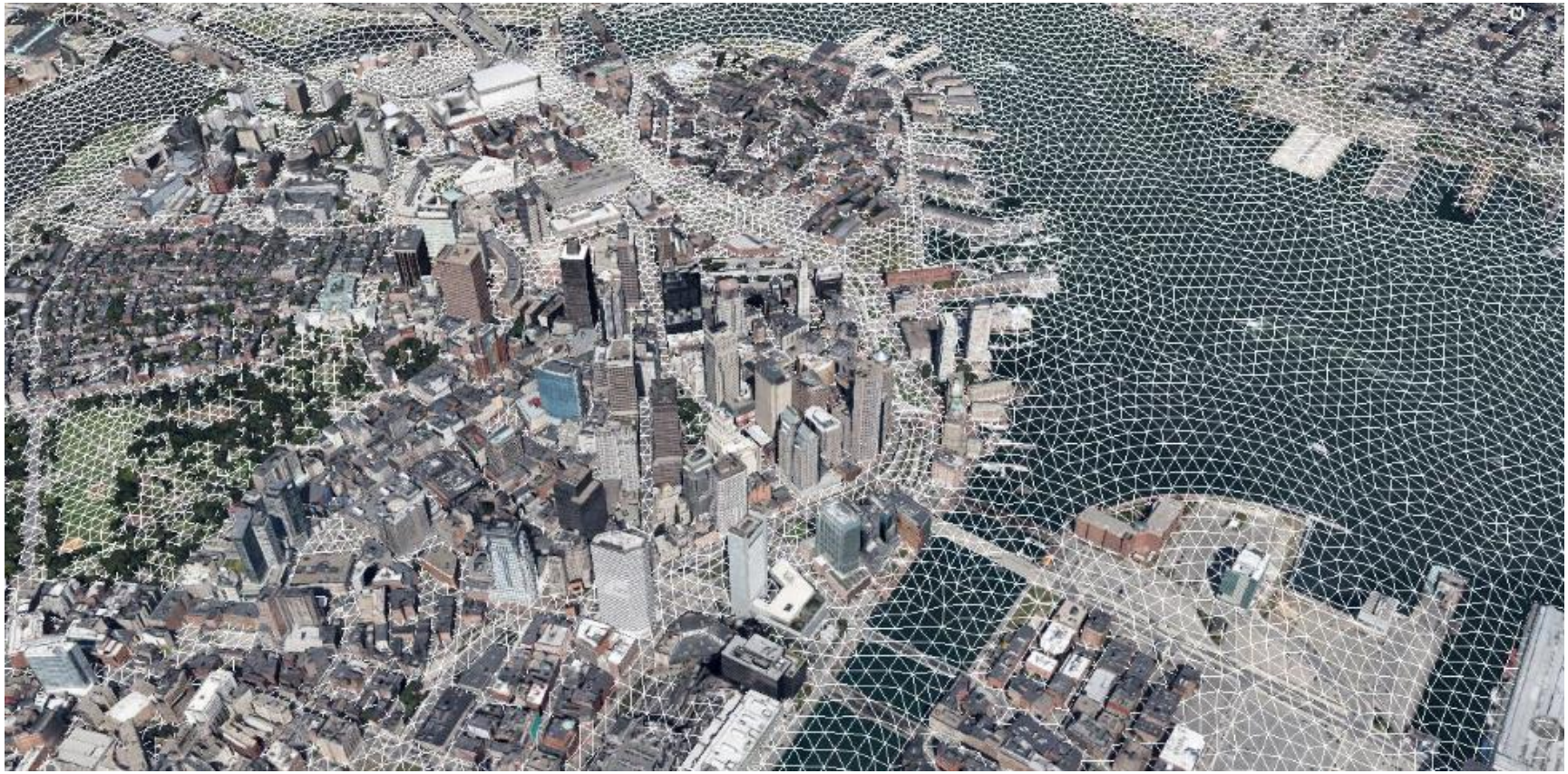
-Loss of habitant

-Erosion

-Open Space Loss

-Wetland Loss

Fine Scale, Dynamic Flood Modeling of Metro Boston



Generation and Evaluation of Adaptation Options

- Trial and Error (Top-Down, Bottom-Up)
- Guided Search such as Robust Decision Making
- Optimization Modeling (multi-stage stochastic linear programming, Real Options, etc)

Scaling Up

Joint Effects of Storm Surge and Sea-level Rise on US Coasts: New economic estimates of impacts, adaptation, and benefits of mitigation policy,
James E. Neumann$_1$, Kerry Emanuel$_2$, Sai Ravela$_2$, Lindsay Ludwig$_1$, Paul Kirshen$_3$, Kirk Bosma$_4$, and Jeremy Martinich$_5$

World Bank Report on The Costs to Developing Countries of Adapting to Climate Change, New Methods and Estimates, The Global Report of the Economics of Adaptation to Climate Change Study, September 2009

Risky Business

More

Global Infrastructure Databases ?

Climate Change and Environmental Justice: Case Study of Boston MA

Ellen Douglas, UMass-Boston, ellen.douglas@umb.edu
Paul Kirshen, Battelle, kirshenp@battelle.org

Also Michael Paolisso, Chris Watson, Jack Wiggin, Allen Gontz, Matthias Ruth, Ashley Enrici, Scott Goodwin

Funded by NOAA Sectoral Applications Research Program (SARP)

Results

First workshop, East Boston, March 9 2009

- 25 participants
- Good diversity of age and ethnicity
- Sequential Spanish/English presentation
- Used free listing method as a way to learn participants' cultural model.

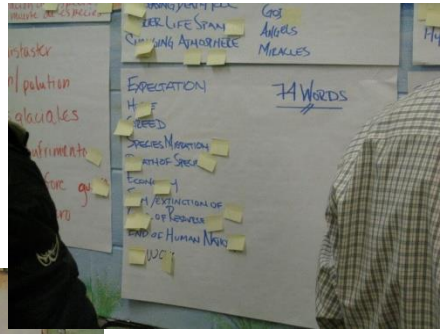
  →word association

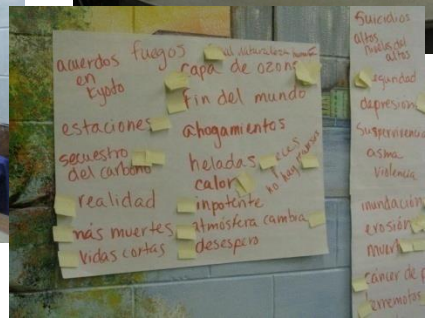
  →rank to determine 50 top words

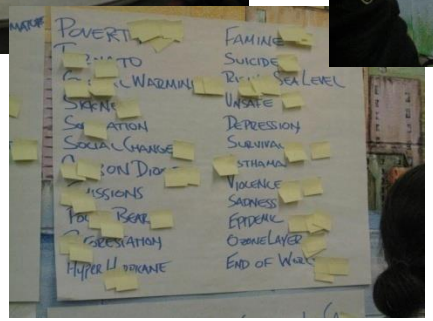
  →participant pile sorting

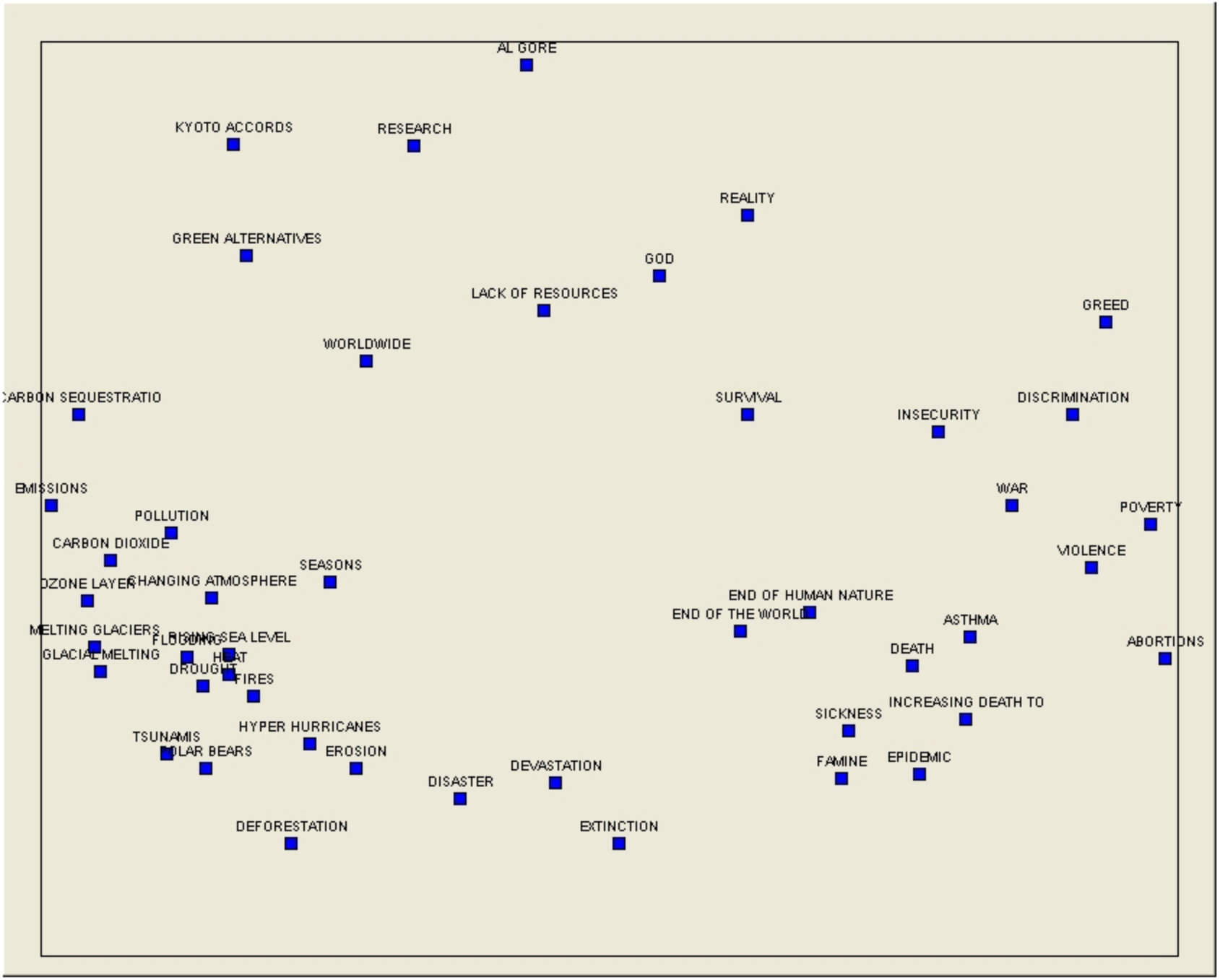
  →discuss reasons behind piles

East Boston Workshop








AL GORE
KYOTO ACCORDS
RESEARCH
REALITY
GREEN ALTERNATIVES
GOD
LACK OF RESOURCES
GREED
WORLDWIDE
CARBON SEQUESTRATIO
SURVIVAL
DISCRIMINATION
INSECURITY
EMISSIONS
WAR
POVERTY
POLLUTION
CARBON DIOXIDE
VIOLENCE
SEASONS
OZONE LAYER
CHANGING ATMOSPHERE
END OF HUMAN NATURE
END OF THE WORLD
ASTHMA
MELTING GLACIERS
RISING SEA LEVEL
FLOODING
ABORTIONS
GLACIAL MELTING
DEATH
HEAT
DROUGHT
FIRES
INCREASING DEATH TO
SICKNESS
HYPER HURRICANES
TSUNAMIS
EROSION
POLAR BEARS
FAMINE
EPIDEMIC
DEVASTATION
DISASTER
DEFORESTATION
EXTINCTION

Adaptation to Climate Change

- Do Nothing
- Accommodate
- Protect
- Retreat

Some Adaptation Obstacles

Sea walls are generally unattractive and block views

Elevation of some buildings would be unattractive and difficult because many buildings are attached to each other. In addition, since many rented their residents, they would not be able to carry out these options

Evacuation is a concern because of the resulting traffic jams, the costs of staying outside of residents for any period of time, most residents not having cars, and a significant number of disabled and elderly people

Permanent retreat is not seen as an option because of desires of residents to remain close to family and friends and general difficulty of obtaining low priced housing; “permanent moving should not be on the table… People in East Boston have a real identity and roots… there needs to be a better plan for staying here”

Need to coordinate flood protection from multiple sources

Dealing with the local municipal bureaucracy is very difficult.

Some Incentives

They have a very broad ranging view of climate change impacts They do not appear to be climate change naysayers.

They are committed to their communities, out of choice and also a lack of other housing options; they don't want to leave.

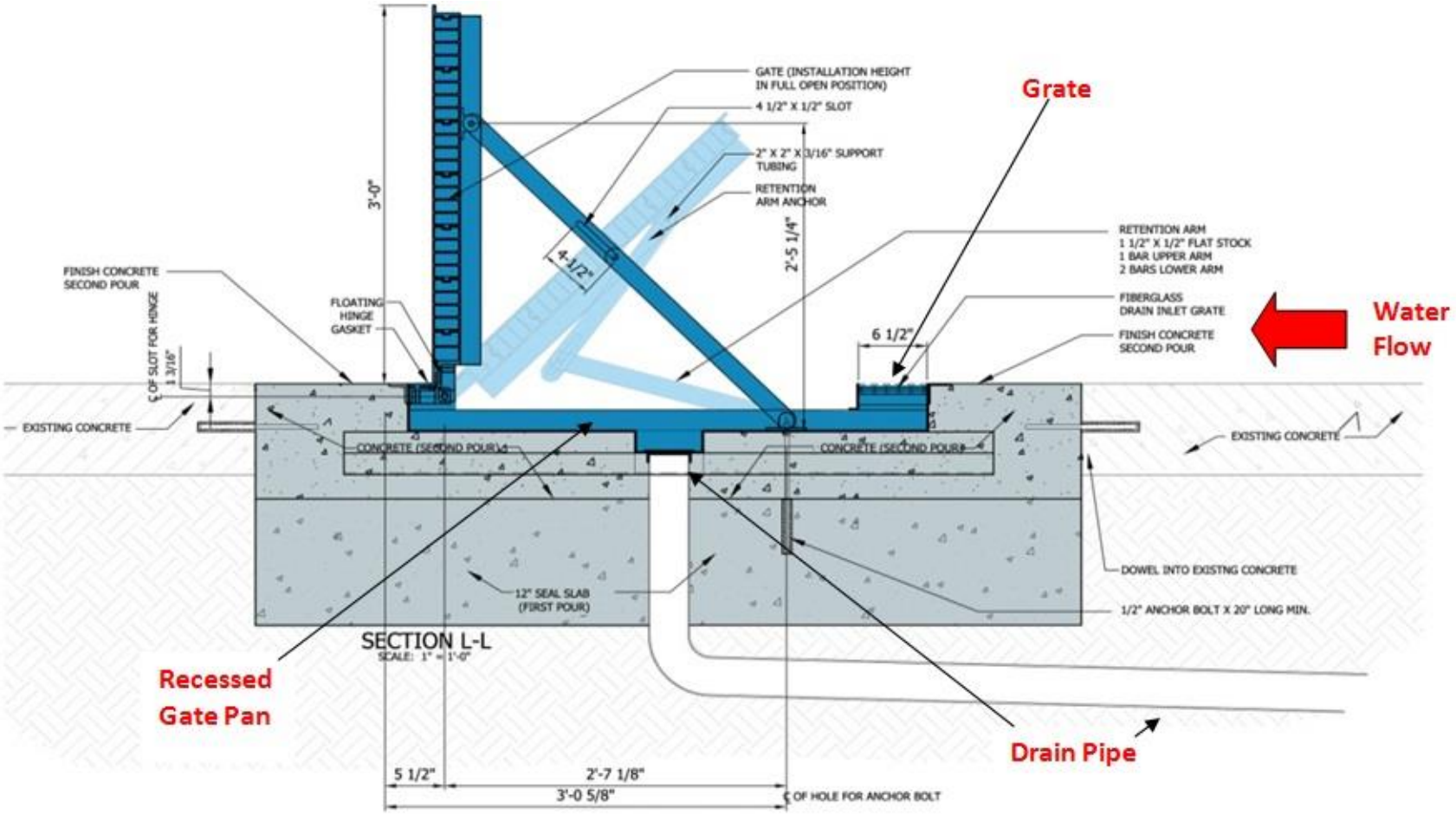
Participants prefer options that enhance their present environment and will not require evacuation or permanently leaving the area.

At the end of the process they were eager to continue learning about climate change and recognized that there is the need for an integrated regional flood management strategy.

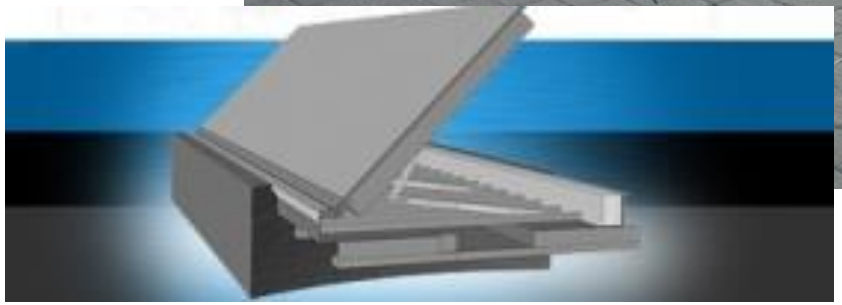
The participants stated stakeholder driven solutions are necessary, and are eager to engage any available institutions and resources to take action; they seemed less powerless than during the first workshop.

Types of Architecturally Blended Flood Gates and Walls

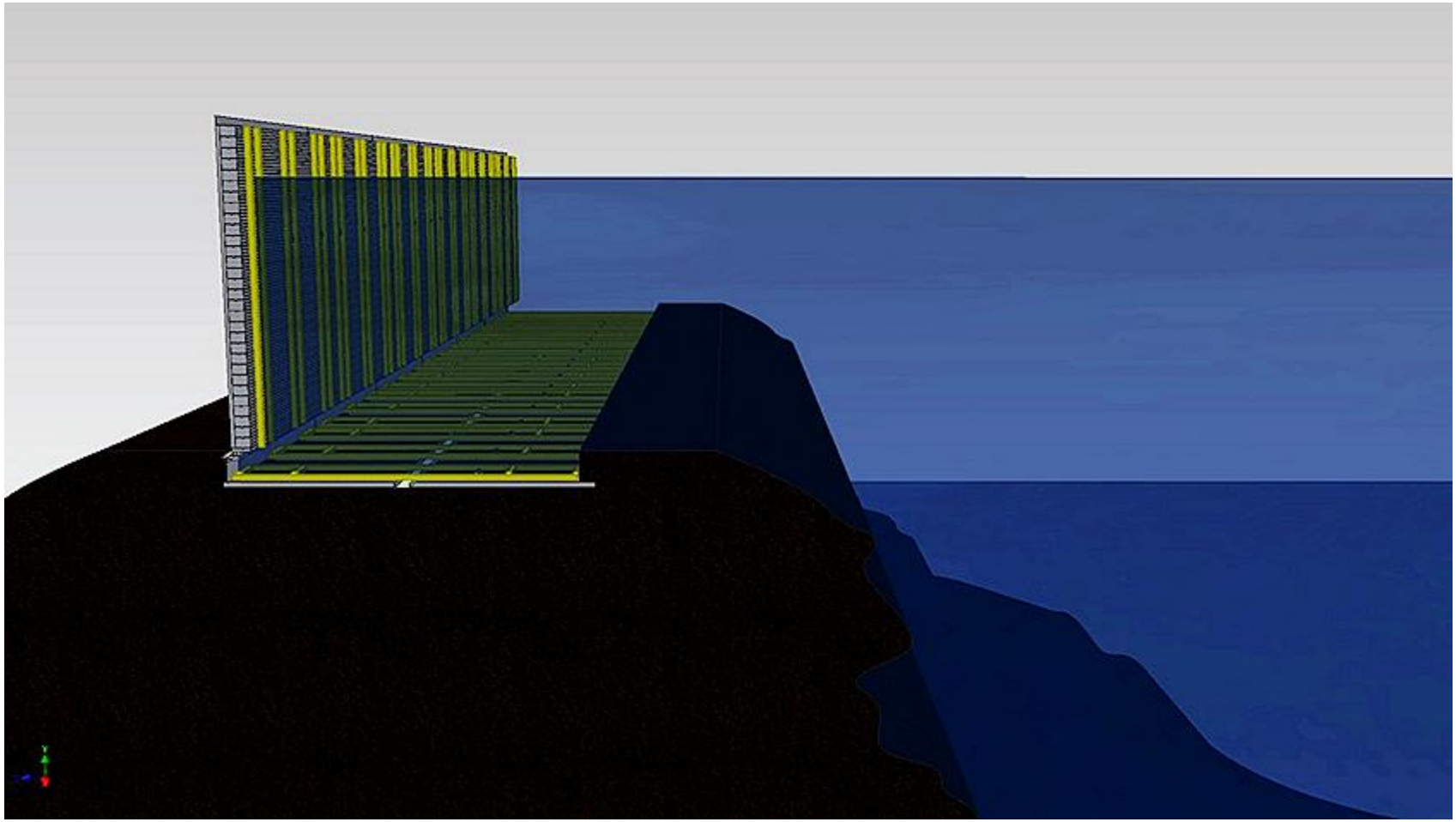
FloodBreak Passive System



Raisable Gate at Driveway



Raise Existing Levees or Floodwalls



Gates Between Walls

Multipurposing

Landscaped Wall

Landscaped Wall

Design Event Can Be Exceeded

Failed Levee

All systems have a failure point, and there is an event that will fail the structures

Landscaped Wall

Landscaped Wall

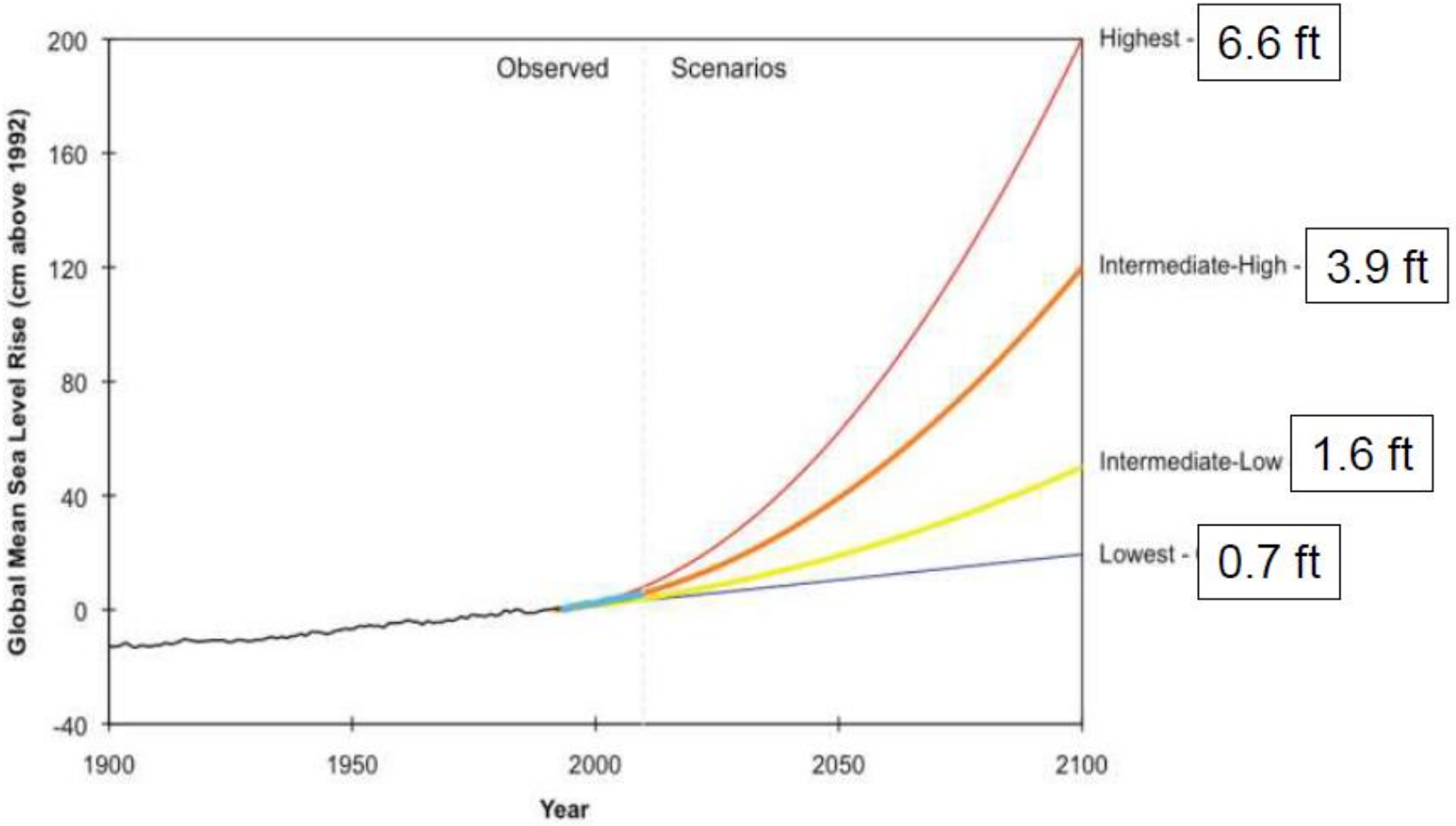
Design Event Can Be Exceeded

Failed Levee

All systems have a failure point, and there is an event that will fail the structures

East Boston Scenarios

The Most Recent SLR Projections



Global mean sea level rise scenarios provided by NOAA as part of the National Climate Assessment report published in December 2012.

Landscaped Wall

Landscaped Wall

Design Event Can Be Exceeded

Failed Levee

All systems have a failure point, and there is an event that will fail the structures


N
Legend
20 ft
10 ft
0 >= Elev < 20 ft NAVD
< 0 ft
600
Feet

Individual Blocks

Flood Log

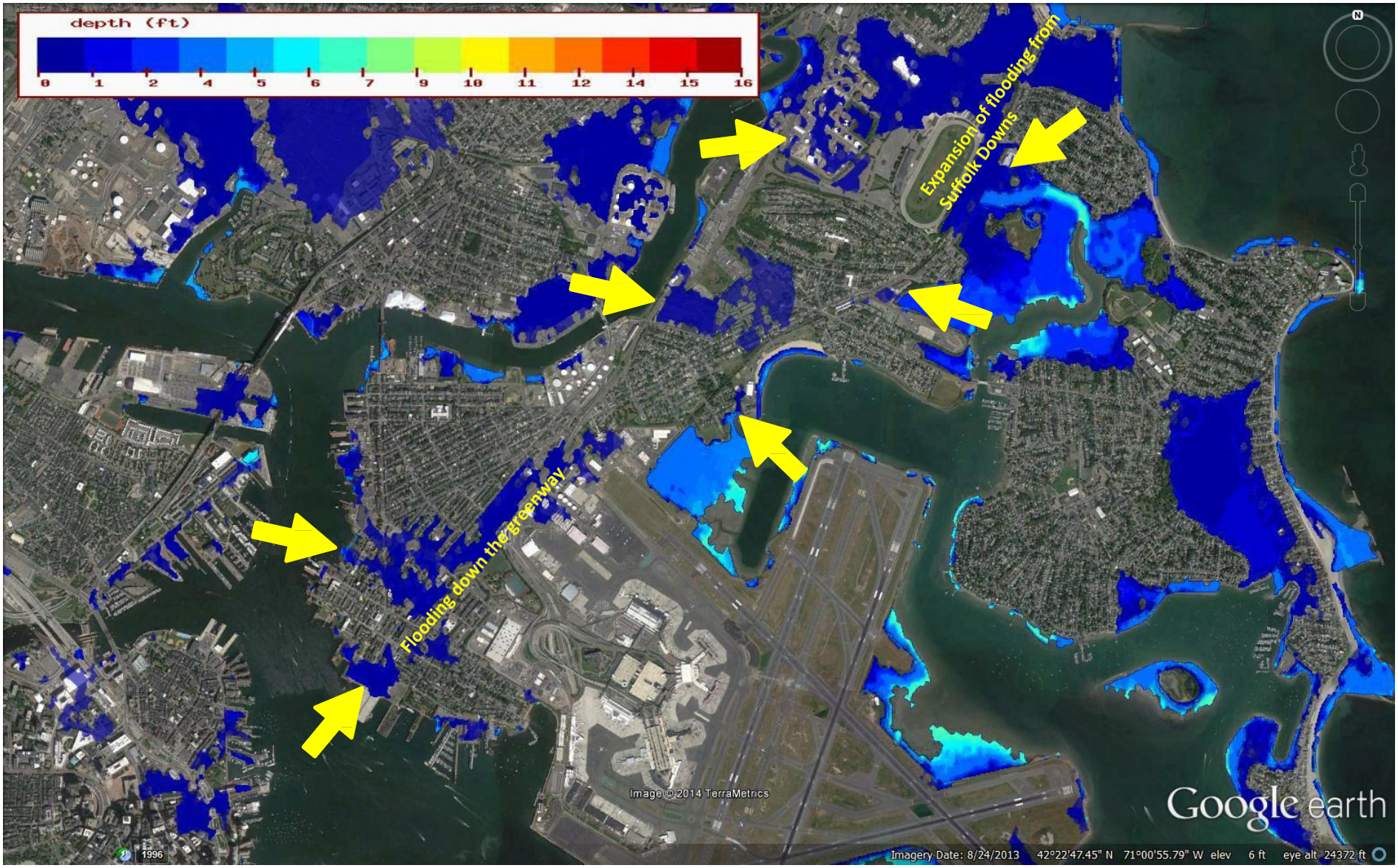
Belle Isle Marsh

Frederick Park

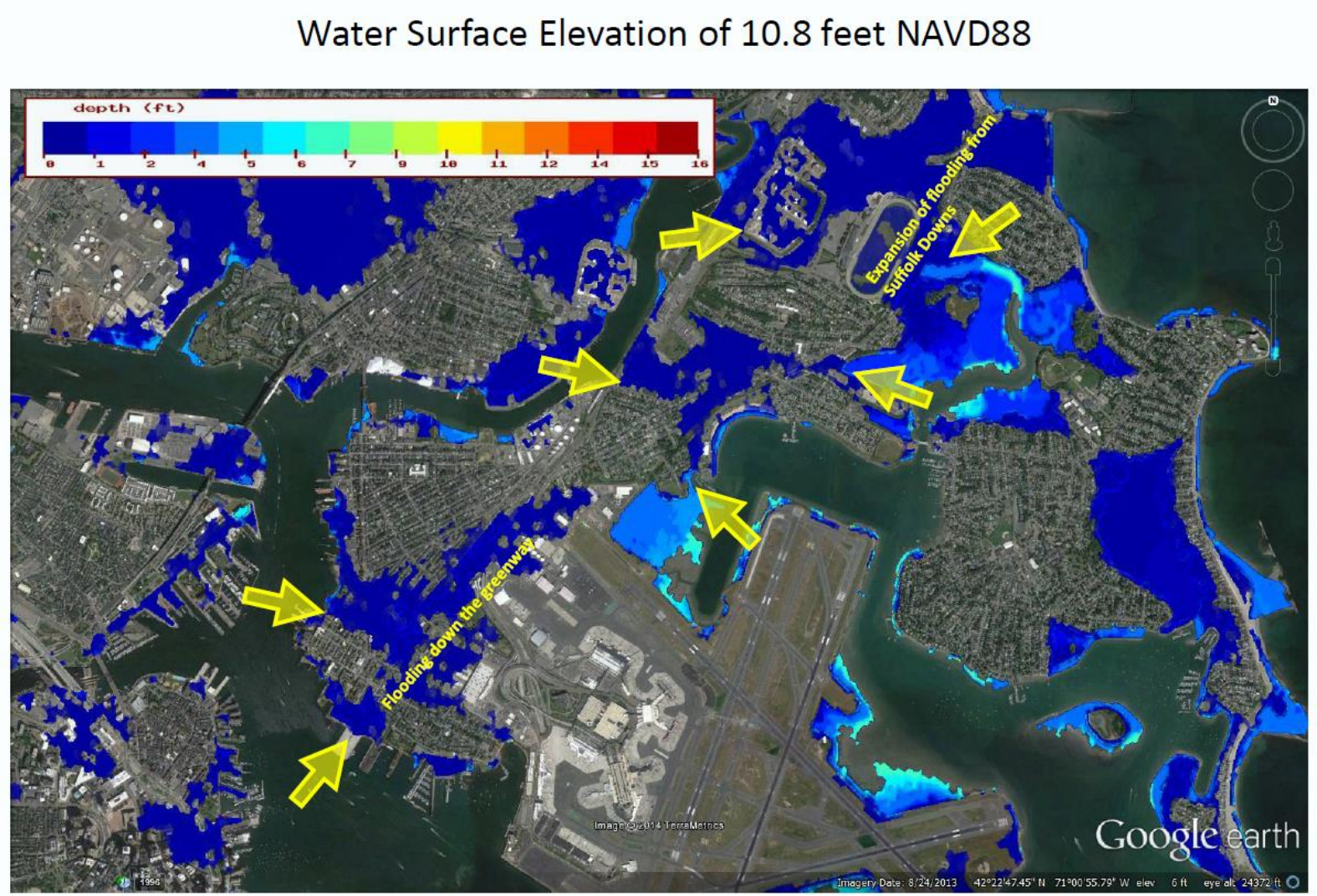

Regional Solution for 2100
Flood Wall
Temporary Road Barrier
Landscaped berm

Review of Flood Scenarios and Where Water Will Enter

100-year Water level Threat Today - Water Surface Elevation of 9.8 feet NAVD88

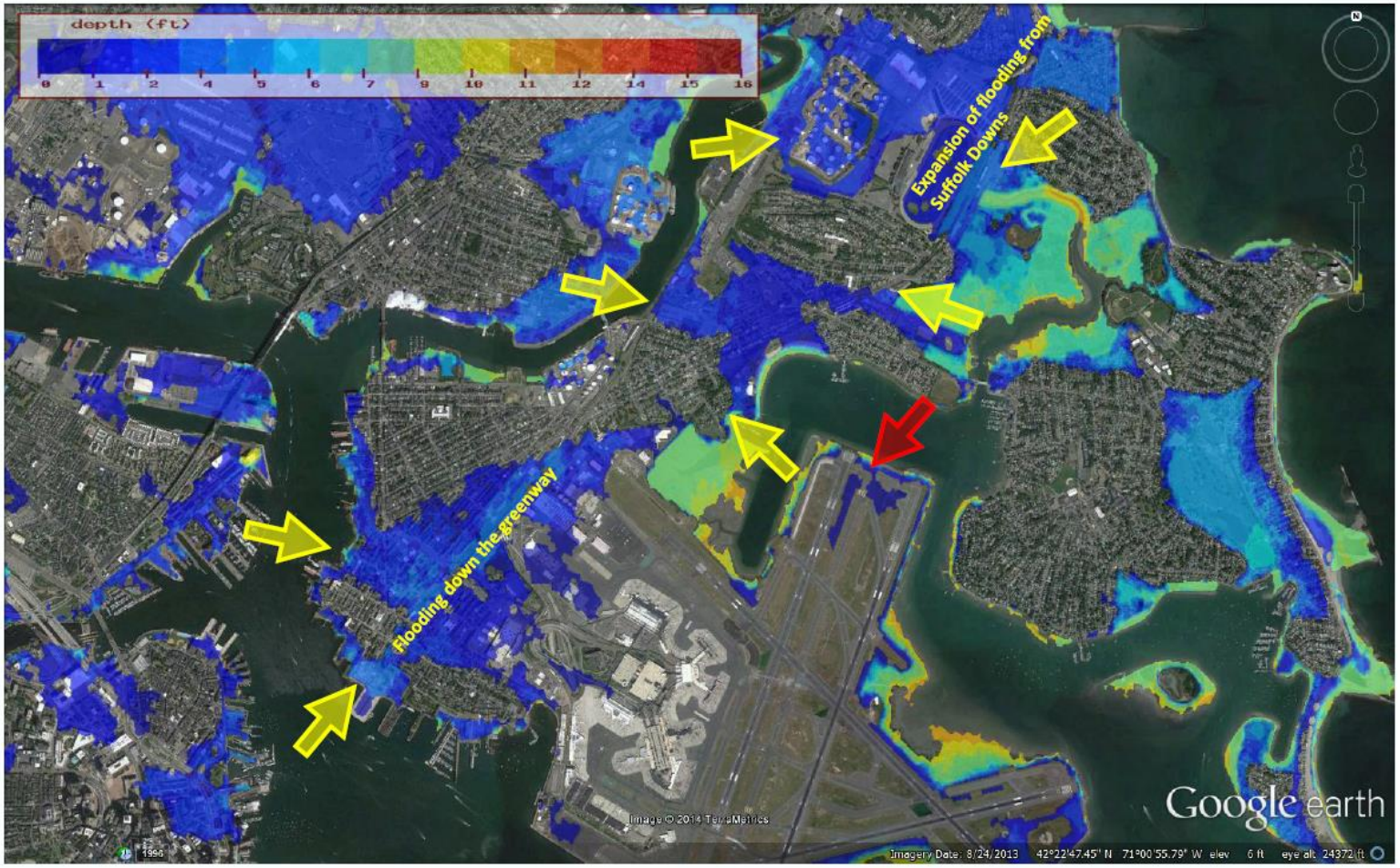


Most Options could be Raised One foot to Protect to this Elevation – 2020 - 2050



Could be 2050 to 2065
MHHW Plus Surge Flooding

Water Surface Elevation of 11.8 feet NAVD88



Could be 2065 to 2085 - Water Surface Elevation of 13.0 feet NAVD88