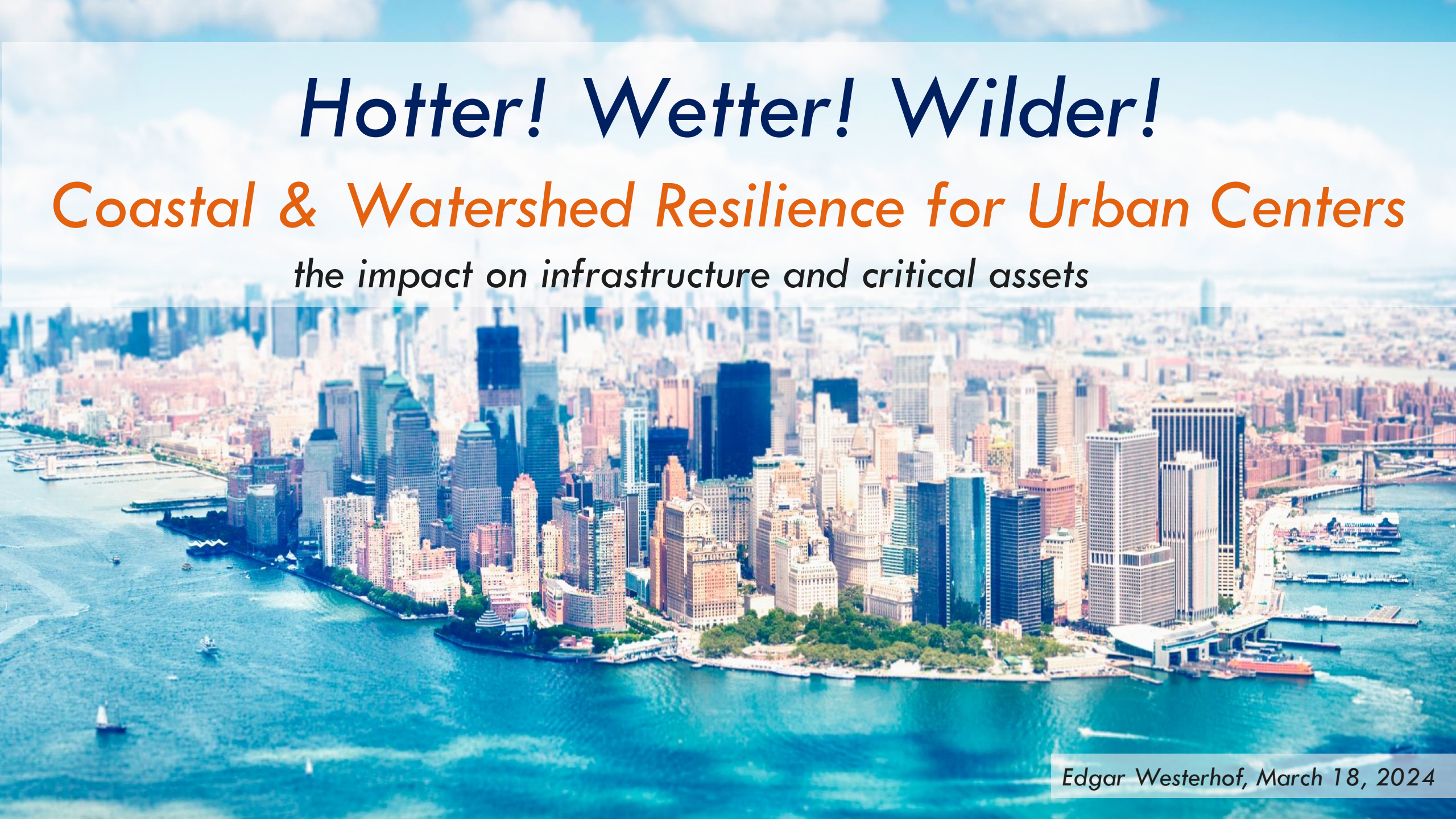
Hotter! Wetter! Wilder!

Coastal & Watershed Resilience for Urban Centers

the impact on infrastructure and critical assets



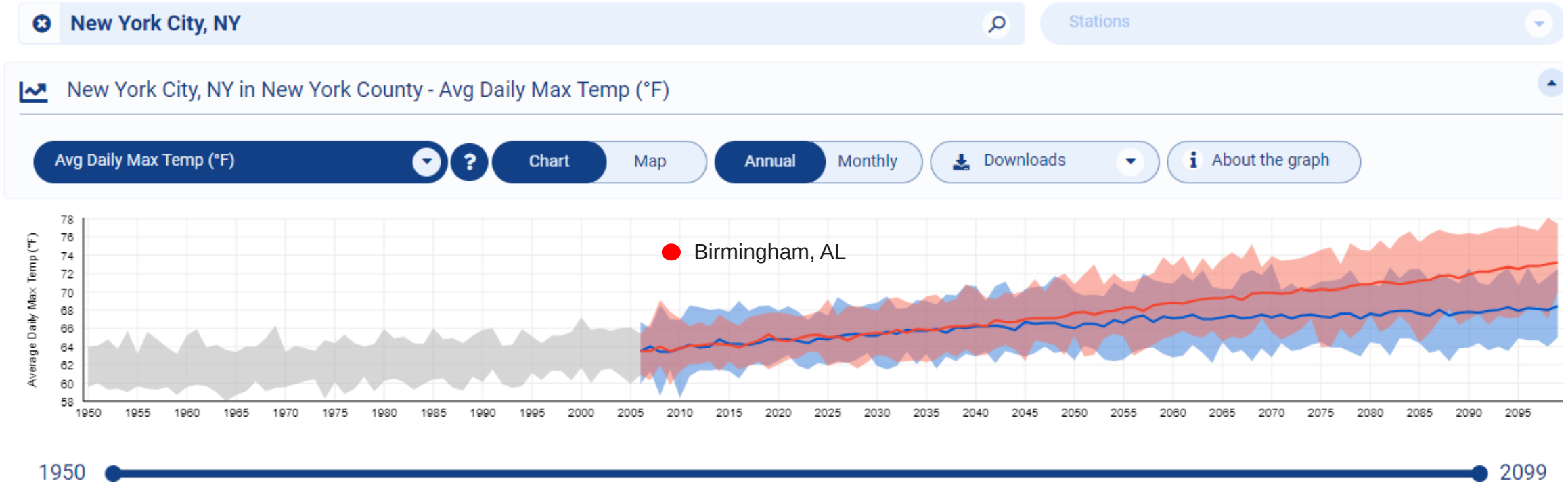
Edgar Westerhof, March 18, 2024


citi bike
citi bike
citi bike

Image Dutch Yachting

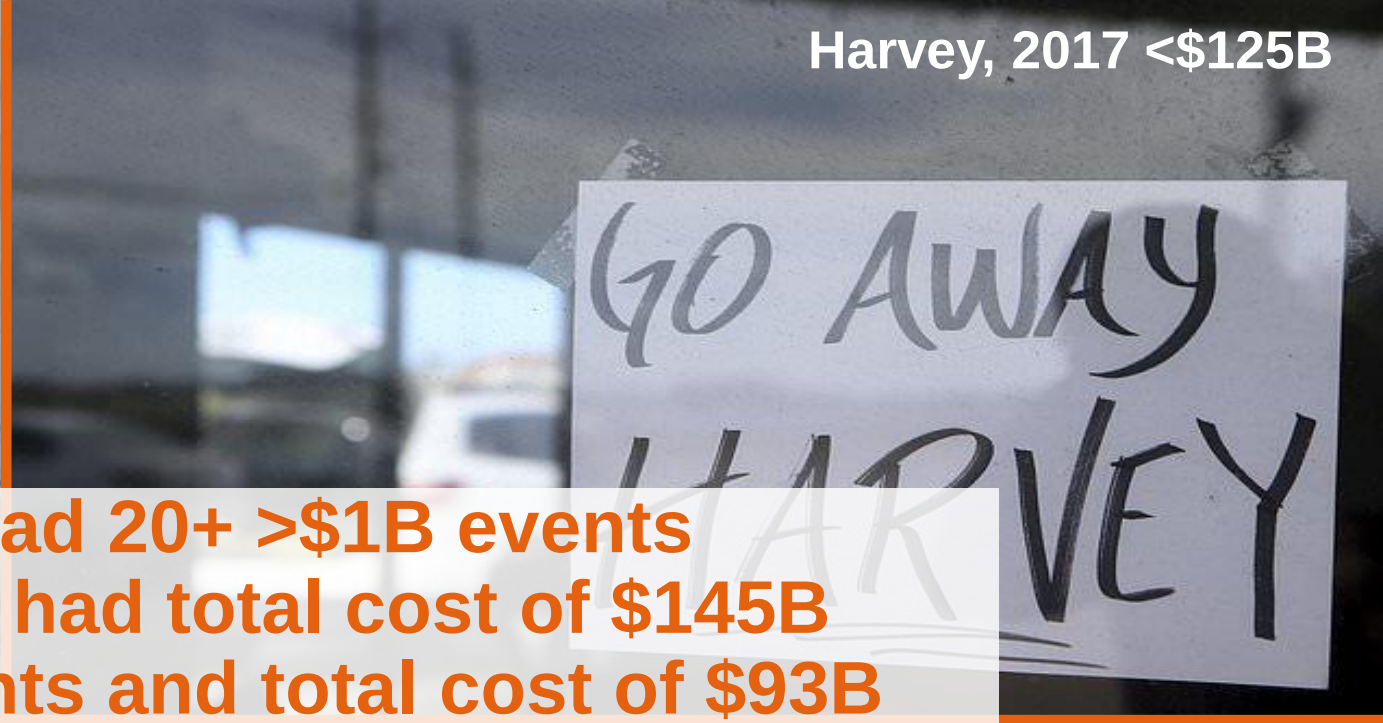

Winter Storm Grayson
Winter Storm Riley

Average temperatures are forecasted to steadily increase



Source: The Climate Explorer

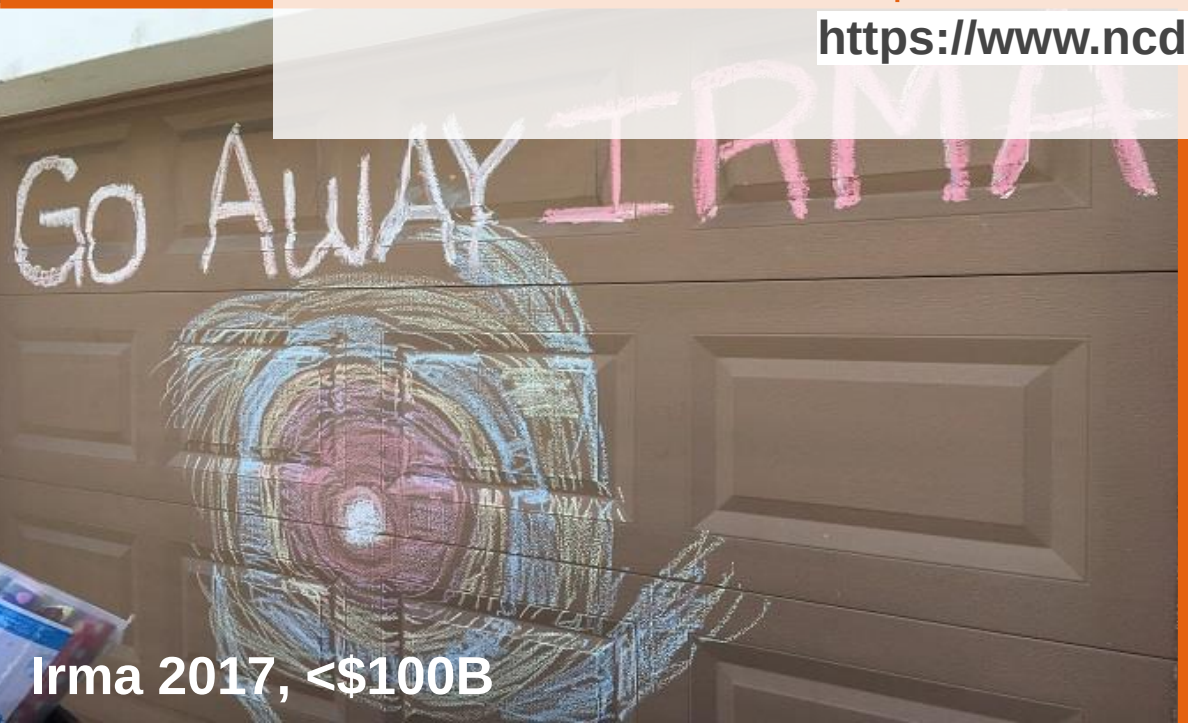
Katrina 2005, <$250B



Harvey, 2017 <$125B

The US in 2020 had 20+ >$1B events
2021 weather events had total cost of $145B
2023 had 28 >$1b events and total cost of $93B

https://www.ncdc.noaa.gov/billions/



Irma 2017, <$100B

Sandy 2012, <$60B

Agenda

1. Setting the Stage
2. Global Best Practices, Lessons Learned & Innovations in Flood Protection
2. US Case Studies: New York City, Houston, San Francisco

A Systems Approach to Water Management in the Netherlands

Image Sources: Rijkswaterstaat, City of Rotterdam

Coastal Protection

Multifunctional urban resilience solutions combining shoreline extension and community resources

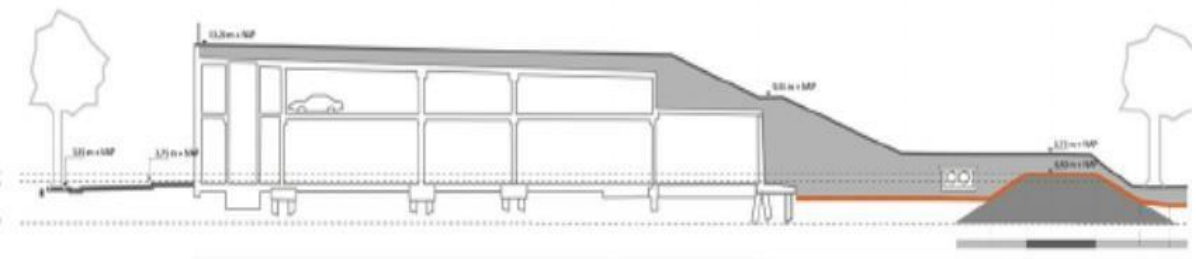



Image Credit City of Katwijk

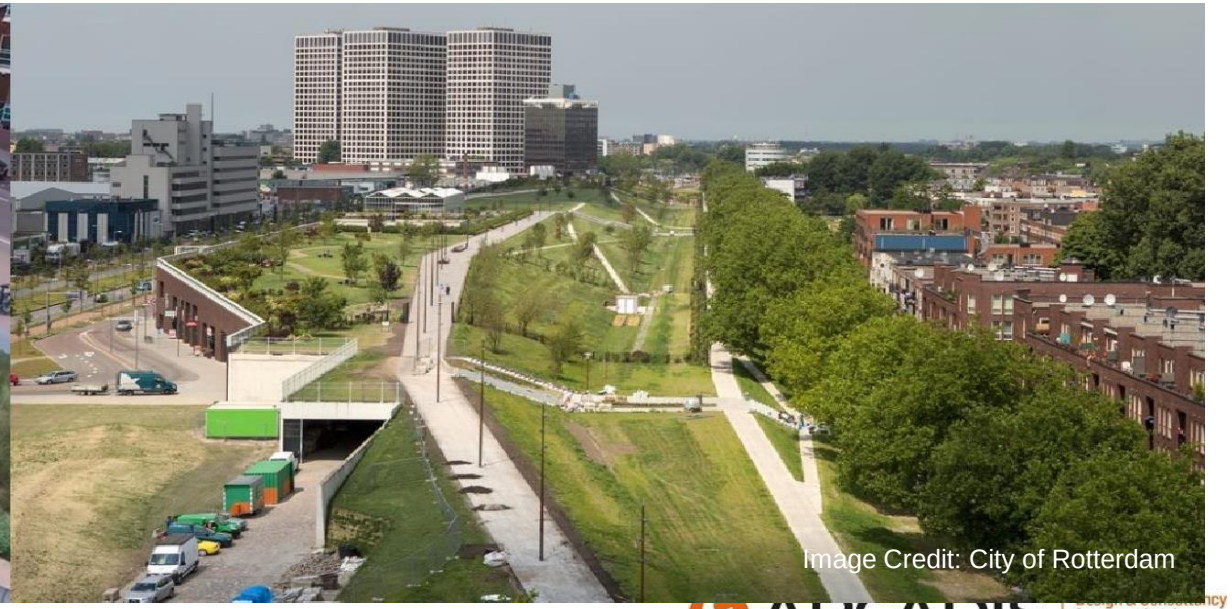


Image Credit: City of Rotterdam

Dutch Storm Surge Barriers

Image Credit: Rijkswaterstaat

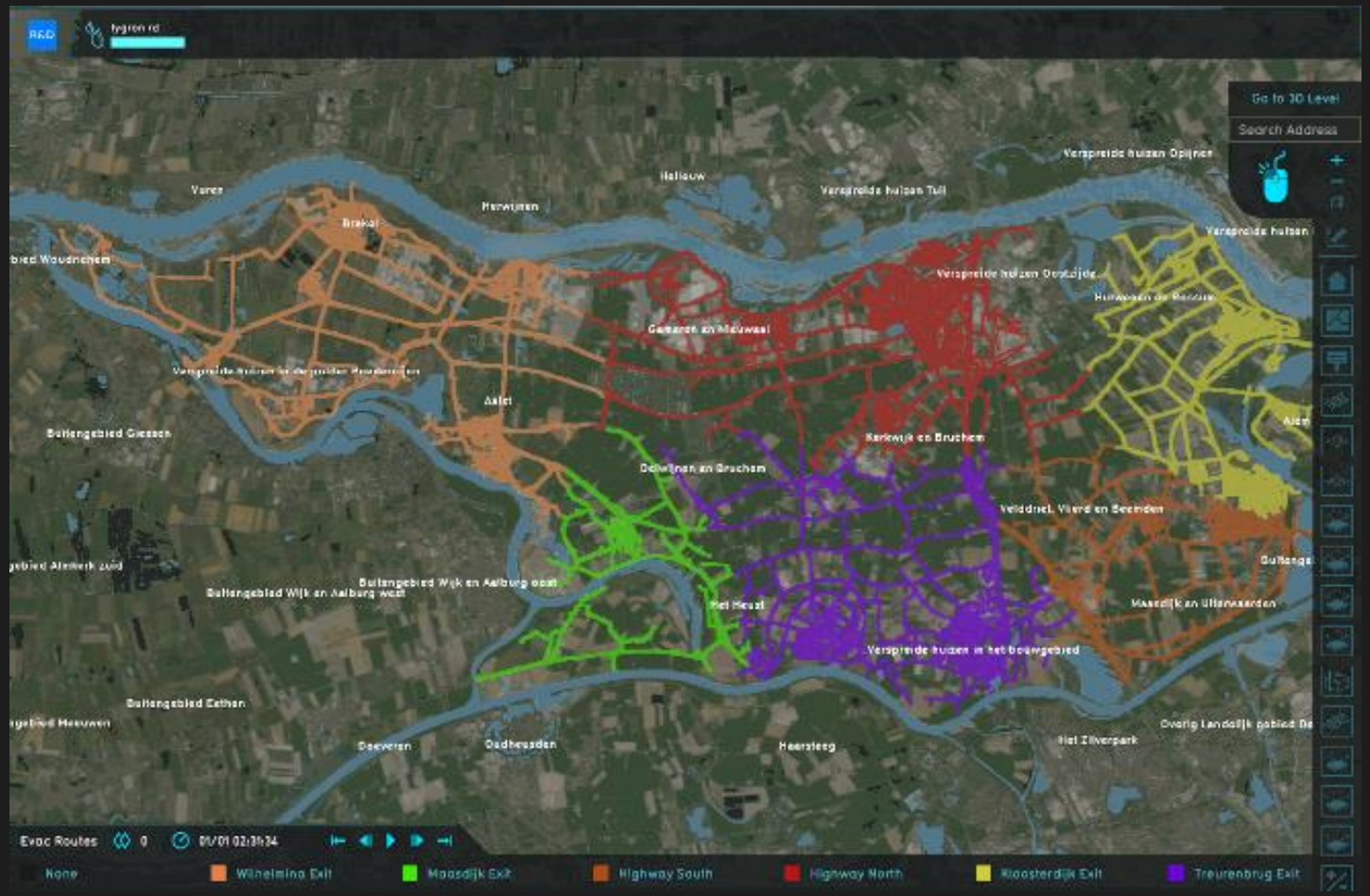
Room for the River – Managed Overflow of River Floodplain

- National authority invested 350 million Euro's in a blue green bypass of the River Waal.
- Based upon reducing flood risk and to avoid future socio-economic losses.
- Nijmegen city used took this momentum to fullfill city's ambition; the river being in the center of its city.
- Investment: national taxes, based upon macroeconomics.

Advanced Analytics

The Tygron digital twin hydro-software can handle additional layers, such as those listed below. The video shows a demonstration of the road access functionality in the Netherlands.

- Damage and casualties
- Evacuation
  - Accessibility
  - Evacuation time
- Cascade effects during flood events
  - Road access
  - Electricity and communications



NEW YORK CITY

COASTAL AND URBAN CLIMATE ADAPTATION PERSPECTIVES

Depth of Inundation for
100 Year Event with 2050
90th Percentile SLR (feet)

- 0 - 2
- 2.1 - 4
- 4.1 - 6
- 6.1 - 8
- 8.1 - 10
- 10.1 - 12
- 12.1 - 14
- 14.1 - 16
- 16.1 - 18
- > 18

West Street
Canal Street
Broadway
FDR Drive
Pearl Street
FDR Drive
Brooklyn Bridge
Manhattan Bridge

CAPACITY BUILDING GROUNDED IN SCIENCE

Understanding Current and Future Risk - Sea Level Rise & High Tides

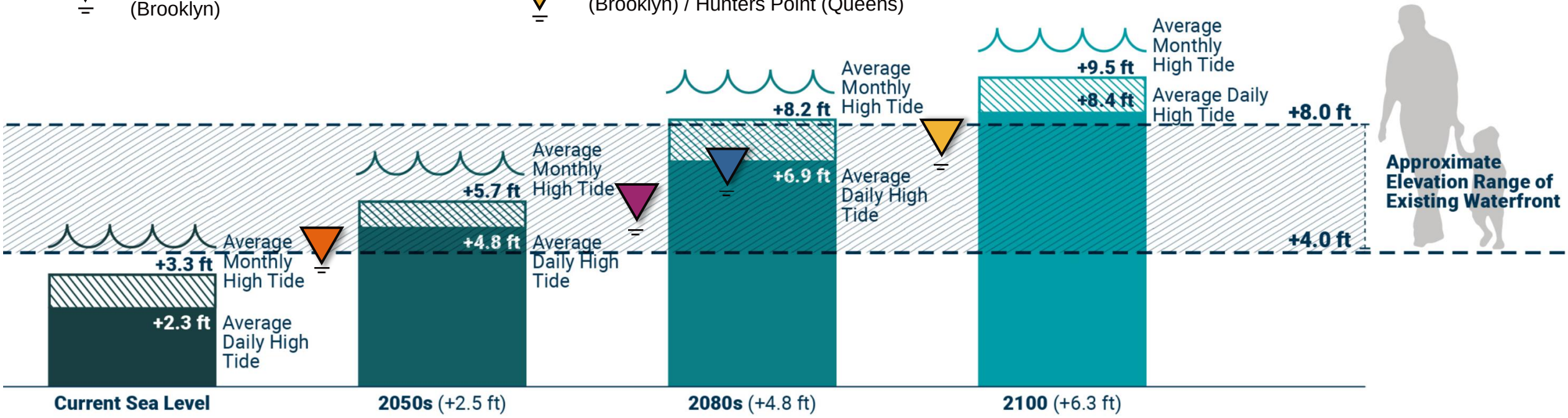
High tide flooding is anticipated to cause up to four feet of flooding by 2100s, the same height as storm surge from Hurricane Sandy in this area.

Arverne & Edgemere (Rockaways) / Hamilton Beach (South Queens)

Brooklyn Navy Yard / Red Hook / Gowanus (Brooklyn) / Chelsea Waterfront (Manhattan) / New Dorp Beach (Staten Island) / Breezy Point (Queens)

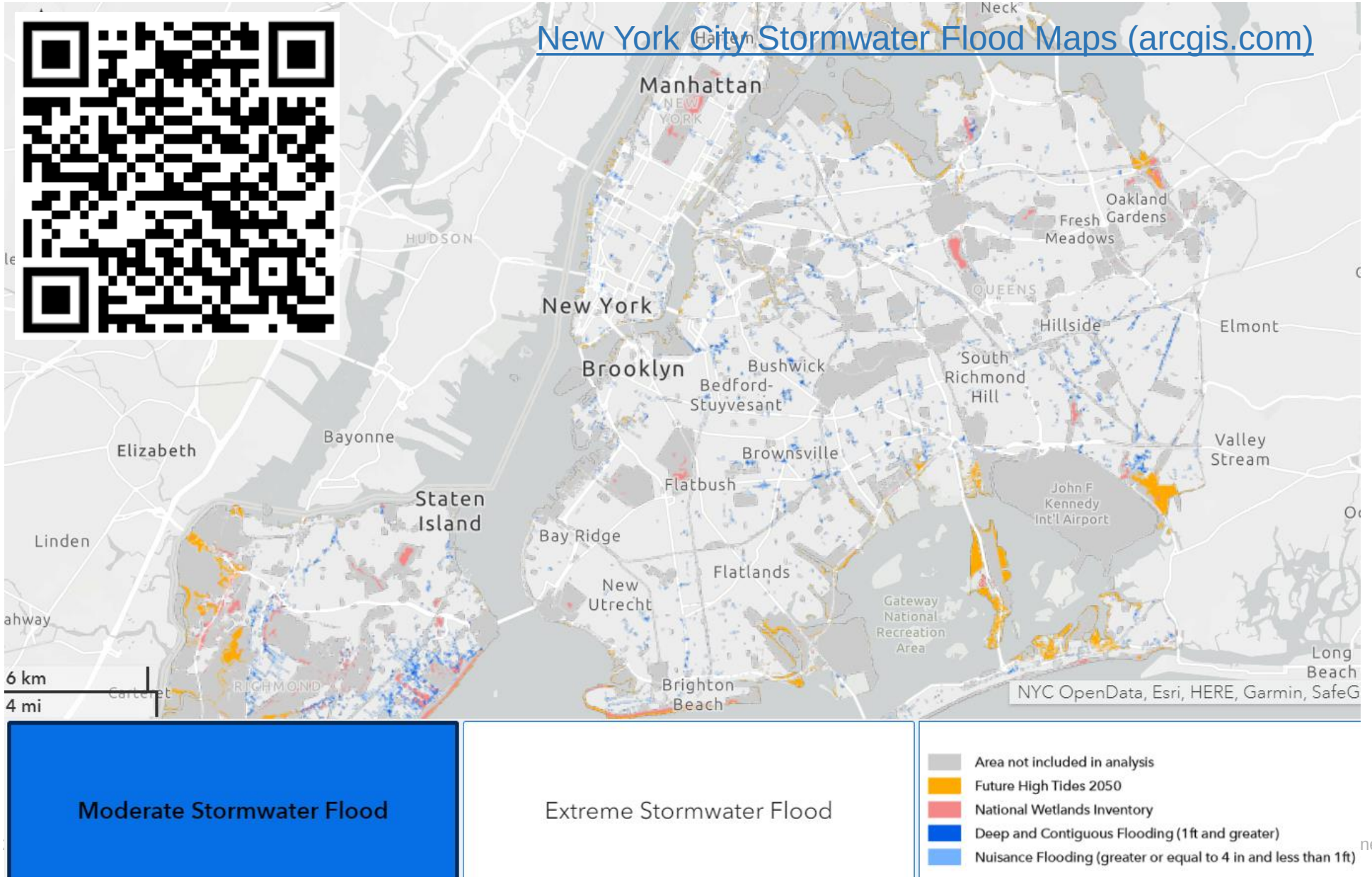
Coney Island & Manhattan Beach (Brooklyn)

Hunts Point & Mott Haven (Bronx) / Sunset Park (Brooklyn) / Hunters Point (Queens)

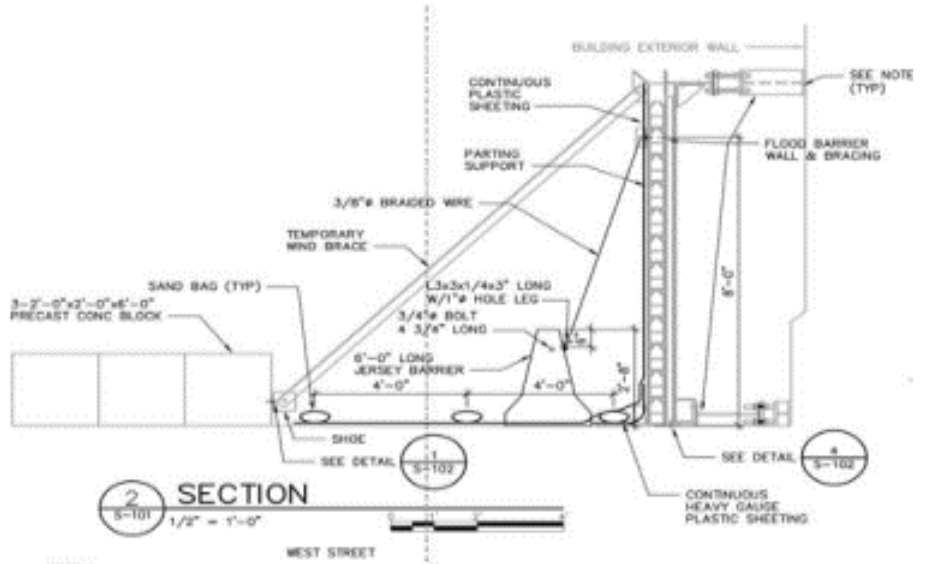


Extreme Precipitation

New York City Stormwater Flood Maps (arcgis.com)



Protection of Critical Assets

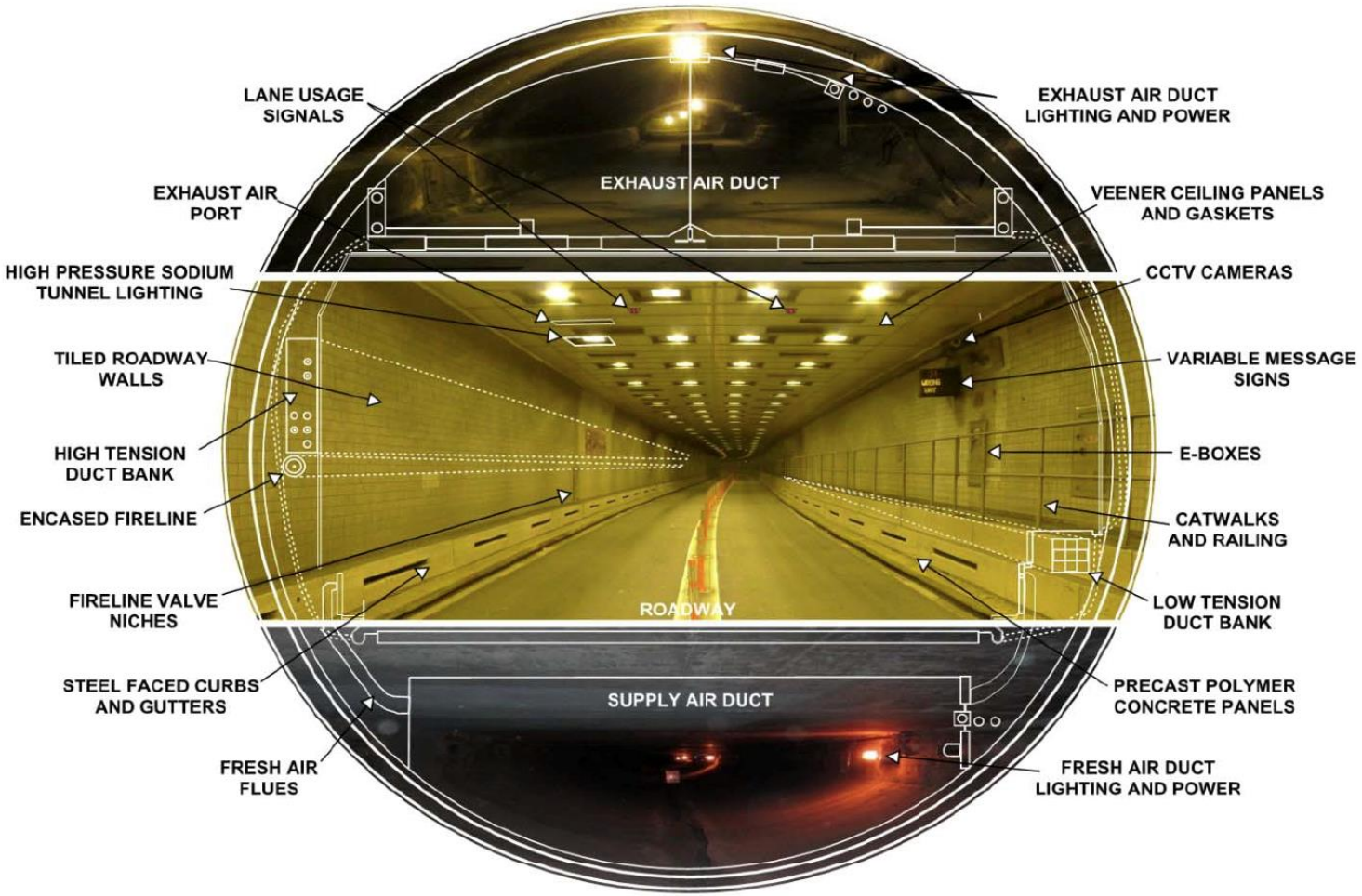


Full Perimeter Protection Of Landmark Buildings | Design, Permitting, Construction & Testing

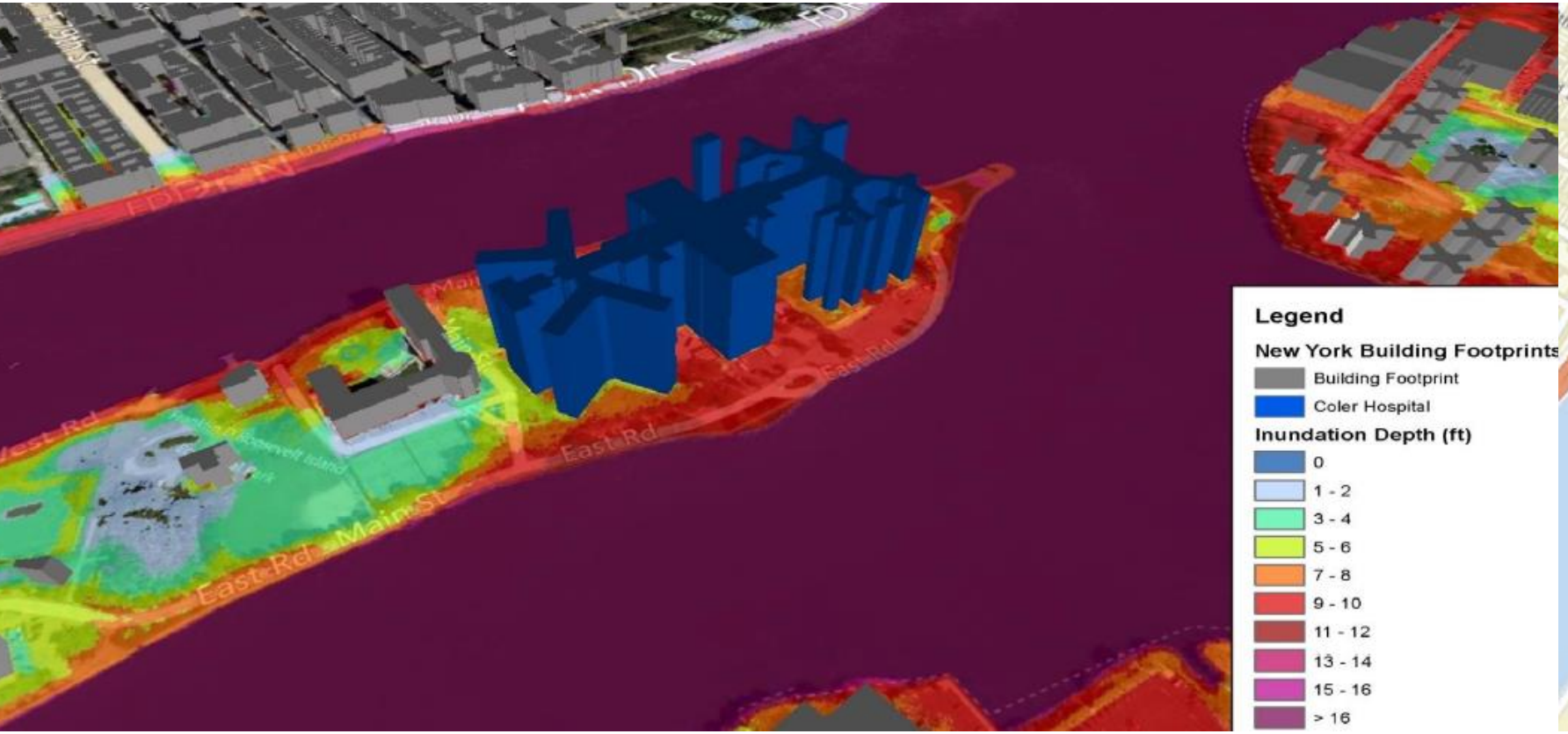
Protecting Critical Connections

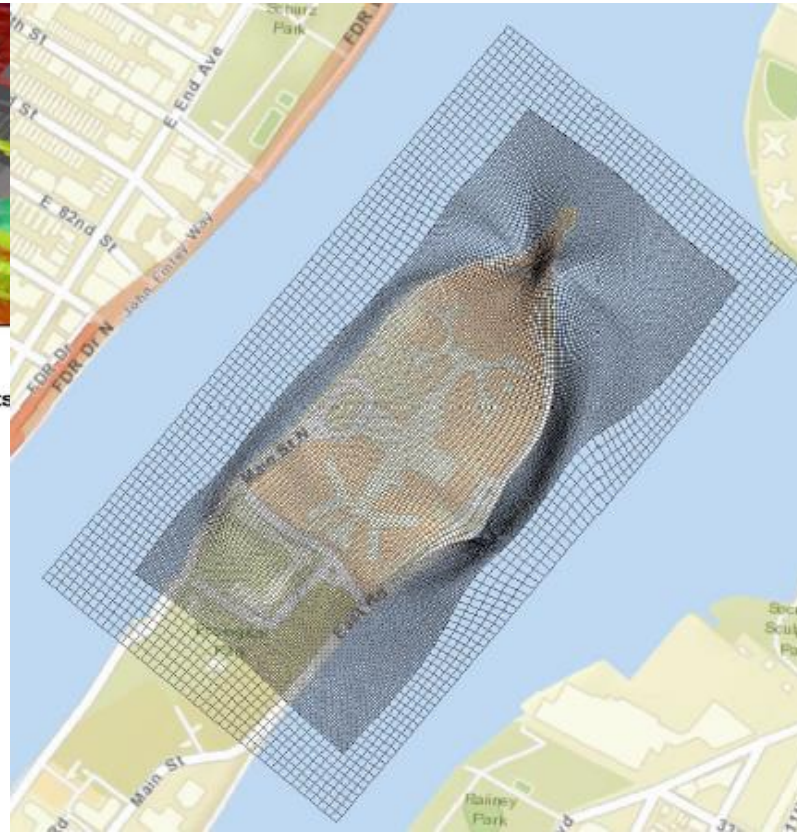
Brooklyn Battery Tunnel

Tunnel Elements and Systems Affected by Sandy

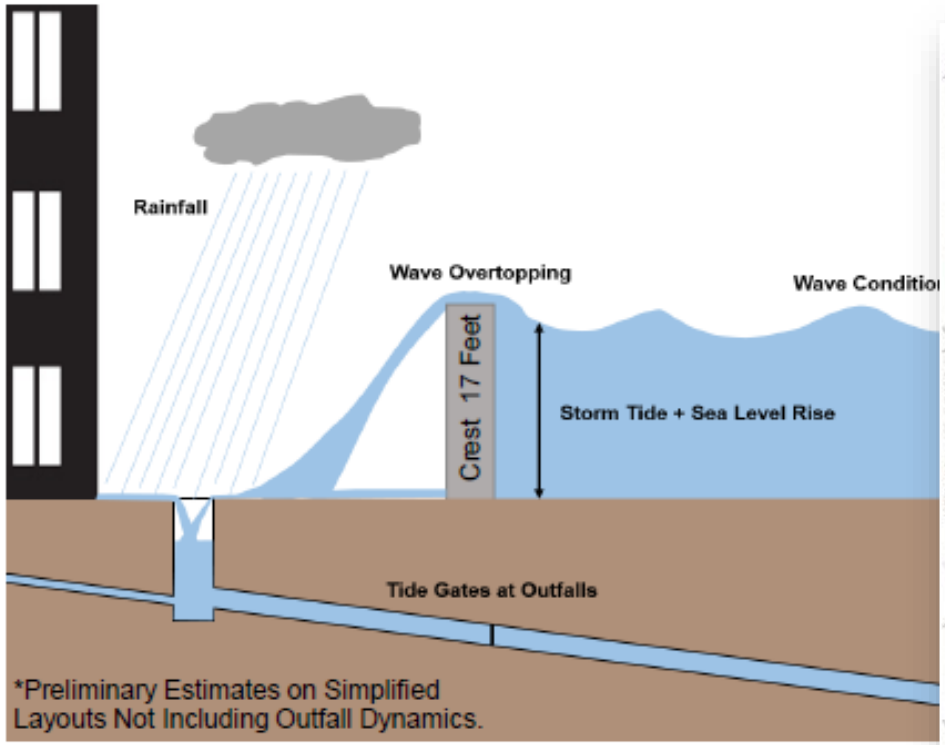


Protecting Critical Assets
Coler Hospital, Roosevelt Island

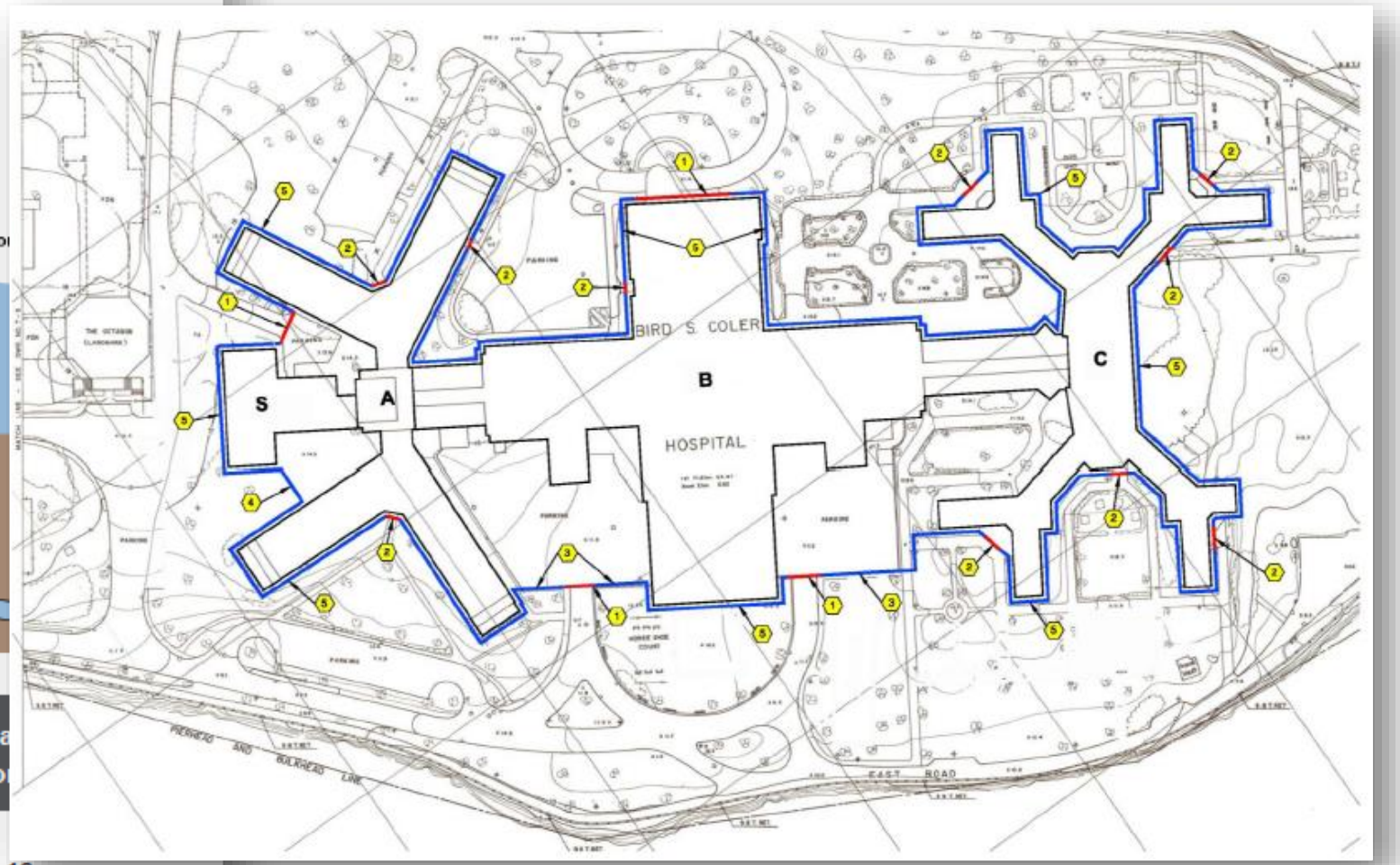




Protecting Critical Assets
Coler Hospital, Roosevelt Island



Sea Level	Interior Ponding * (Feet NAVD88)	Volume Mana Feet * (Millio
Current-Day	10.5	
2080s 10th	12.0	12
2080s 50th	16.0	32



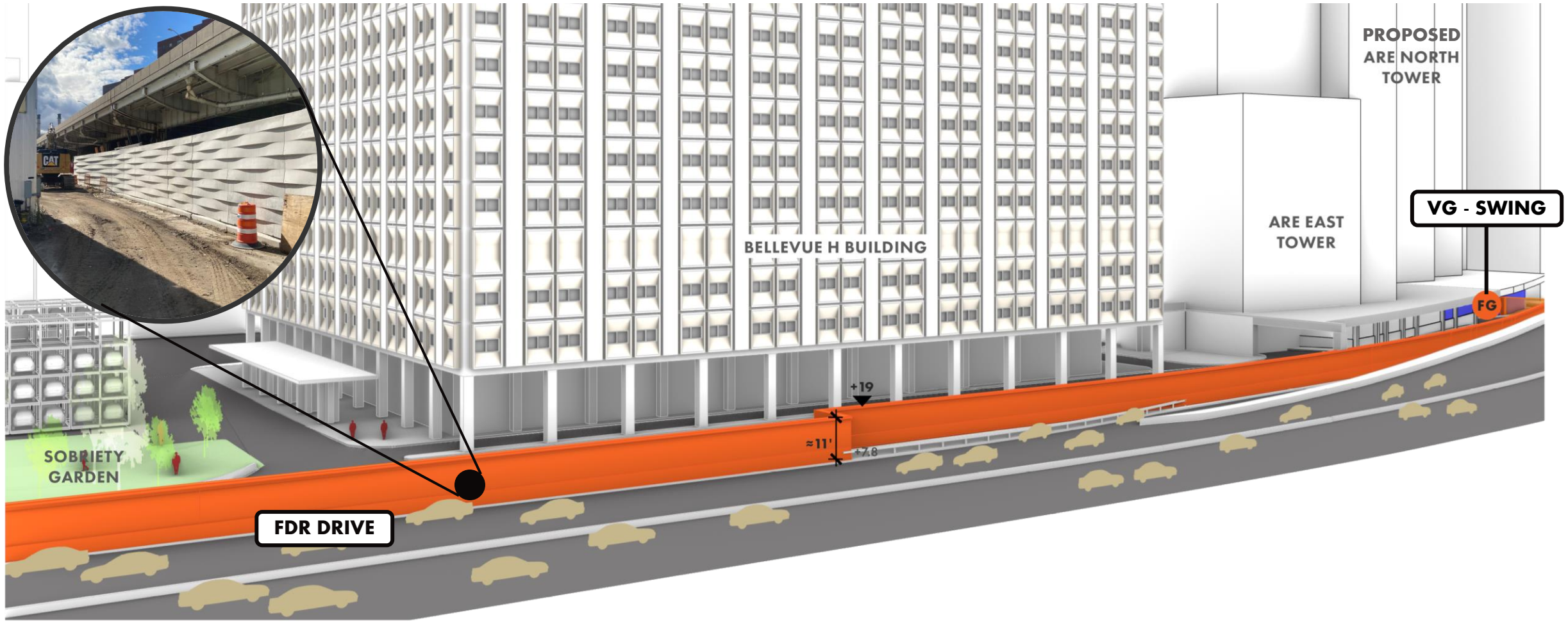
Coler Hospital: FEMA Hazard Mitigation Plan

Protecting Critical Assets

Coler Hospital, Roosevelt Island

Bellevue Hospital

Bellevue Hospital Floodwall Visualization



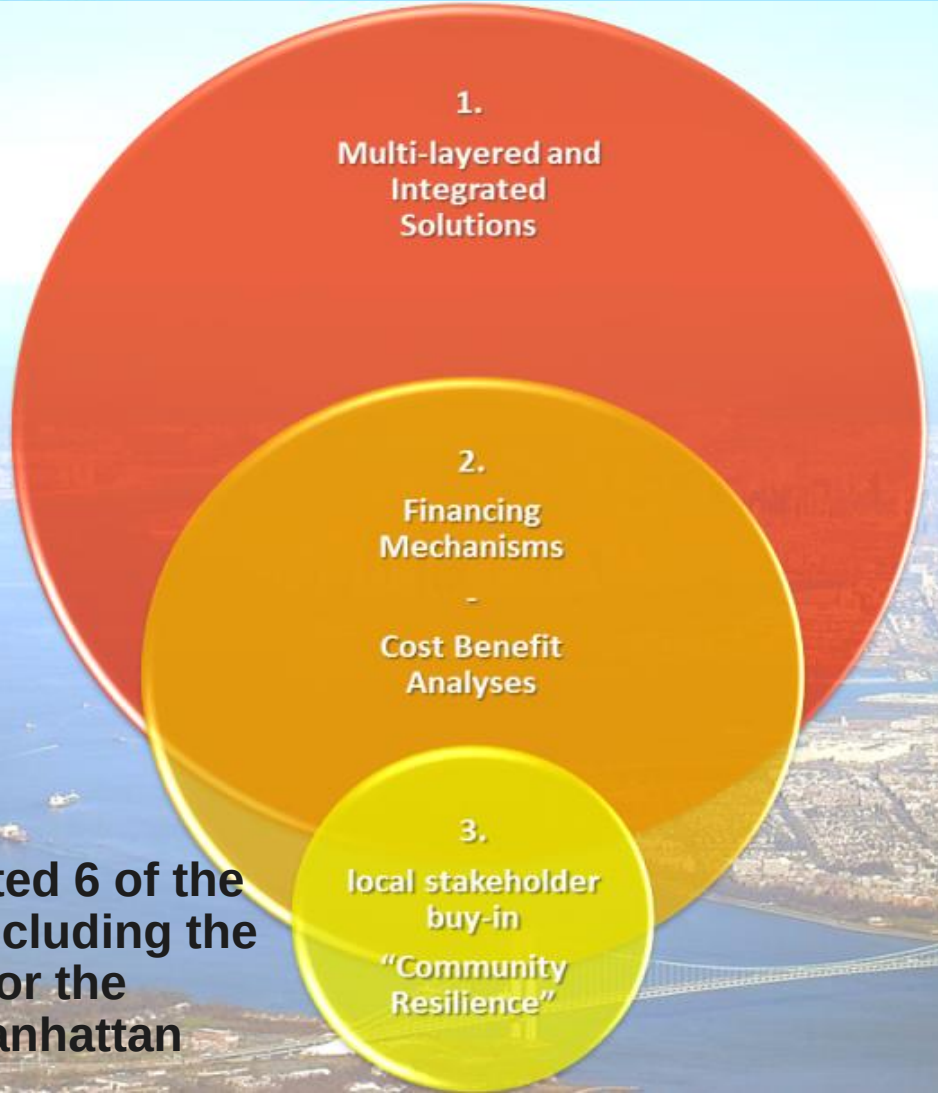
Manhattan's BIG U Flood Protection Plan

Source Rebuild by Design BIG Team

REBUILD BY DESIGN

Promoting Resilience Post-Sandy Through Innovative Planning and Design

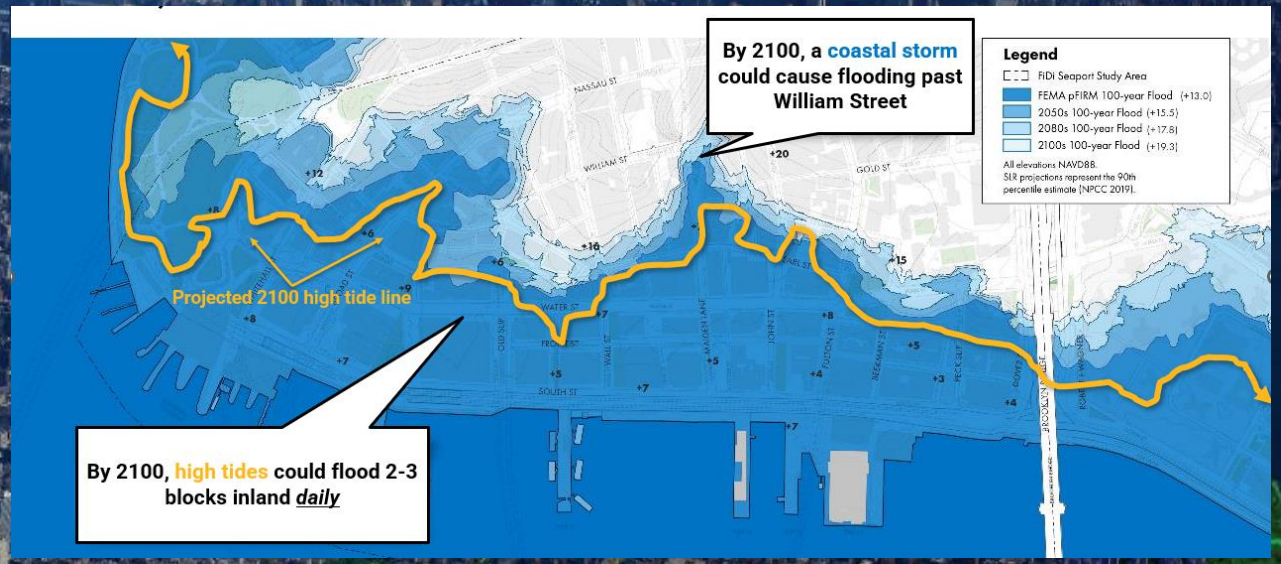
An Initiative Of The President's Hurricane Sandy Rebuilding Task Force



Arcadis supported 6 of the 10 proposals, including the winning BIG U for the protection of Manhattan

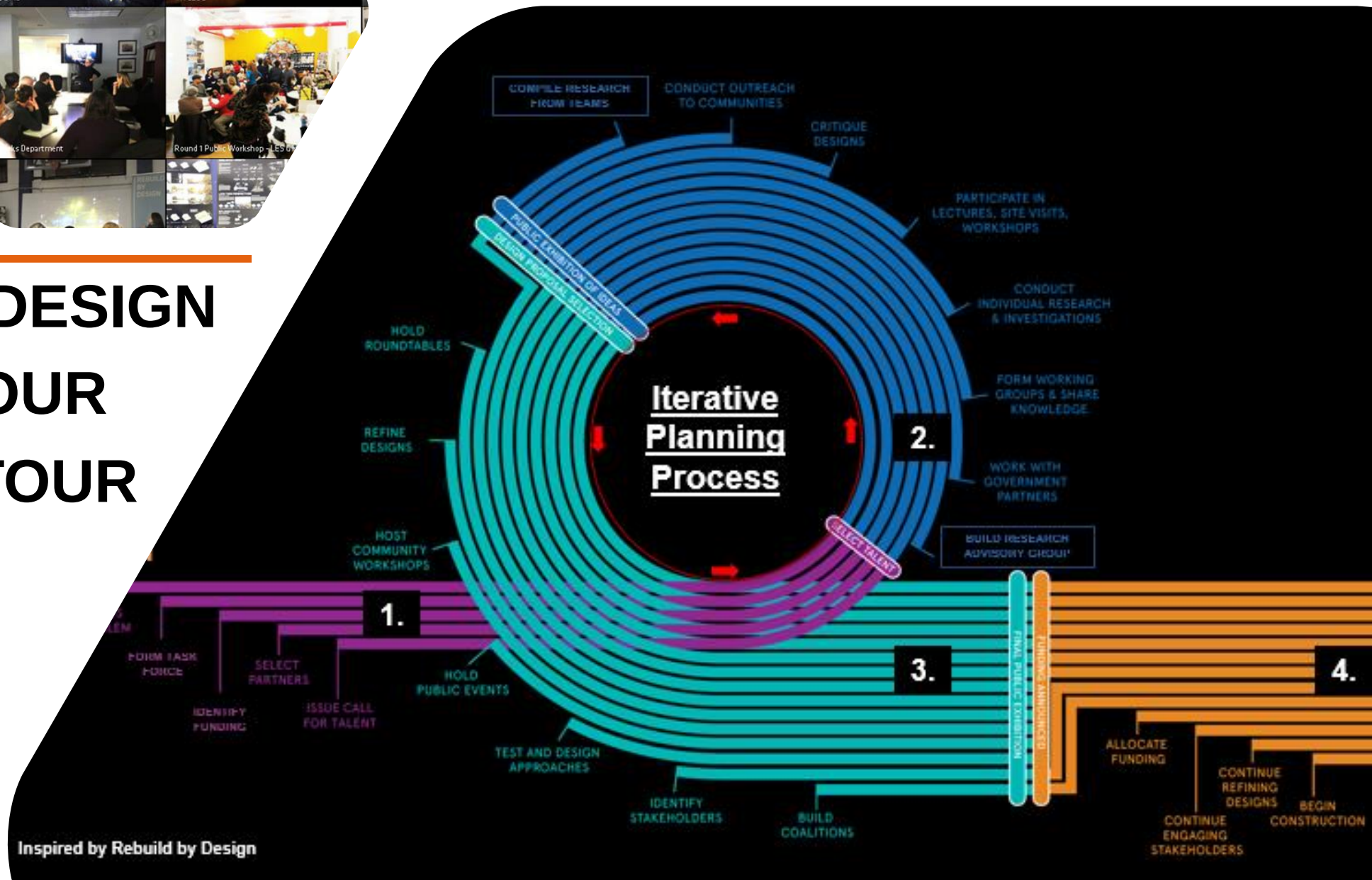
Special Water Envoy, Henk Ovink, Source, NYT: How to Think Like The Dutch in a Post Sandy World

Two types of climate risks - daily tidal flooding and coastal storms, Financial District, Manhattan.



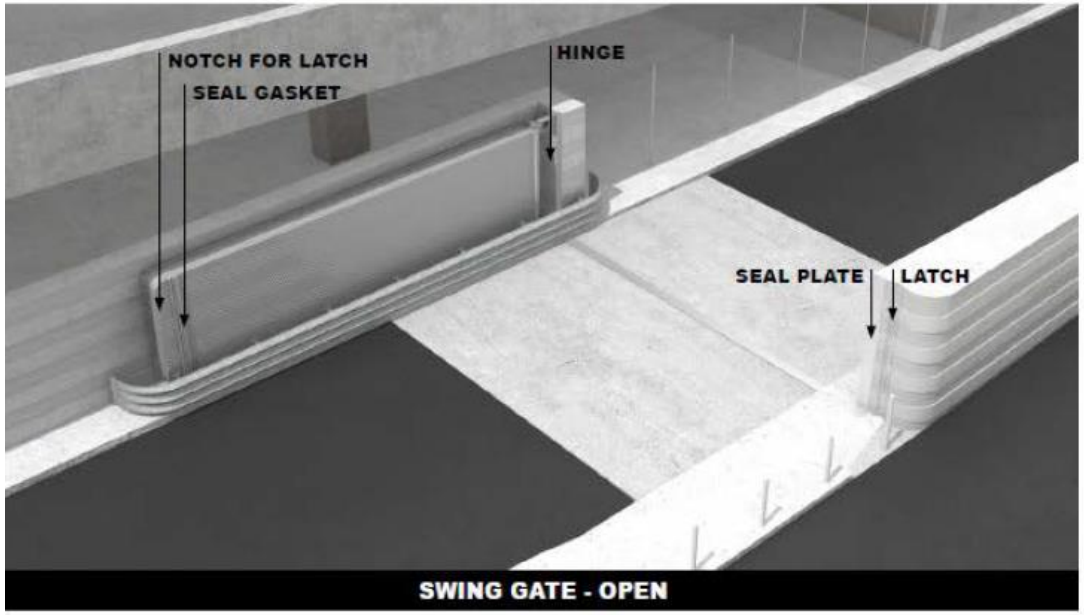
Source Rebuild by Design BIG Team

DESIGN YOUR DETOUR



East Side Coastal Resilience – Concept to Realization

Credit: One Architecture


NOTCH FOR LATCH
SEAL GASKET
HINGE
SEAL PLATE
LATCH
SWING GATE - OPEN

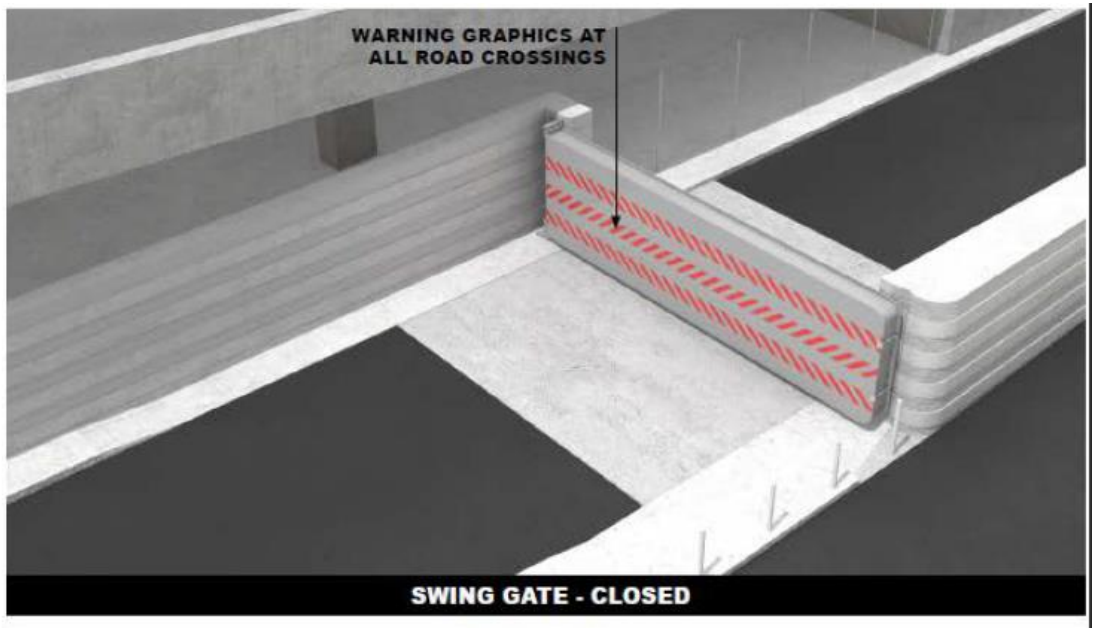
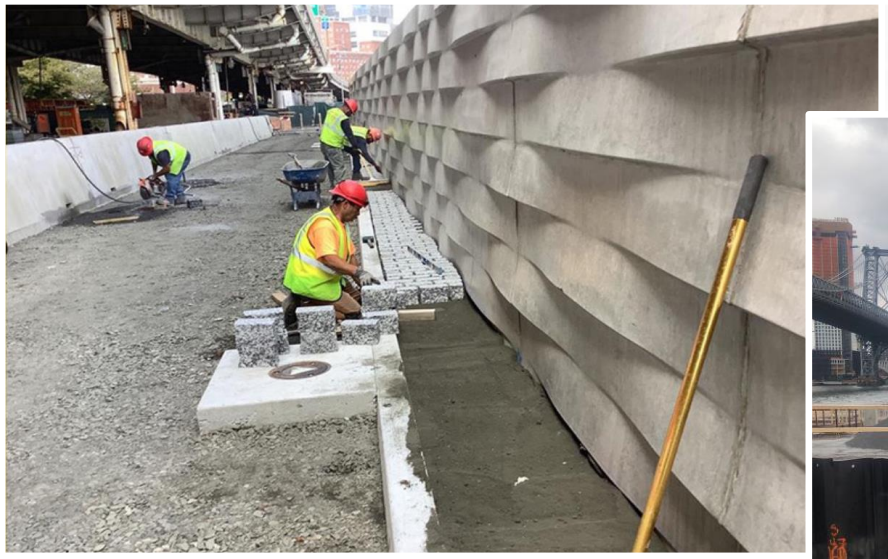
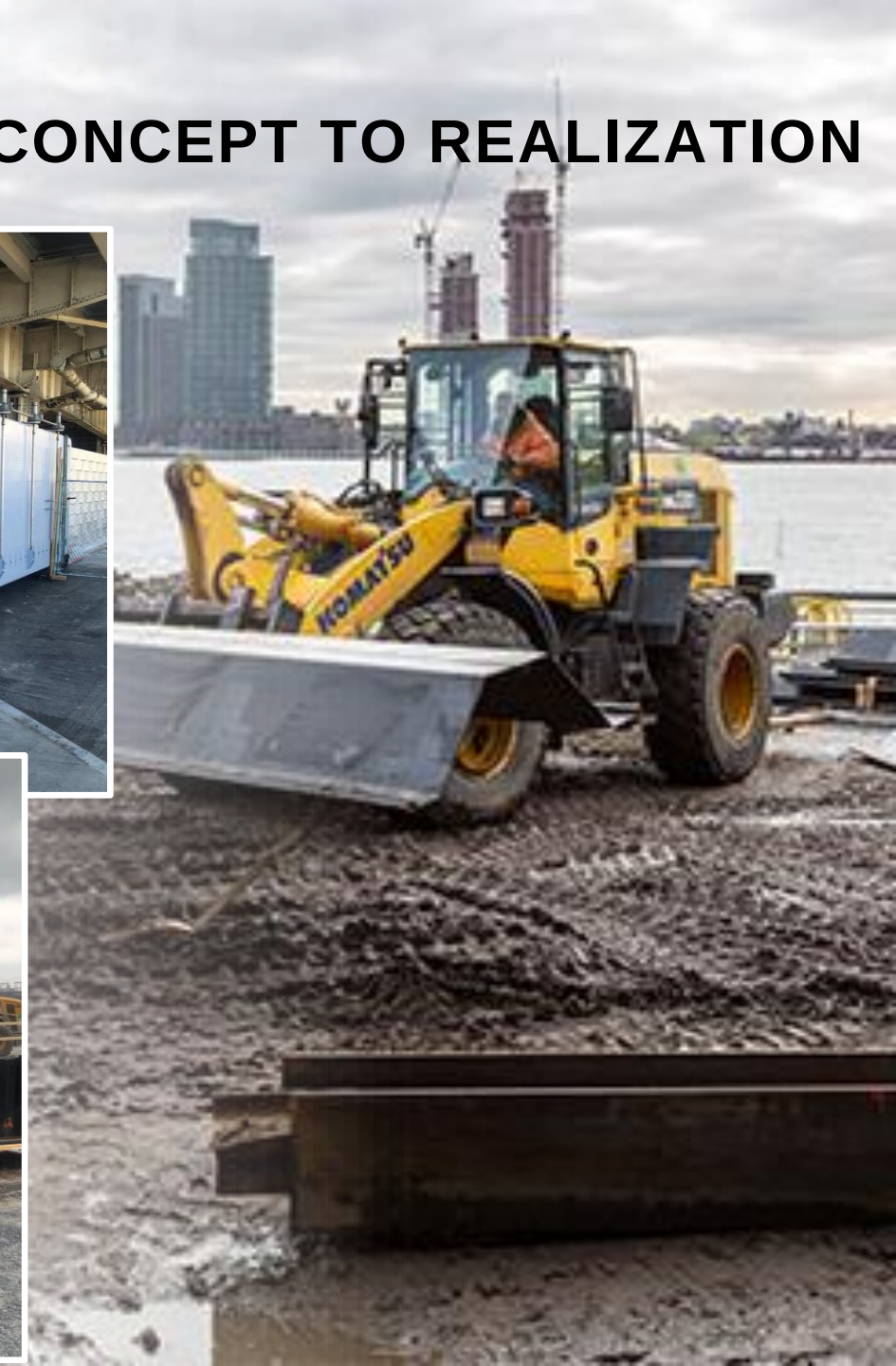

WARNING GRAPHICS AT
ALL ROAD CROSSINGS
SWING GATE - CLOSED


Image Credit: NYC DDC

MOVING FROM CONCEPT TO REALIZATION

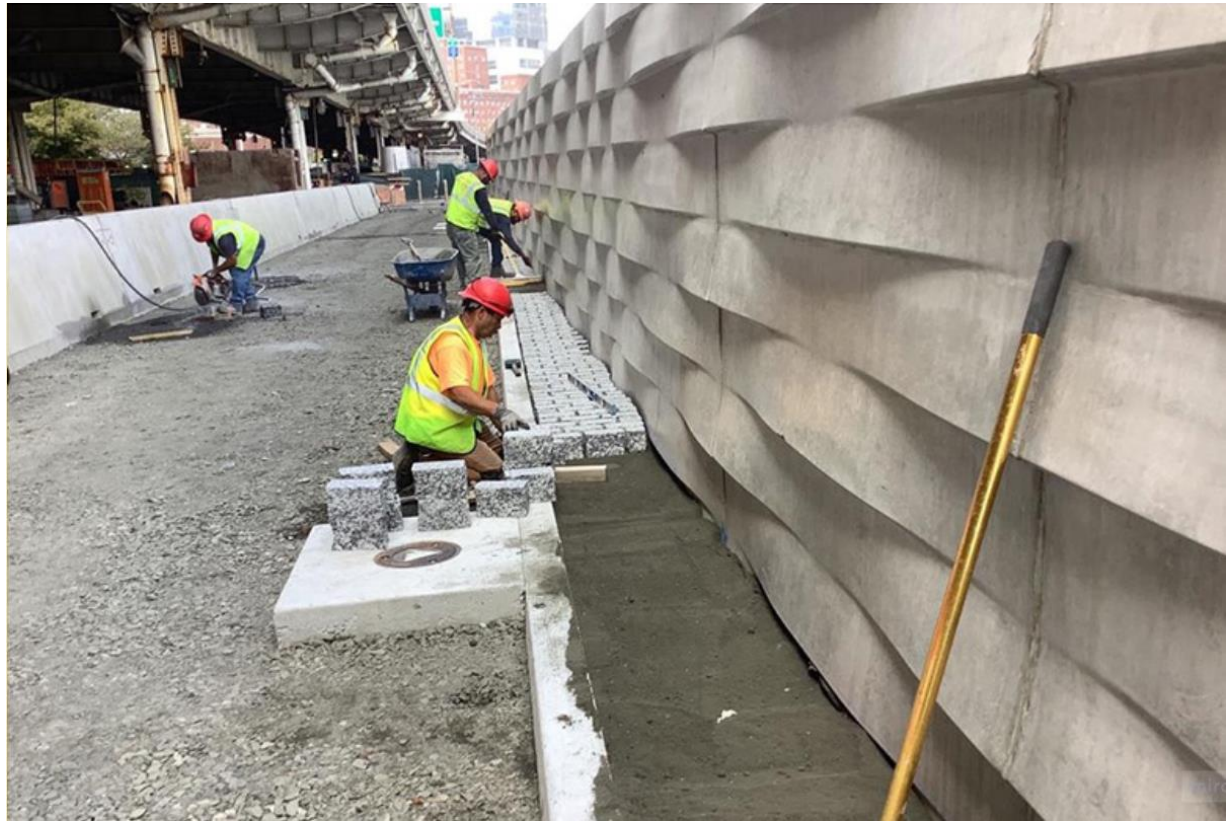




INSTALLATION OF NORTHERN CLOSURE GATE

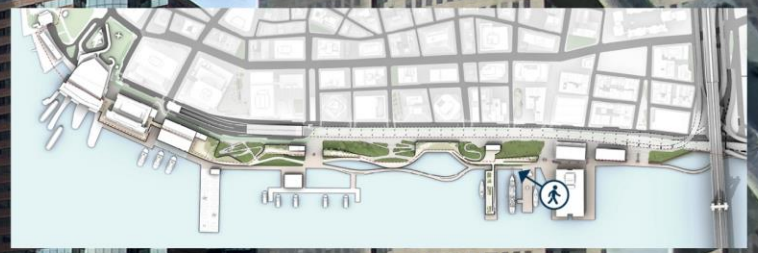
Source: NYC DDC

WALL ALIGNMENT AND NEW PARK AT EAST 23RD STREET

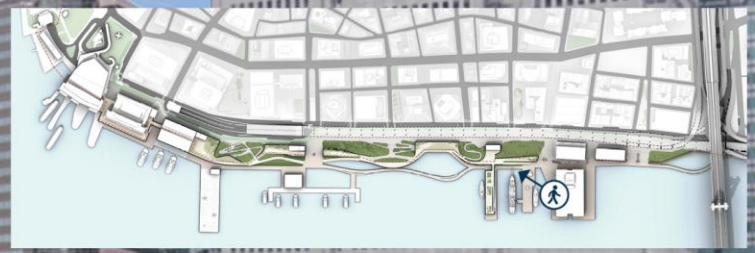


UN WATER CONFERENCE - DUTCH ROYAL HIGHNESS VISITS NEW YORK

South Street Seaport, Existing Conditions



South Street Seaport, Proposed New Waterfront



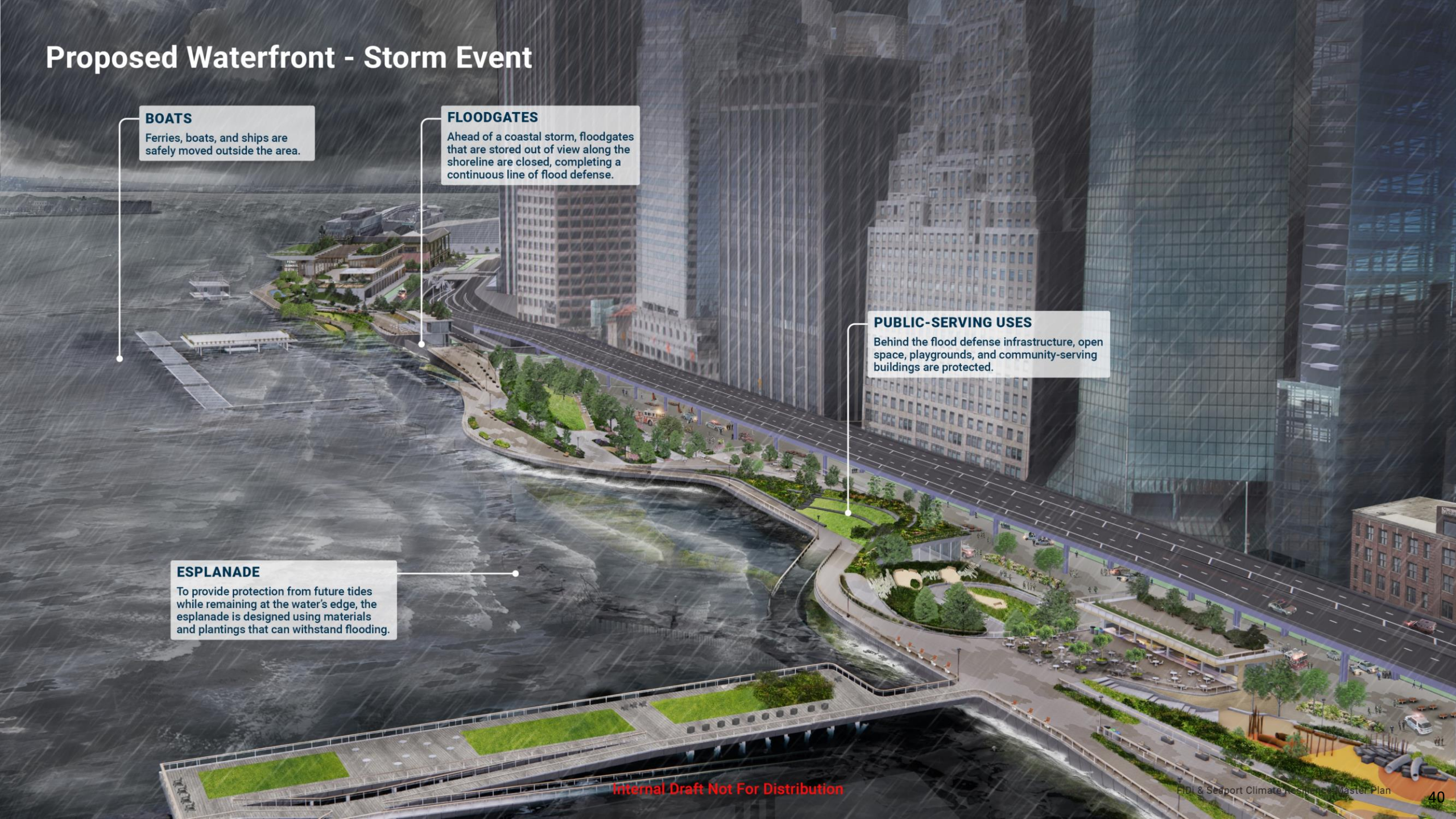
Financial District and Seaport Climate Resilience Master Plan

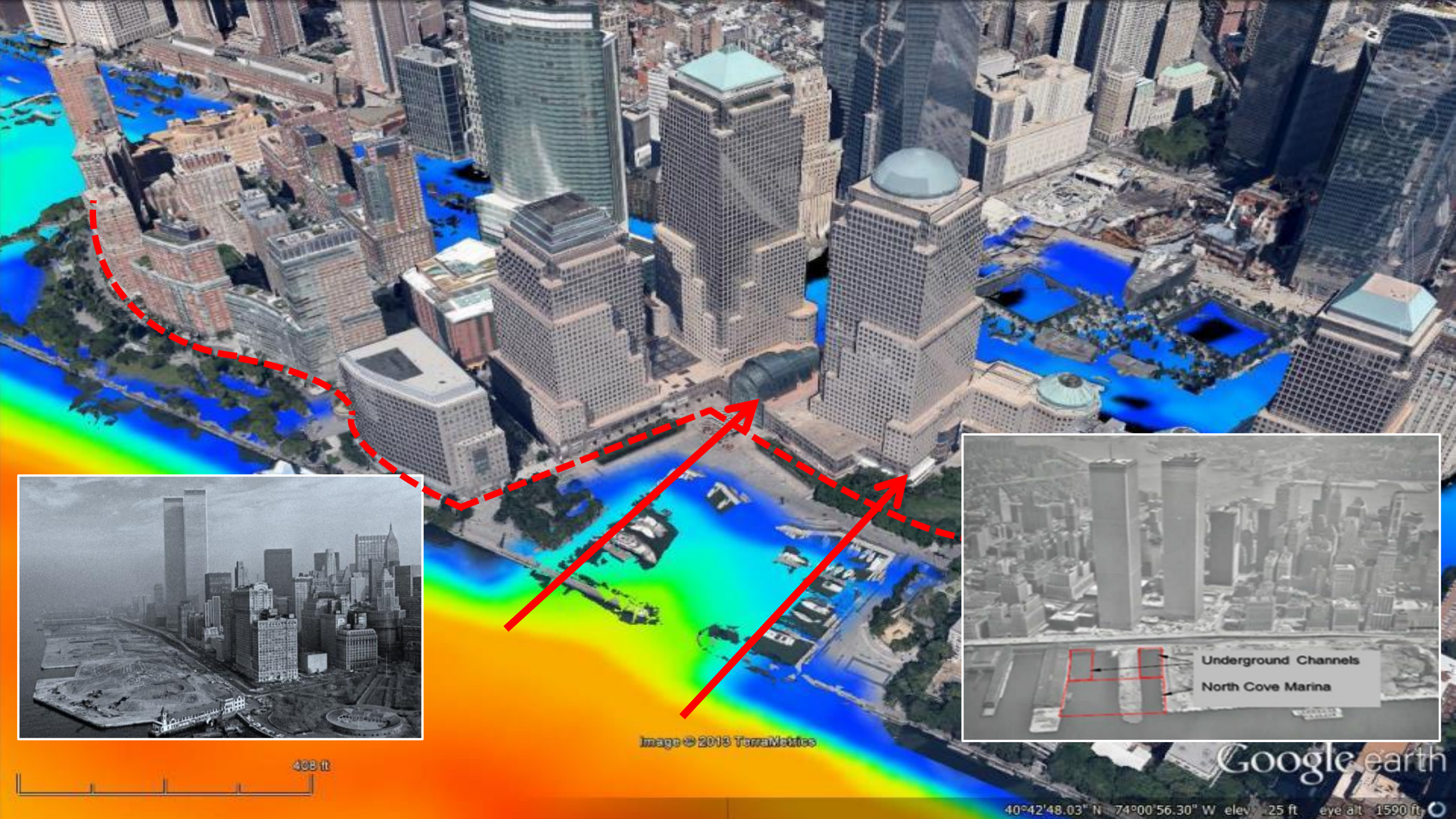
NYC/EDC

NYC Mayor's Office of Climate & Environmental Justice

ARCADIS

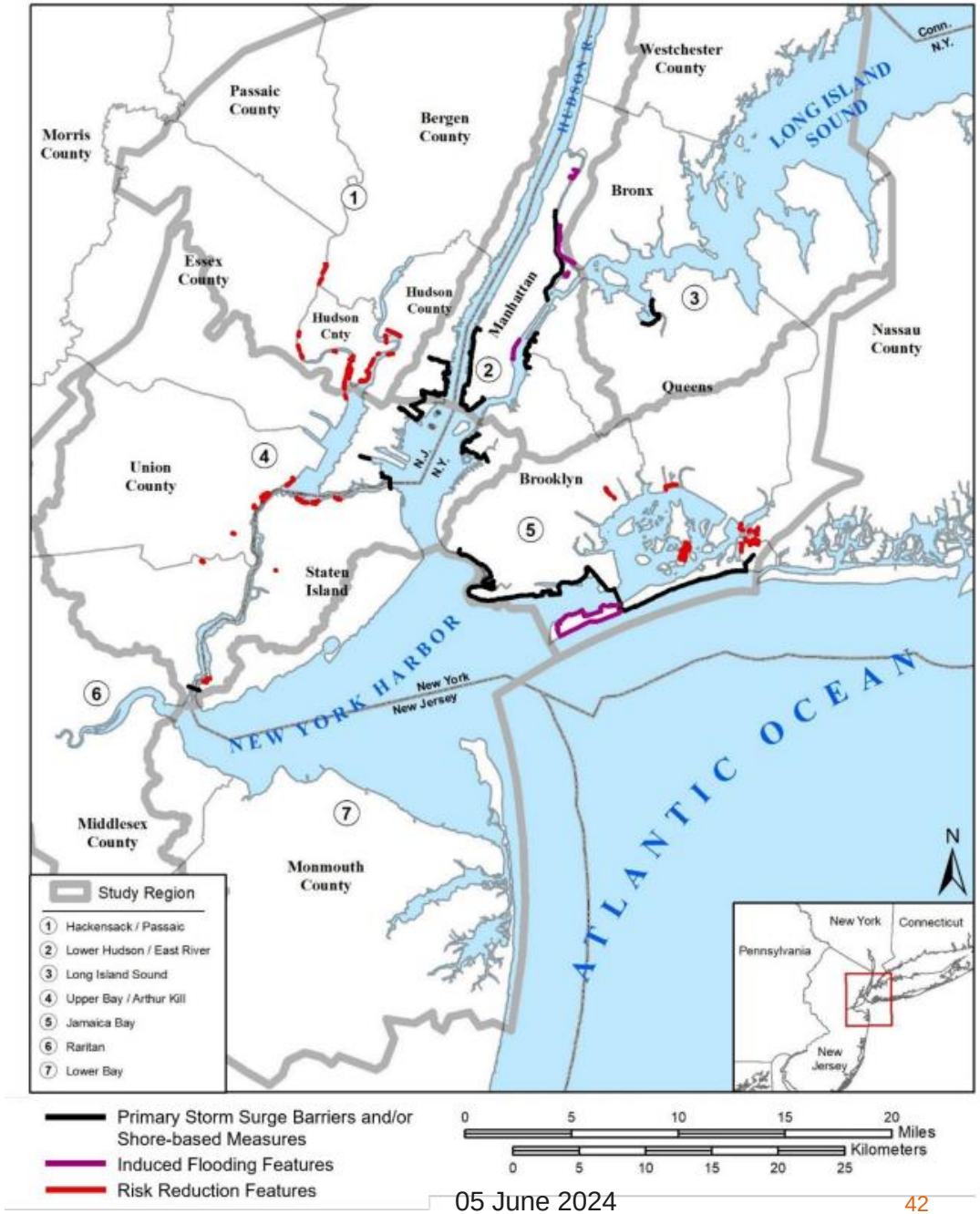
Proposed Waterfront - Storm Event

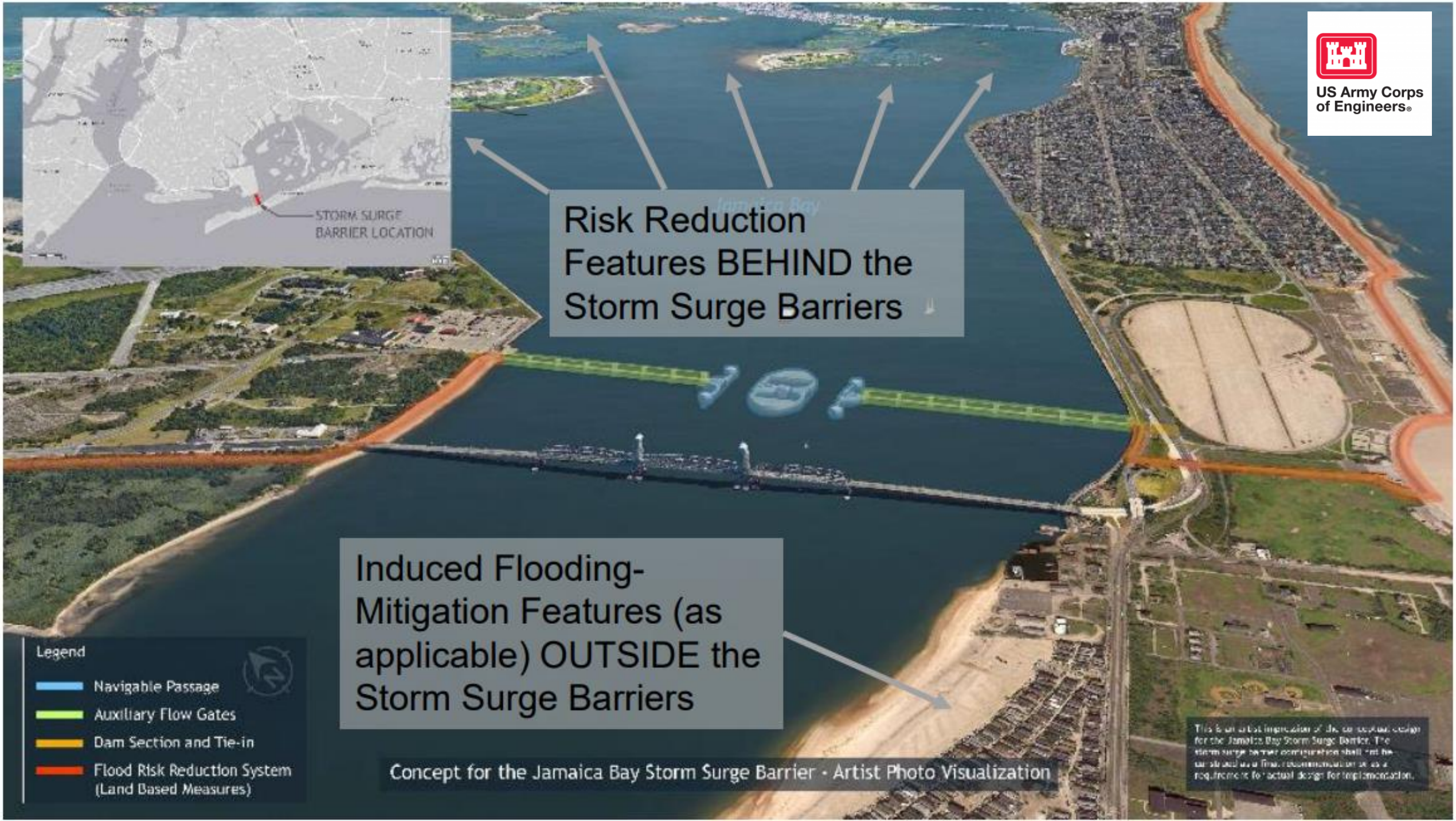



Underground Channels
North Cove Marina
Image © 2013 TerraMetrics
Google earth
40°42'48.03" N 74°00'56.30" W elev 25 ft eye alt 1590 ft

NY District
HATS Observations

- Plan components show high level of integration with existing / planned strategies, a systems approach that gives the study regional potential.
- Coastal protection through shore based and off shore barrier solutions aiming to protect long waterfront stretches of exposed communities.
- The evaluation of applying storm surge barriers has matured.
- The work does not stop if “3B” were to be implemented, what plan components from other strategies may apply over time?
- Drainage outfall and backflow issues, causing severe high tide inundation of low lying communities?
- What is the plan for waterfront communities who currently don’t and may not get have a plan, what will the process of retreat look like?




STORM SURGE BARRIER LOCATION
Risk Reduction Features BEHIND the Storm Surge Barriers
Induced Flooding-Mitigation Features (as applicable) OUTSIDE the Storm Surge Barriers
Legend
Navigable Passage
Auxiliary Flow Gates
Dam Section and Tie-in
Flood Risk Reduction System (Land Based Measures)
US Army Corps of Engineers®
Concept for the Jamaica Bay Storm Surge Barrier · Artist Photo Visualization

Living Breakwaters - From Concept to Construction

Attenuate Wave Energy & Prevent Shoreline Erosion

ARCADIS

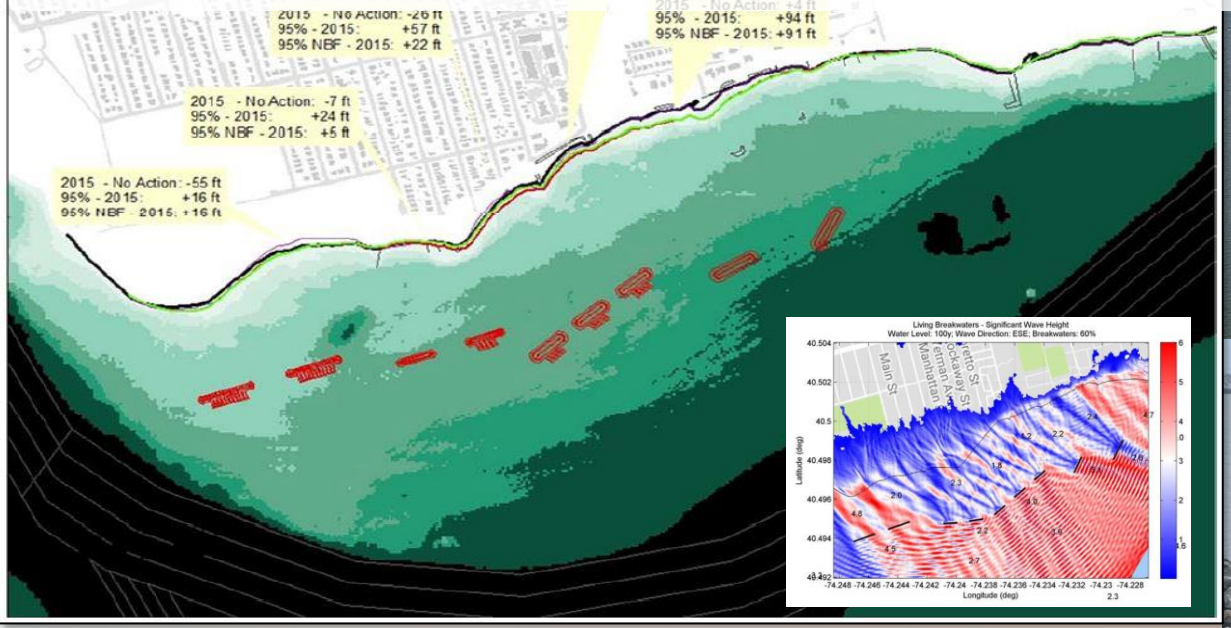
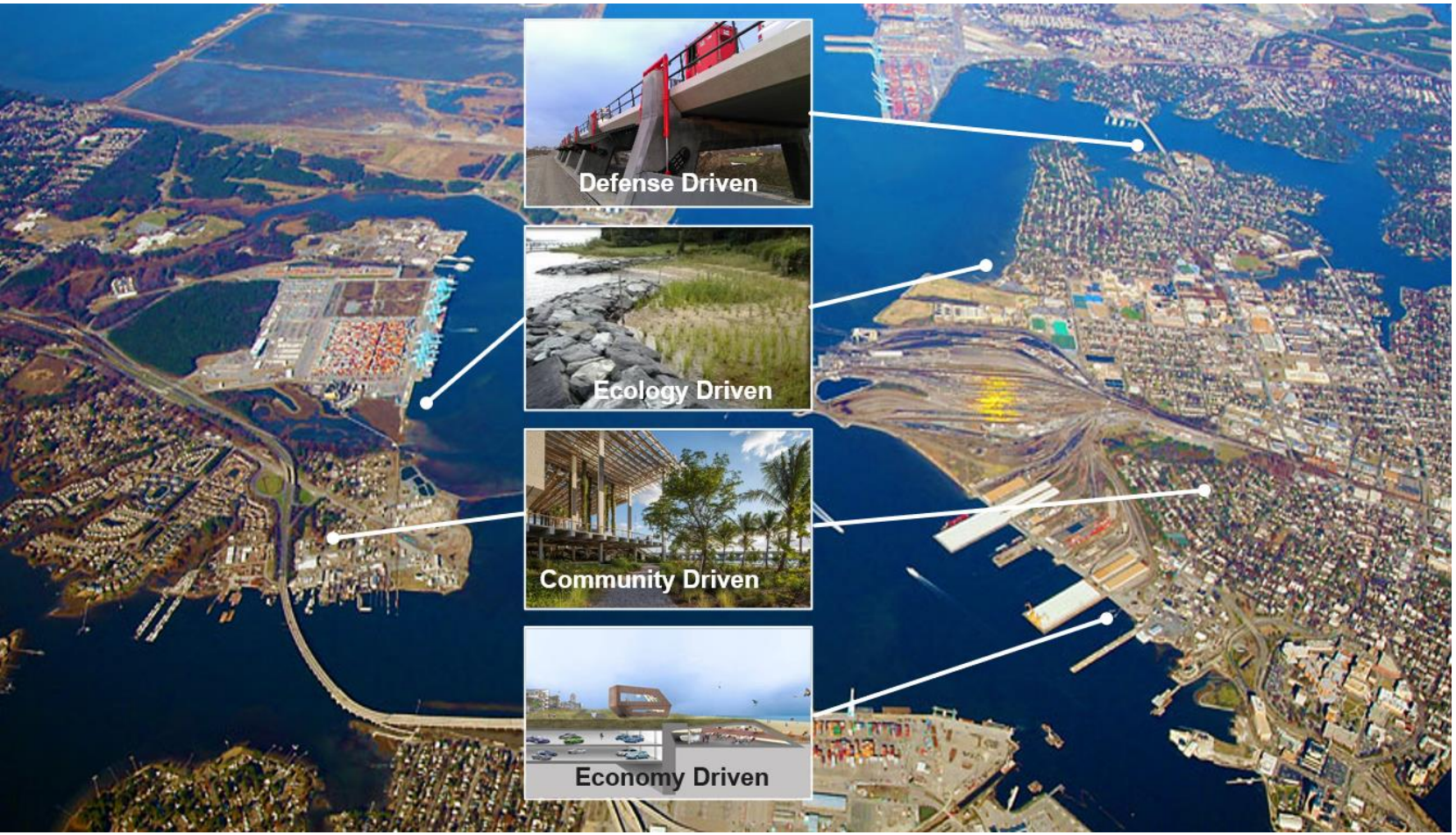


Image Credit Scape

A Systems Approach to Sustainable Water Management



- Acknowledge regional context and implications and potential of local interventions
- Plan collaboratively with neighboring communities and invested participants
- Update local ordinances to support resilience
- Identify current and future land-use + waterfront typologies

A Governance Approach to Sustainable Water Management

Connect all scales and build the business case

Built Asset Management

Digital/Cyber

Operations

Organization Culture

Regulatory Framework

Polices and Standards

Roles, Responsibilities and Authorities

Financial Resources

Human Resources

Emergency and Risk Management

Long-Term Strategic Planning

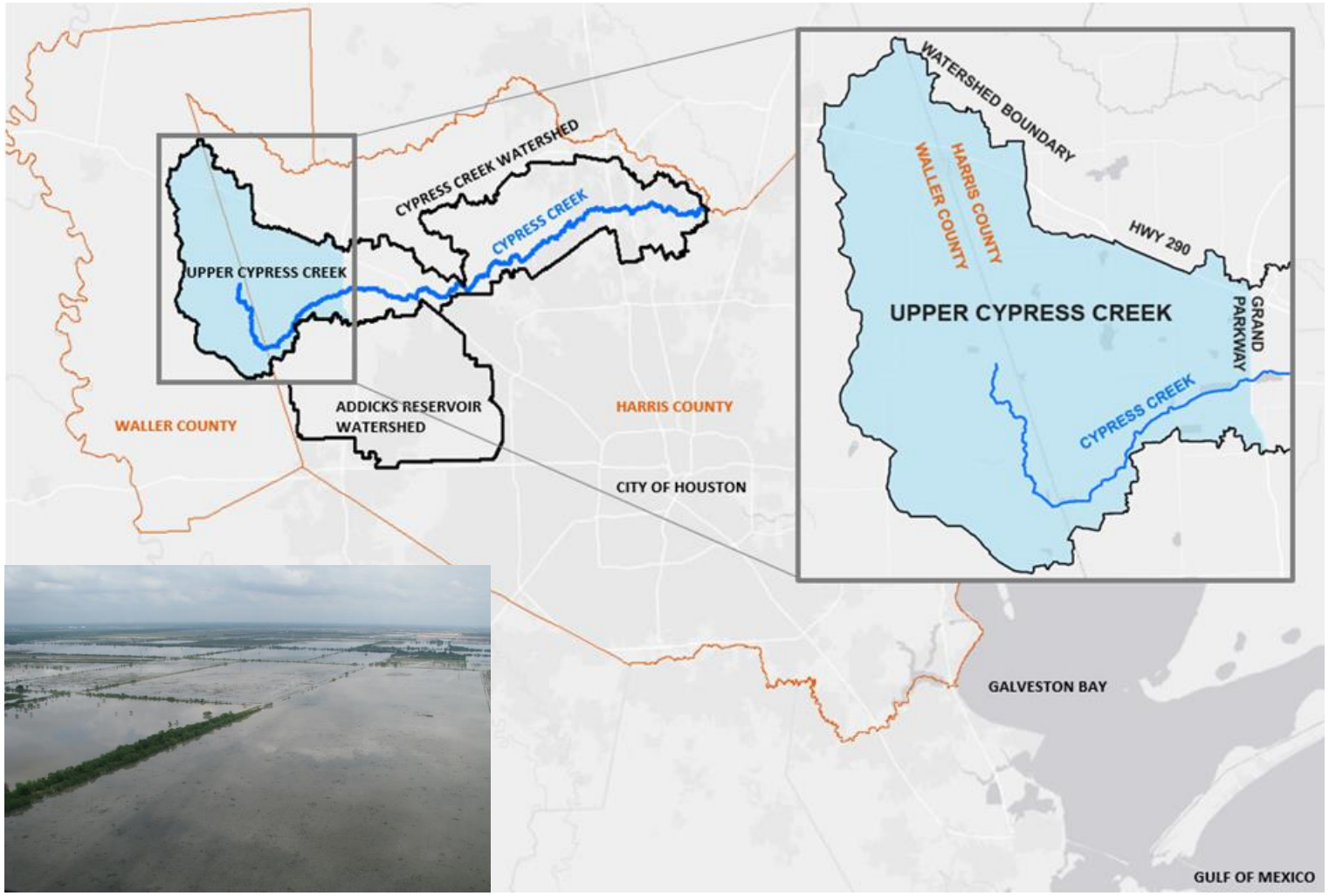
Stakeholder Coordination

Houston Post-Harvey
Upper Cypress Creek / Addicks Reservoir Shallow Storage Areas

ARCADIS

HARRIS COUNTY FLOOD CONTROL DISTRICT

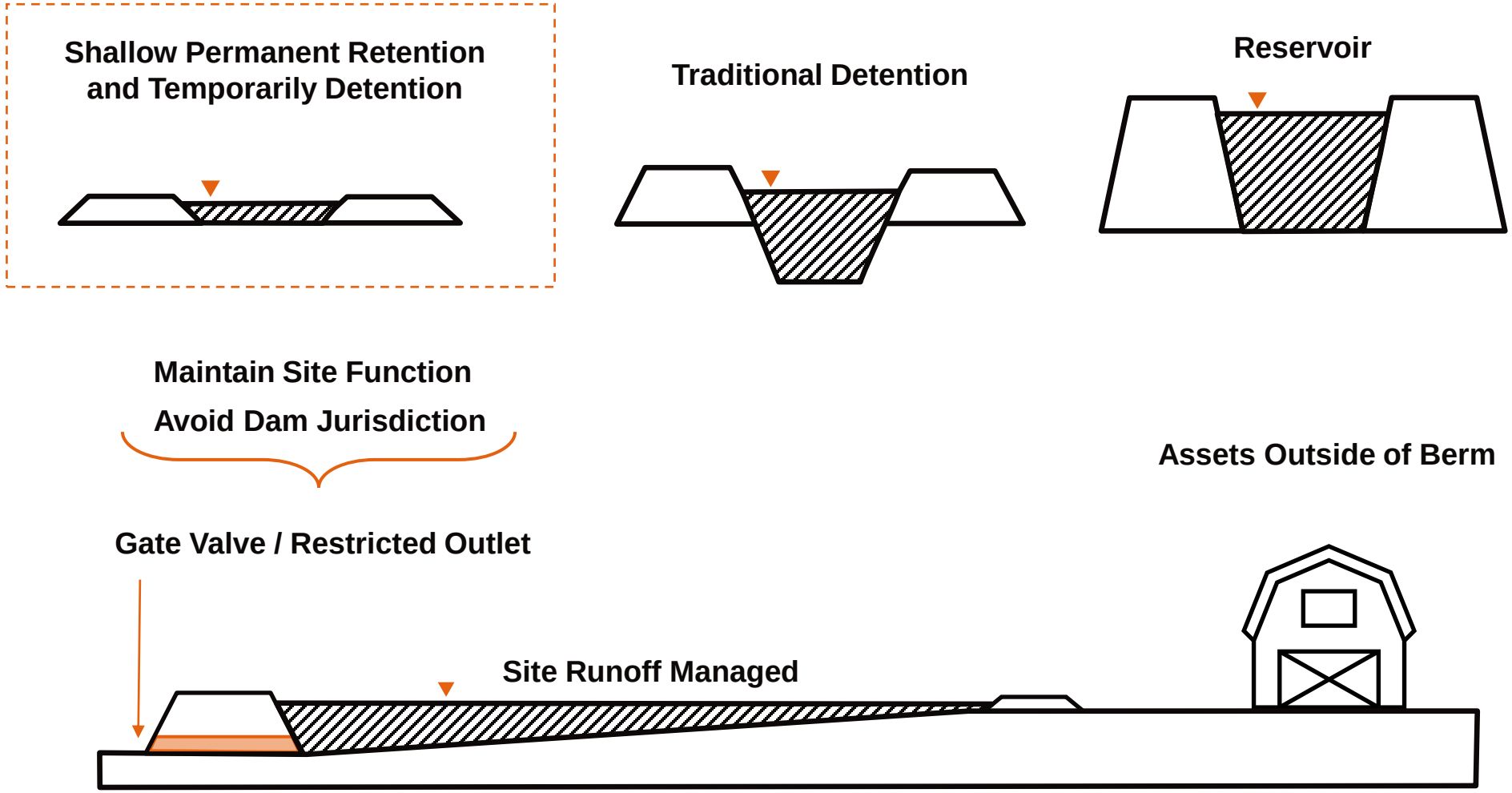
Project Goals



- Evaluate feasibility of shallow storage areas
- Reduce overflow to Addicks reservoir
- Reduce peak flow rates to Middle Cypress Creek
- Compare to Plan 3 / Plan 5 reservoirs ($650M)
- Feasibility only, not implementation
- Hybrid approach with regional retention

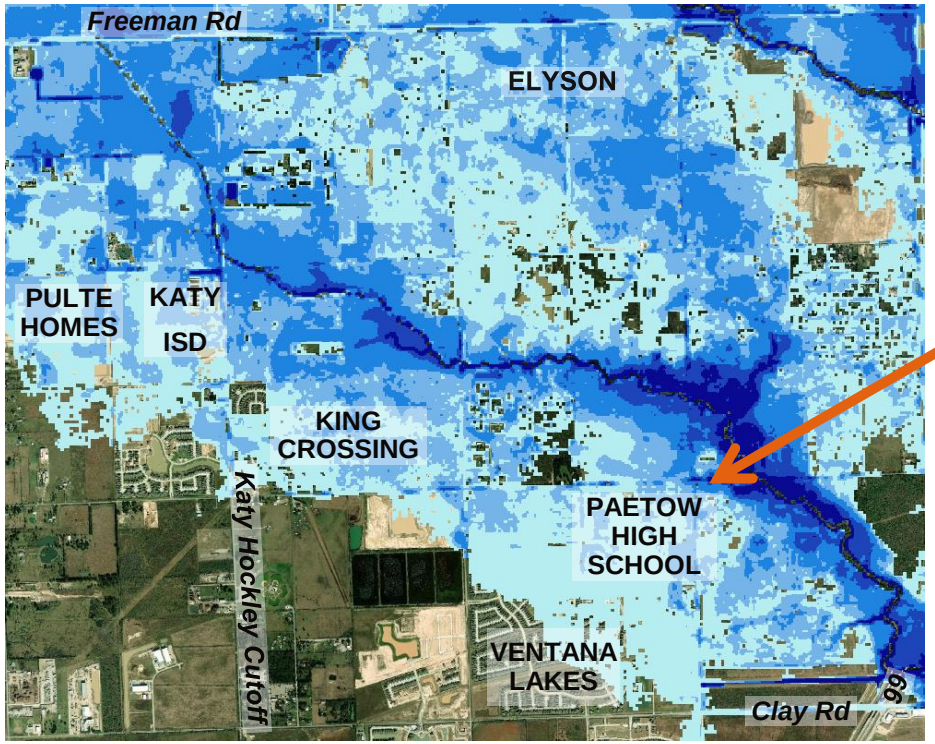
Flood Risk Management Techniques

Through Permanent Retention and Temporary Detention

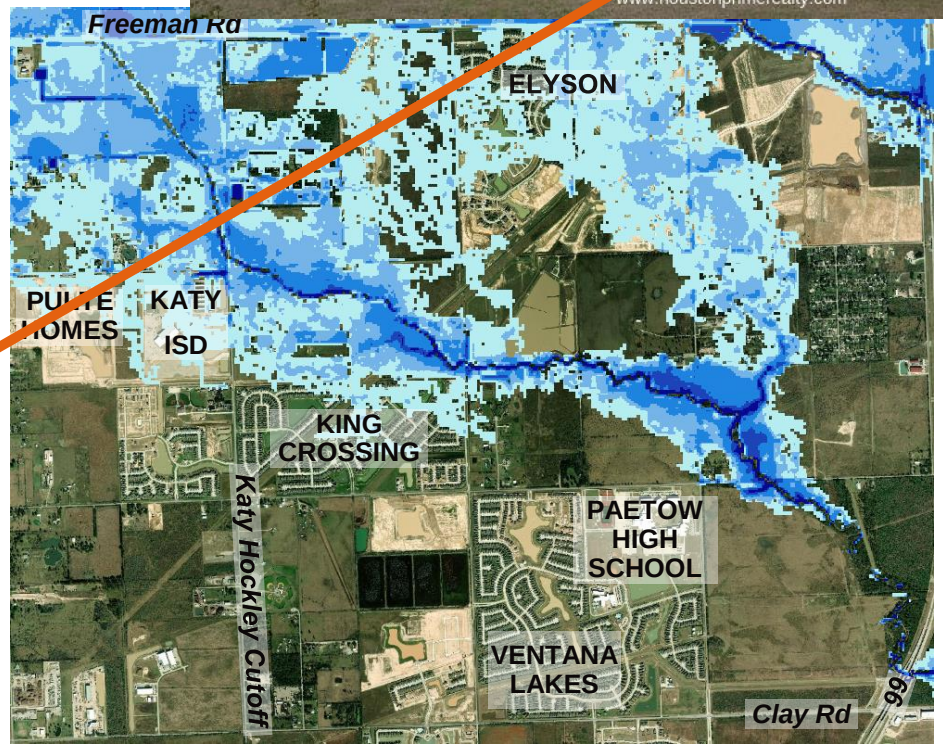


100-Year Property Benefits

100-Year Overflow



Existing performance



Performance with shallow storage

Flood Depth (feet)	0.0 – 0.5	0.5 – 1.0	1.0 – 2.0	2.0 – 3.0	3.0+

5 - Day Simulation Volume

SAN FRANCISCO – PORT OF SF

SEAWALL EARTHQUAKE SAFETY & DISASTER PREVENTION PROGRAM

Project Goals:

- Improve Disaster Preparedness
- Reduce Earthquake Damage
- Improve Flood Resilience
- Enhance the City & the Bay
- Preserve Historic Resources
- Engage the Community

PORT OF SAN FRANCISCO

Photo: Joel Macor

“Adaptation Pathways”
Miami-Dade County Sea Level Rise Strategy

Arcadis

Improving the quality of life.

Thank You!

EDGAR WESTERHOF

National Director for Climate Adaptation

o 718 397 2386

e edgar.westerhof@arcadis.com