Resiliency:
National Case Studies

AECOM

NEW JERSEY

NEW YORK

SAN FRANCISCO

MIAMI

BOSTON

REBUILD BY DESIGN

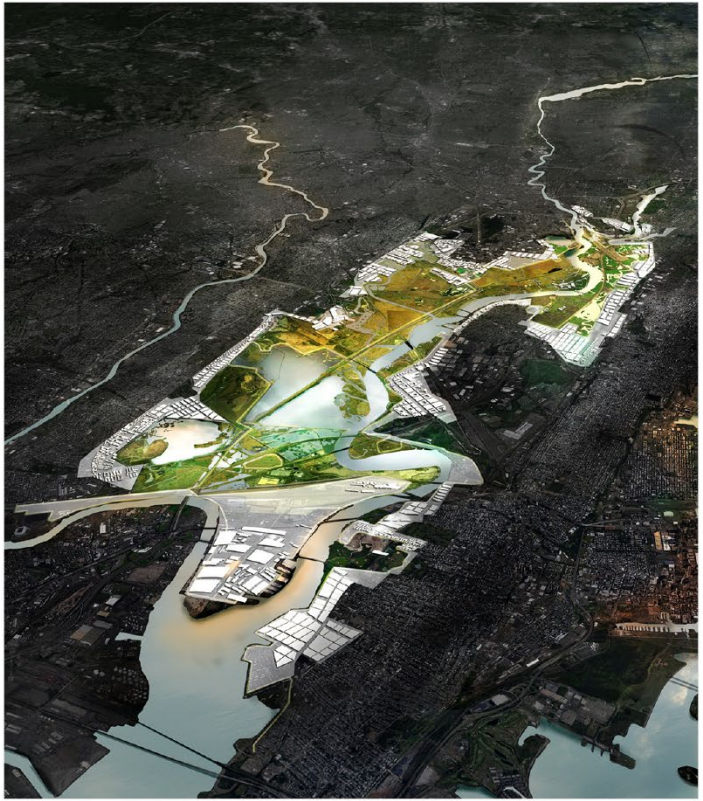
MEADOWLANDS

HURRICANE SANDY

AECOM

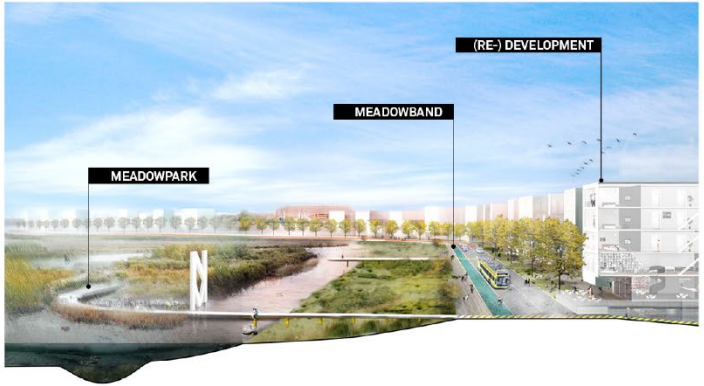
REBUILD BY DESIGN: COMPETITION & AWARD

U.S. DEPARTMENT OF HOUSING & URBAN DEVELOPMENT

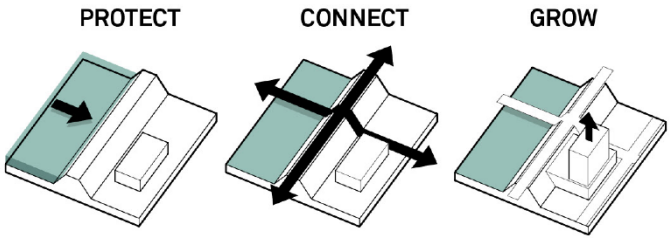


COMPETITION RENDERING

Competition Graphic: MITCAU, ZUS, ORG



COMPETITION SECTION PERSPECTIVE



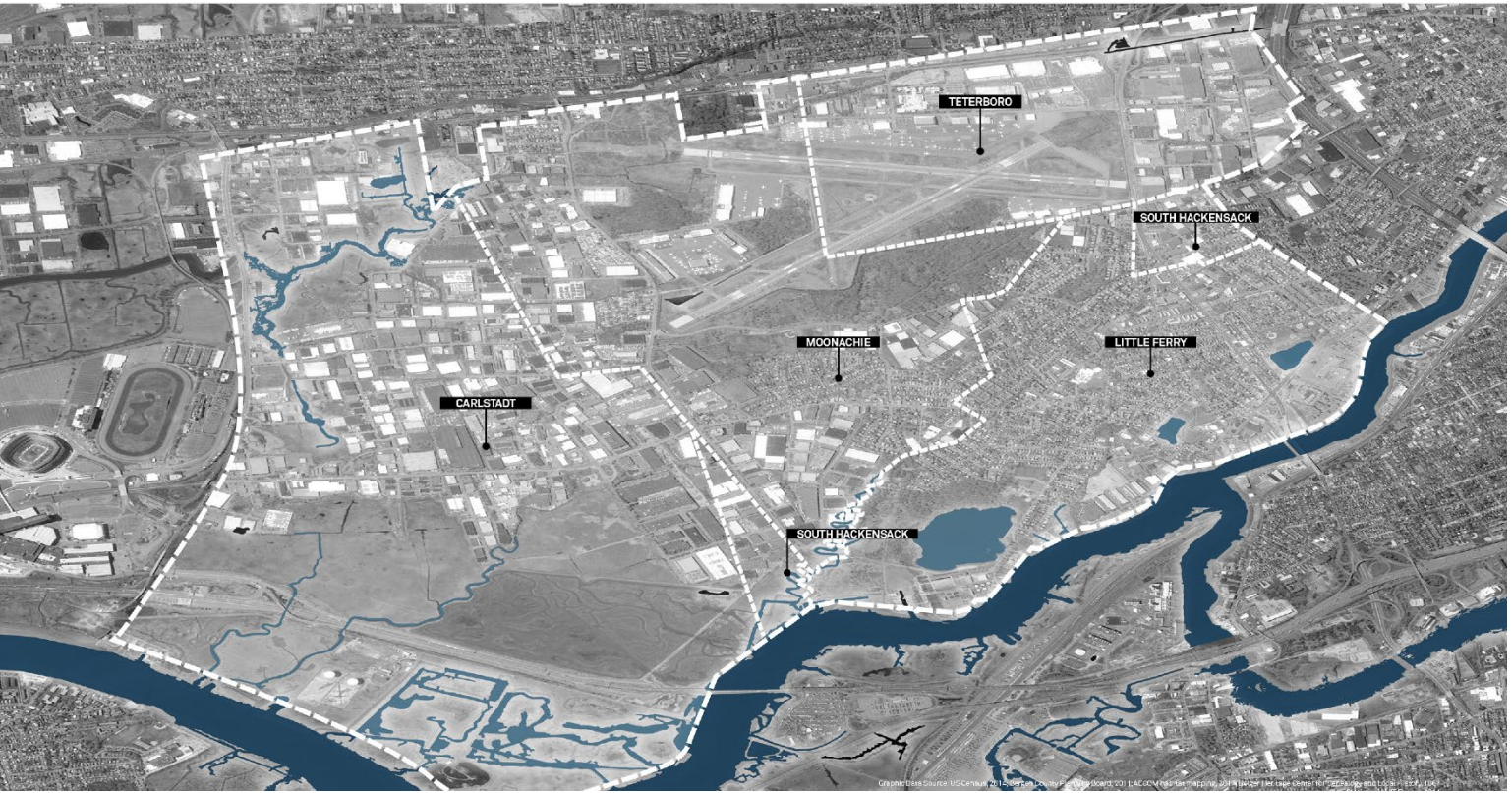
COMPETITION LENSES

- Original RBD Concept
- **Protect:** Flood Protection
- **Connect:** Transportation Improvements
- **Grow:** Re-Development
- Cost Estimate (Competition Cost) **Phase 1: $850M+**

AECOM

REBUILD BY DESIGN COMPETITION & AWARD

5 MUNICIPALITIES



Pilot Area 1

- 5,500 Acres
- 16,000 Residents
- Teterboro Airport
- Regional Transportation Corridors
- Regional Warehouse and Distribution Centers

AECOM

PROJECT AREA CHALLENGES

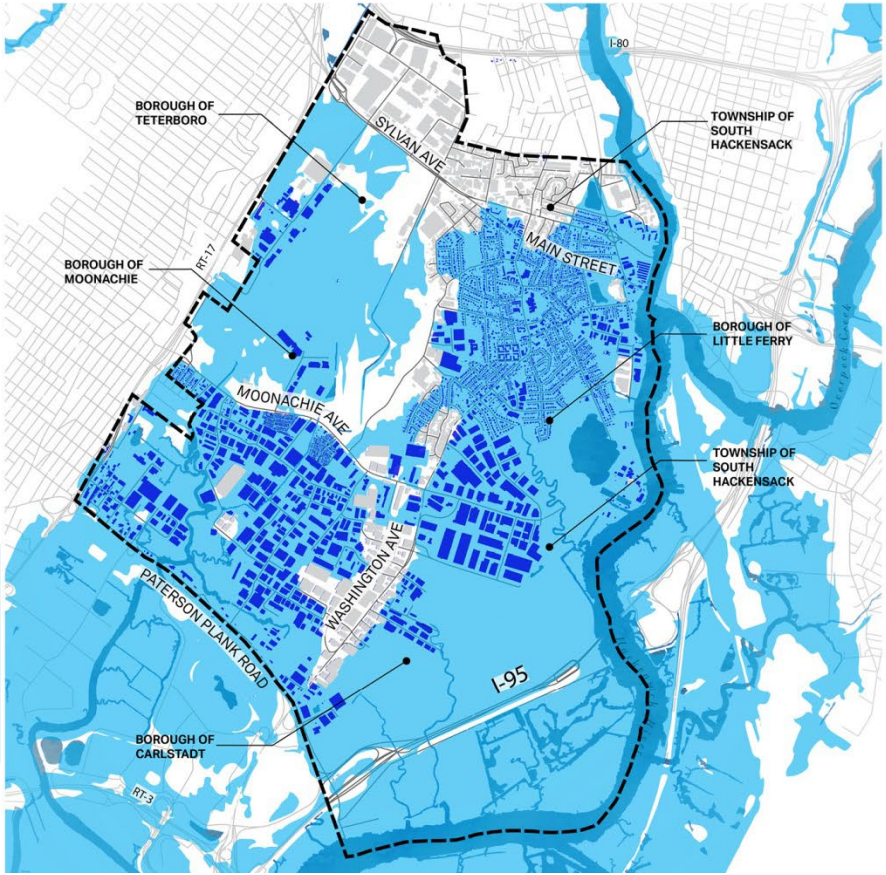
EXISTING FLOODPLAIN

- ***98% OF THE PROJECT AREA IS WITHIN THE 100-YEAR FLOODPLAIN***

Legend

- Municipality
- 100-YearFloodplain
- Properties Within 100-Year Floodplain
- Properties Not Within 100-Year Floodplain

Location Key

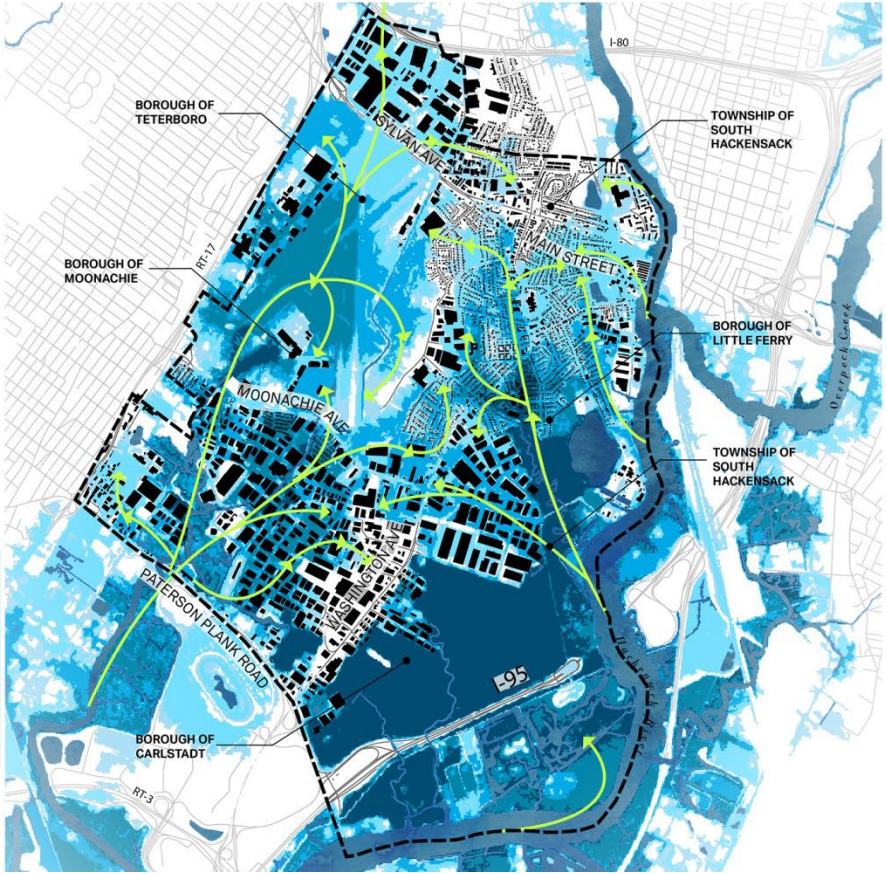


AECOM

PROJECT AREA CHALLENGES

SEA LEVEL RISE BY 2075

- ***SEA LEVEL IS ESTIMATED TO RISE BETWEEN 1.2 – 2.4 FEET IN THE PROJECT AREA***
- ***STORM SURGE IS ESTIMATED TO INCREASE 0.8-1.6 FEET***



Legend

- Municipality
- Direction of Water
- Water
- 0' Sea Level Rise
- 1' Sea Level Rise
- 2' Sea Level Rise
- 3' Sea Level Rise
- 4' Sea Level Rise
- 5' Sea Level Rise
- 6' Sea Level Rise

Location Key

N

1000' 2000'

AECOM

PROJECT AREA CHALLENGES

1

Challenges from

MAJOR STORM SURGE Flooding

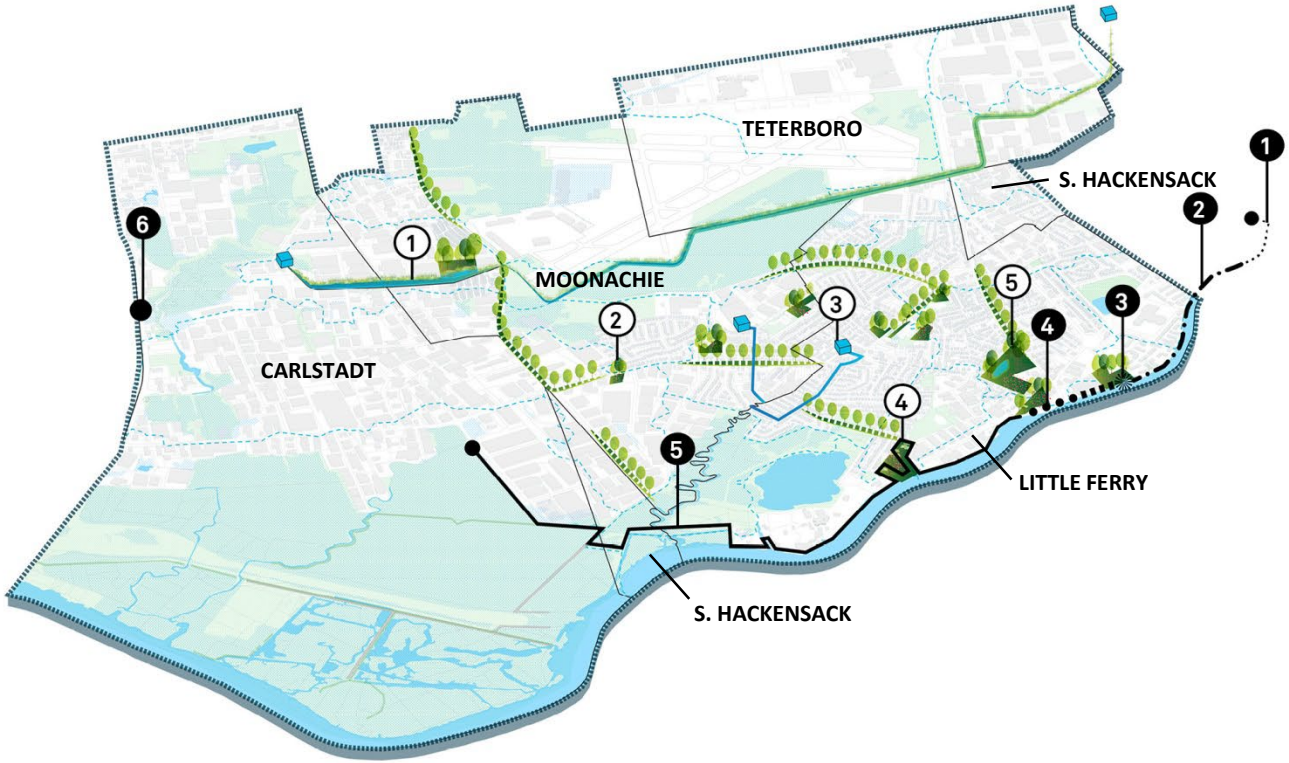
2

Challenges from

FREQUENT RAIN Flooding

THE PREFERRED ALTERNATIVE

A PLAN FOR BOTH CHALLENGES



Stormwater Management

1. East Riser Channel Improvements + Enhanced Wetland Open Space
2. Green Infrastructure + Enhanced Existing Open Space
3. Force Main + Public Facility Improvements
4. Green Infrastructure + Enhanced Open Space
5. GI Improvements to Existing Park + 3 New Wetland / Open Spaces

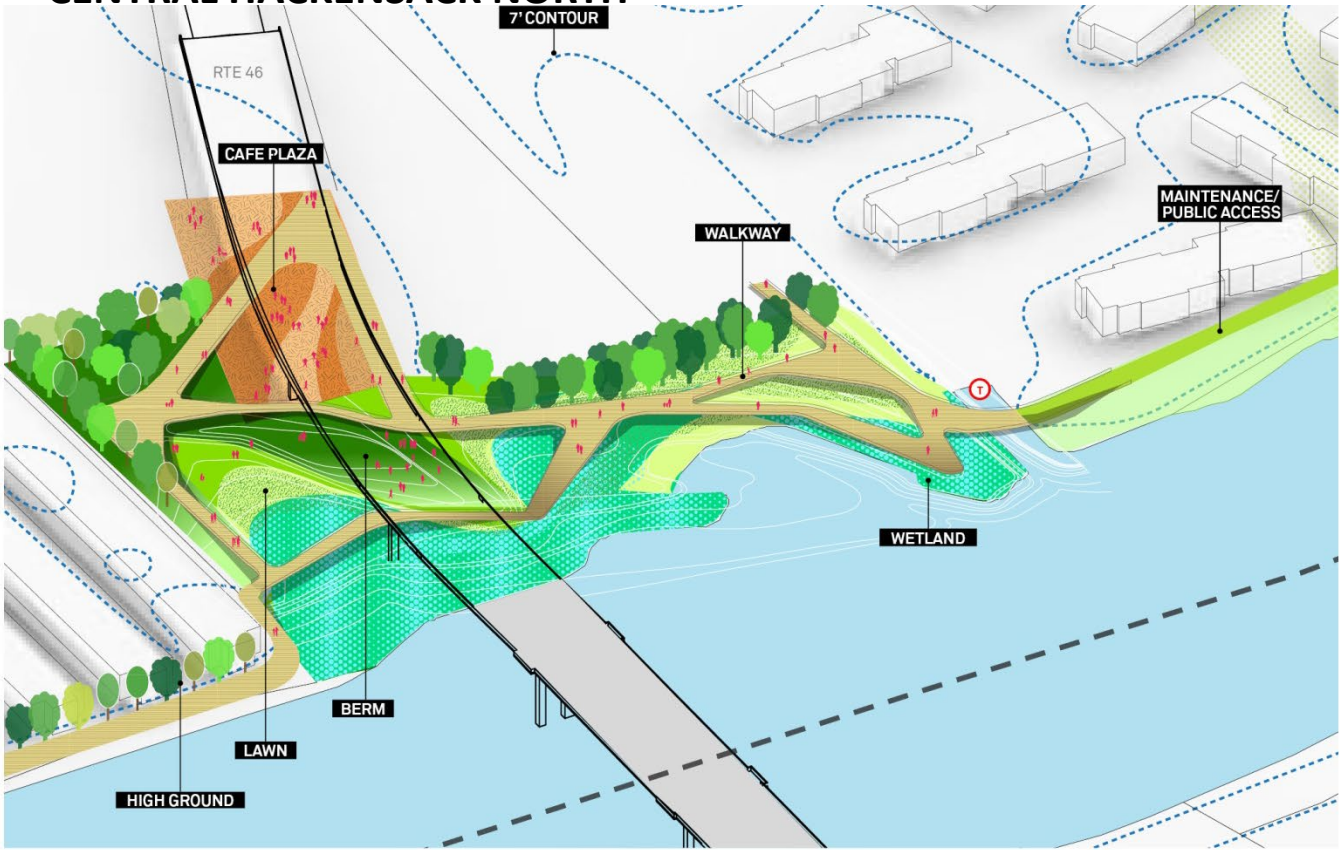
Storm Surge Protection

1. Existing Riverwalk
2. Sheet Pile Cantilever
3. Berms at Fluvial Park
4. Cantilever Walkway
5. Sheet pile or Floodwall
6. Surge Barrier

AECOM

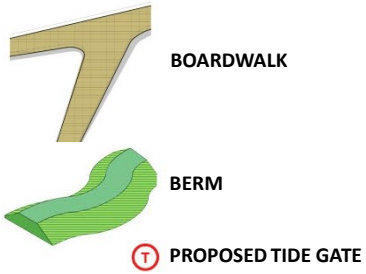
FLUVIAL PARK

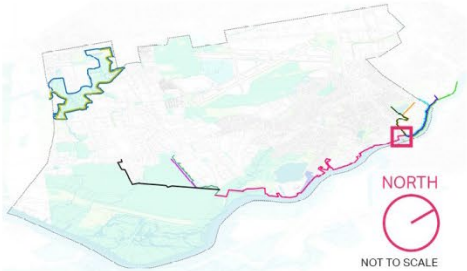
CENTRAL HACKENSACK NORTH



APPLYING THE "KIT OF PARTS"

- A berm system turns into a public space under Route 46
- The berm system allows for inundation on the river's side during a flood event





FLUVIAL PARK CONNECTION

CENTRAL HACKENSACK NORTH

FLUVIAL PARK CONNECTION

CENTRAL HACKENSACK NORTH

CANTILEVER WALKWAY

CONCEPTUAL RENDERING FOR ILLUSTRATIVE PURPOSES

- The Cantilever Walkway combines flood protection and public access

1. Public walk
2. Modular planter
3. Cantilever access
4. Recreational space

AECOM

REBUILD BY DESIGN

HUDSON RIVER

JERSEY CITY HOBOKEN WEEHAWKEN | NEW JERSEY

State of New Jersey Department of Environmental Protection

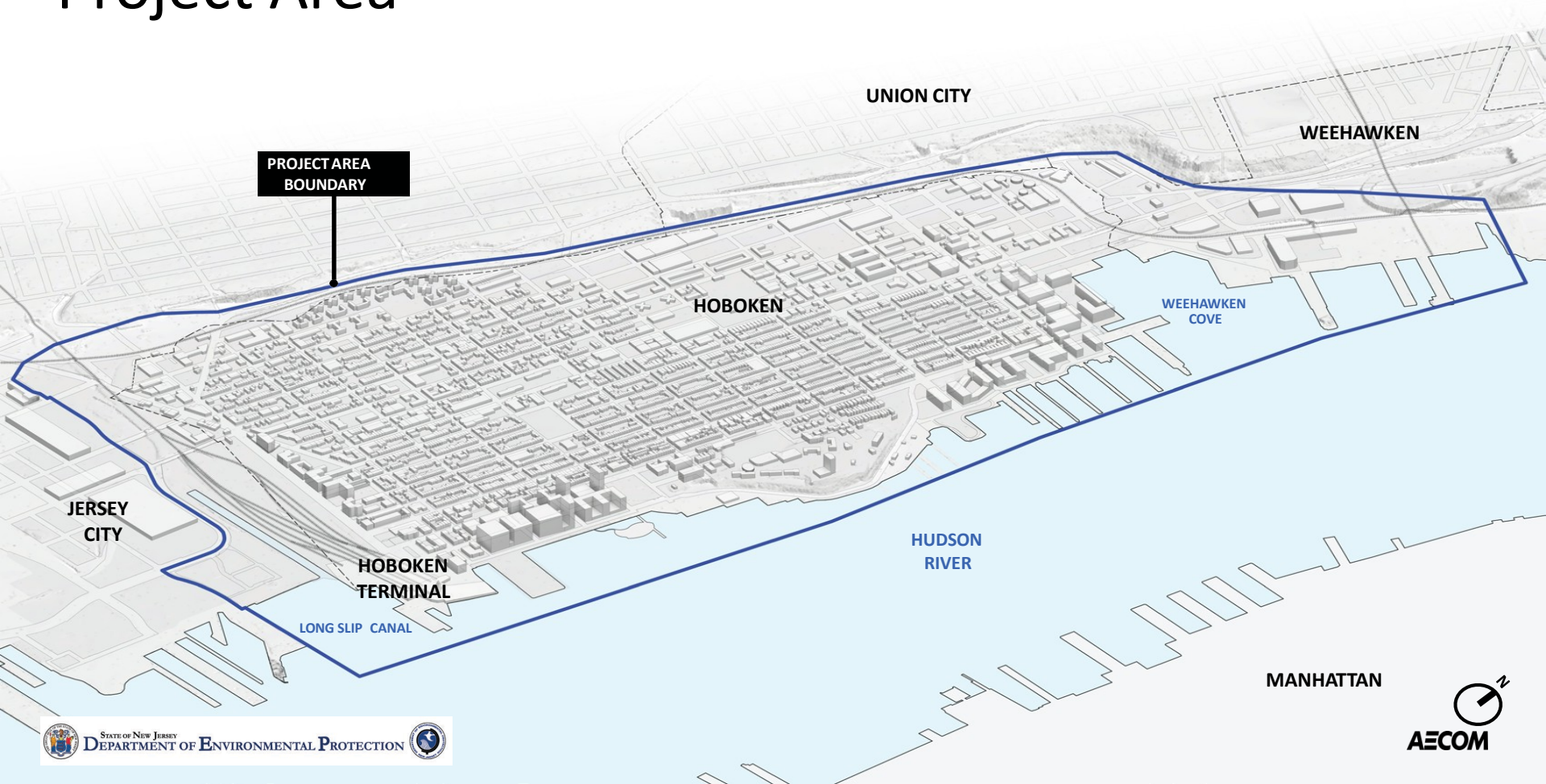
AECOM

Post-Sandy 2012

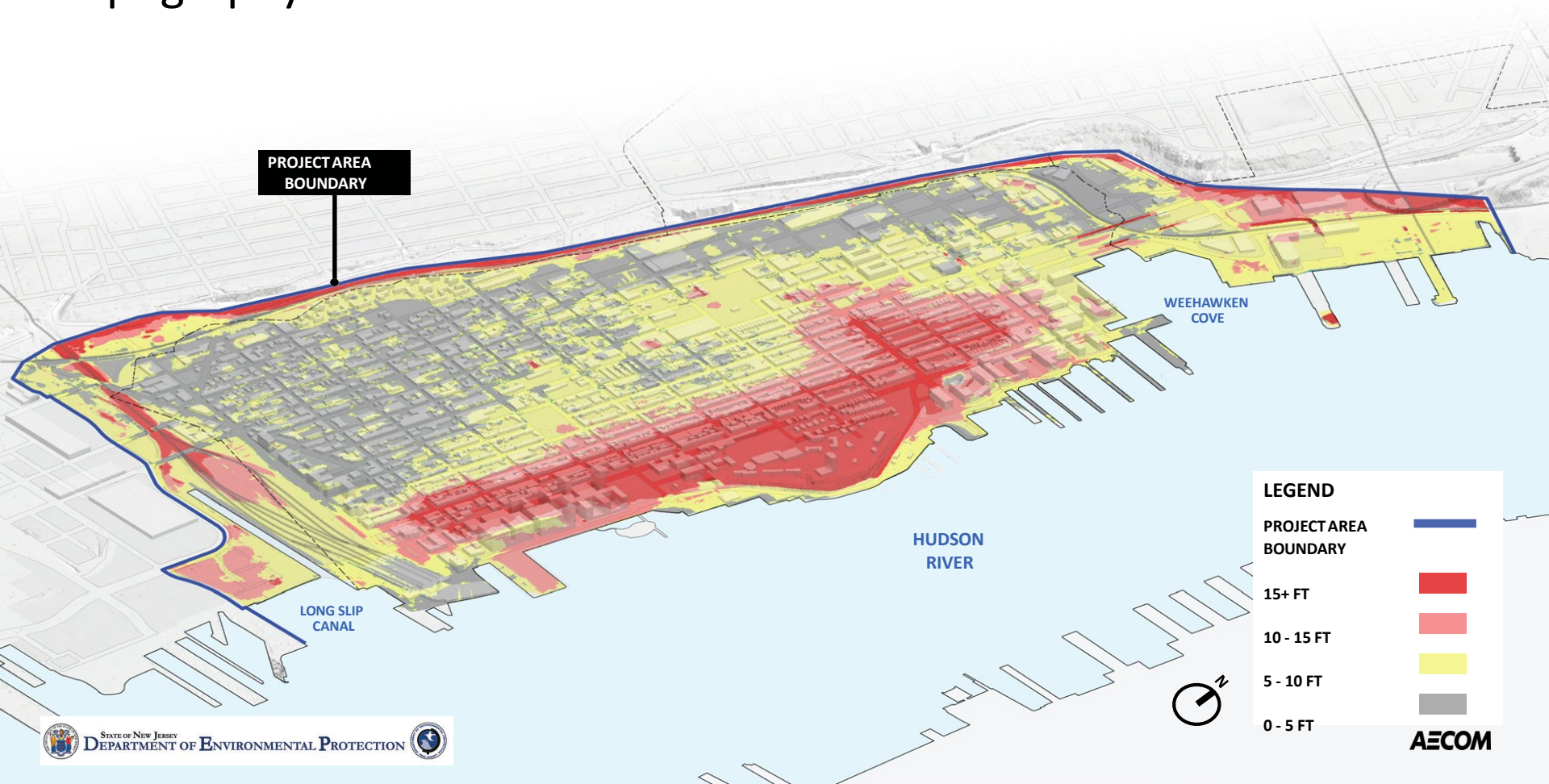
Post-Sandy 2012

Nor’easter 2018

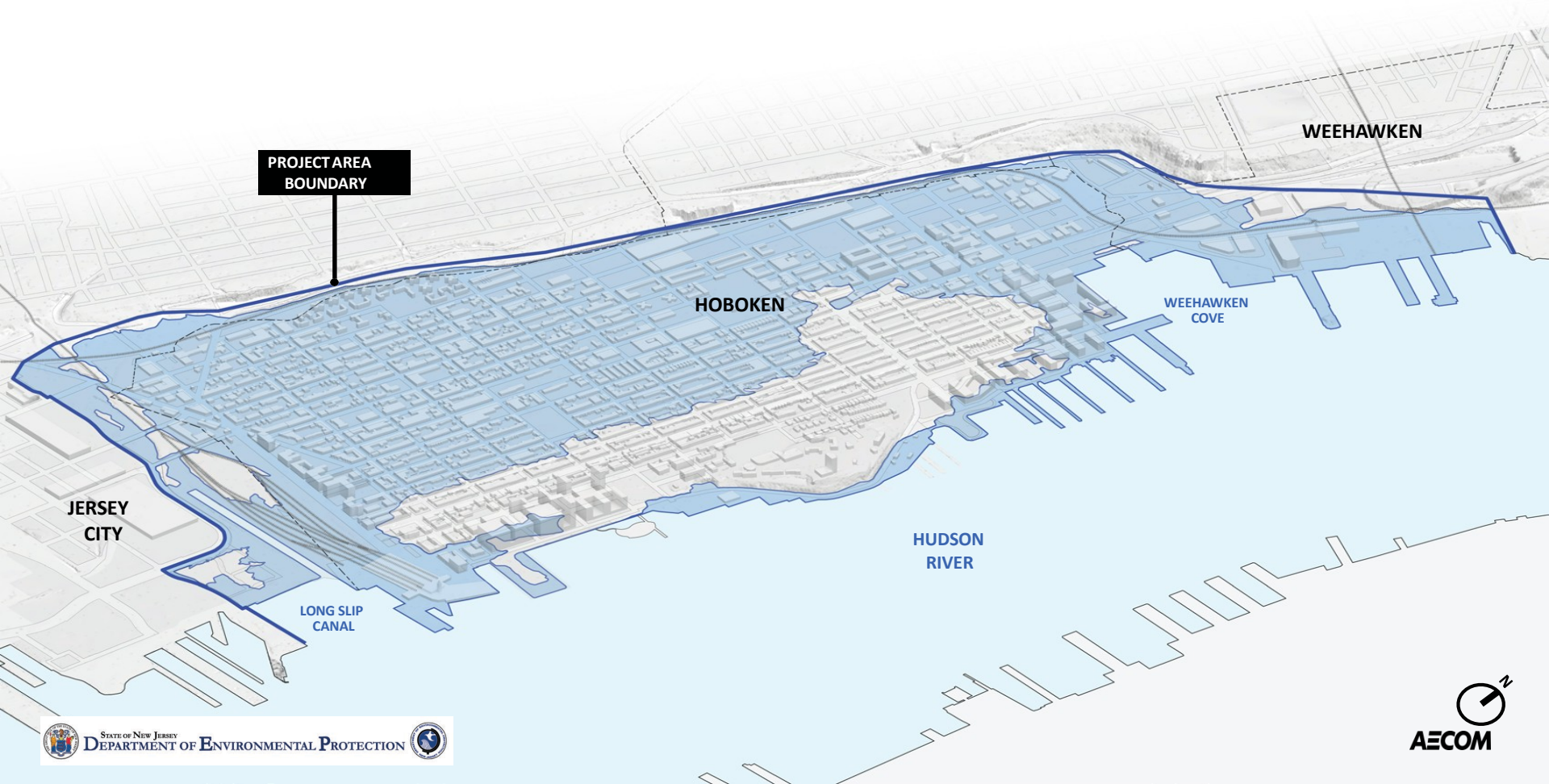
Project Area



Topography

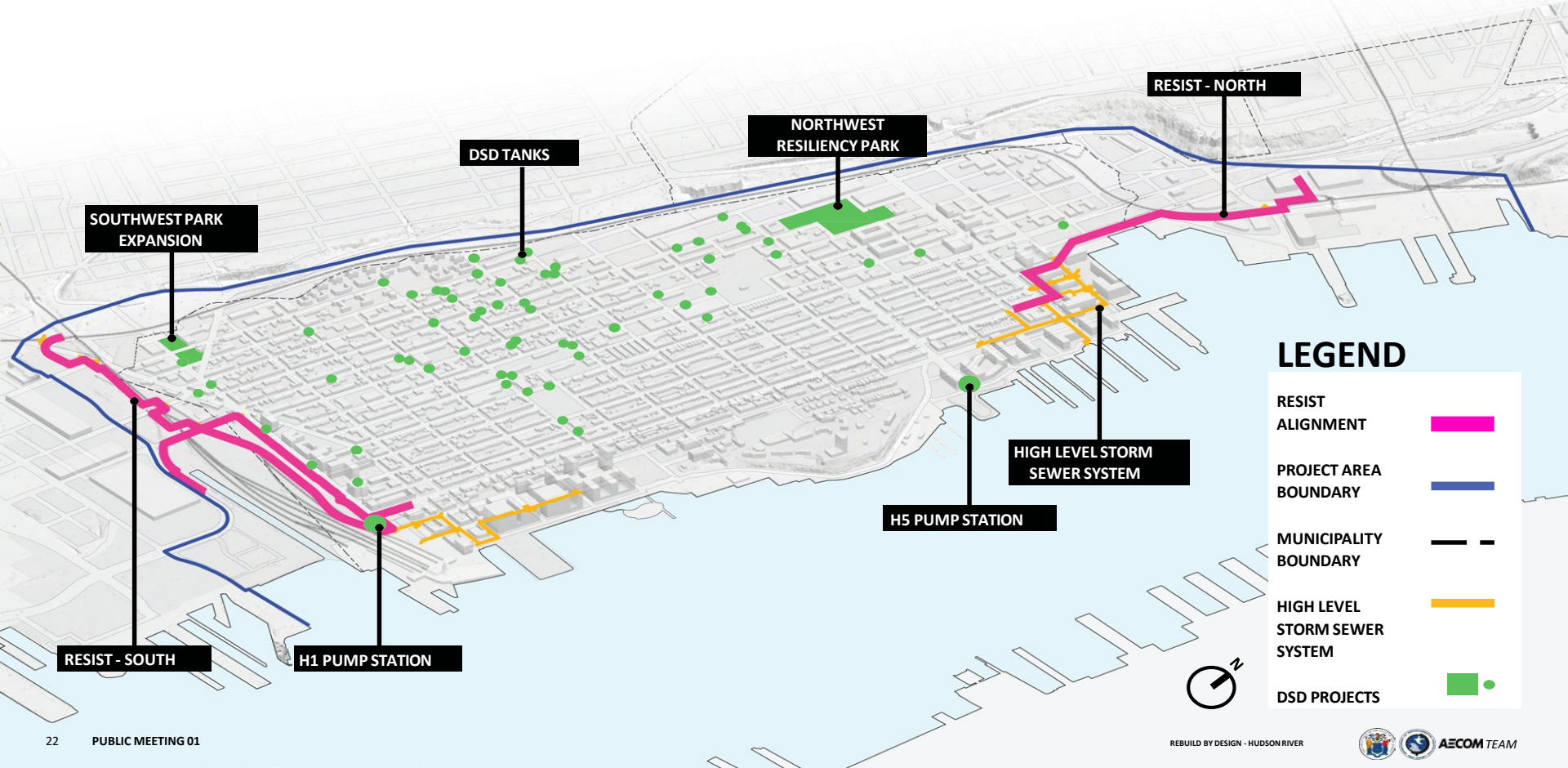

PROJECT AREA BOUNDARY
WEEHAWKEN COVE
HUDSON RIVER
LONG SLIP CANAL
LEGEND
PROJECT AREA BOUNDARY
15+ FT
10 - 15 FT
5 - 10 FT
0 - 5 FT
N
STATE OF NEW JERSEY
DEPARTMENT OF ENVIRONMENTAL PROTECTION
AECOM

100-year Floodplain



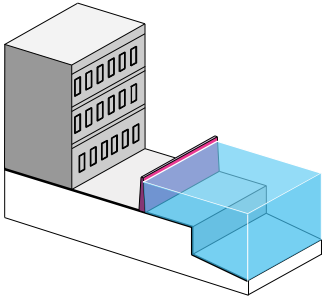
COMPREHENSIVE WATER MANAGEMENT STRATEGY

RESIST, DELAY, STORE, DISCHARGE

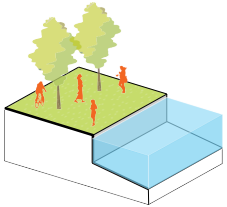


DESIGN PRINCIPLES

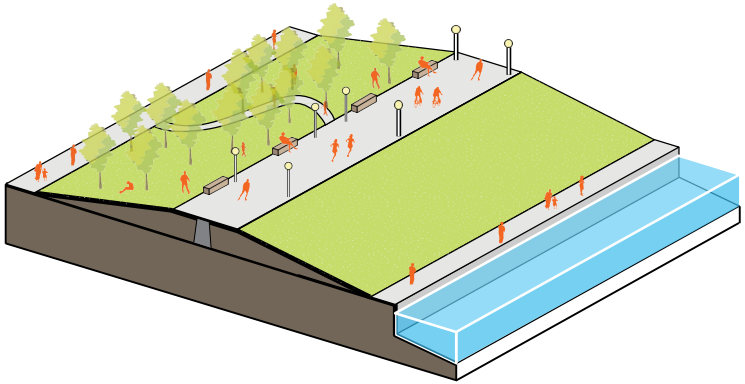
MULTI-PURPOSE



FLOOD RISK REDUCTION



PUBLIC BENEFIT



MULTI-PURPOSE FLOOD RISK REDUCTION ALIGNMENT

MULTI-PURPOSE ALIGNMENT

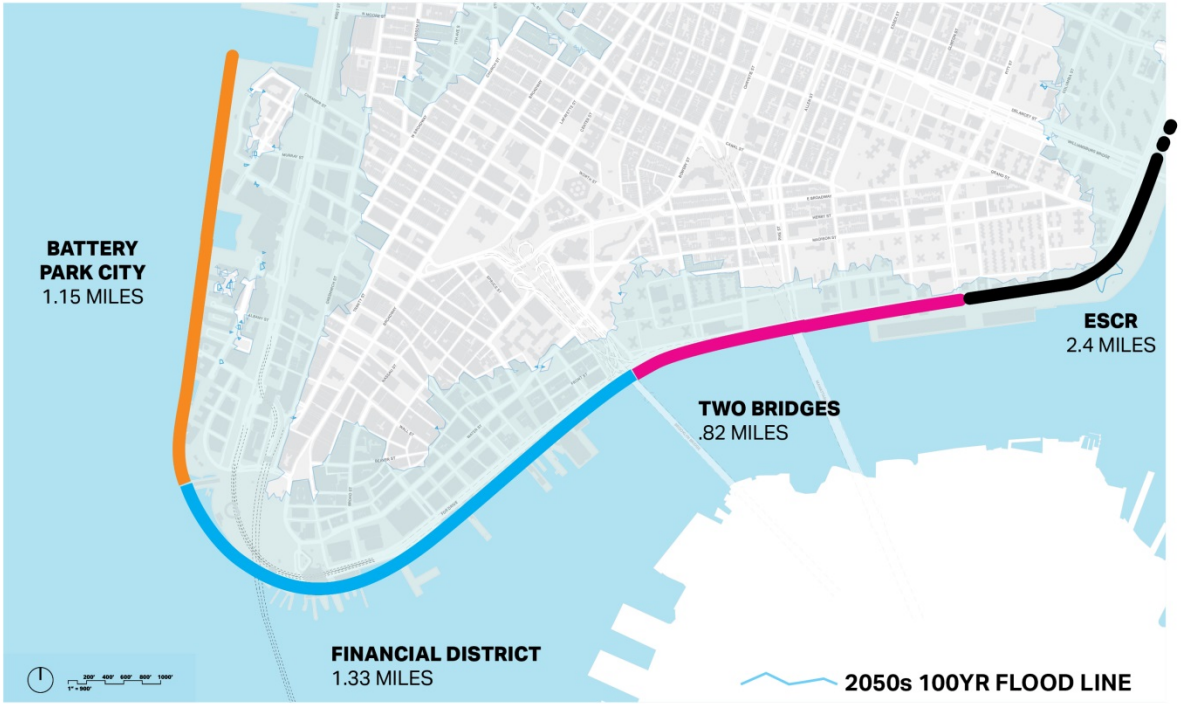
MULTI-PURPOSE ALIGNMENT

lower manhattan
COASTAL RESILIENCY

TWO BRIDGES

LMCR OVERVIEW

1. Develop long-term strategy and feasible concept design for all of Lower Manhattan
2. Prioritize project concepts toward implementation and conduct advanced planning when possible
3. Engage with community on core design principles and priorities

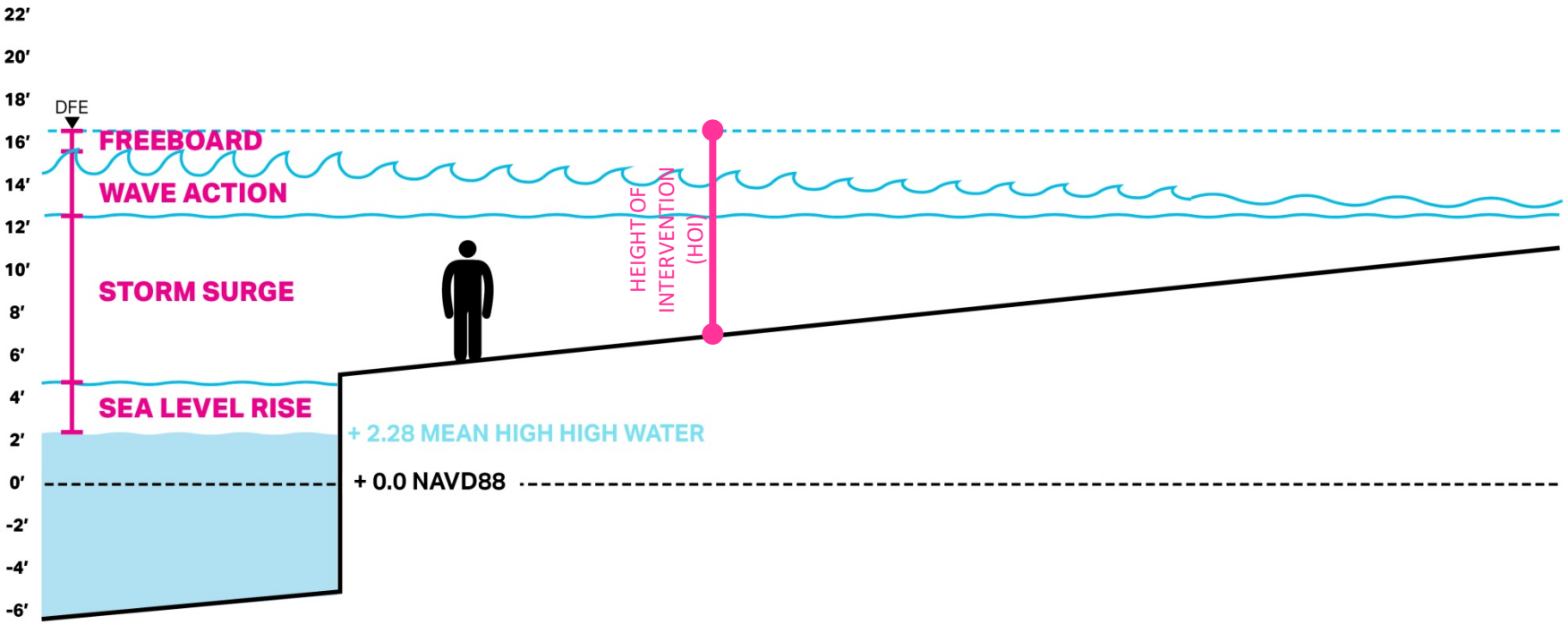


CORE MISSION

FLOOD RISK REDUCTION

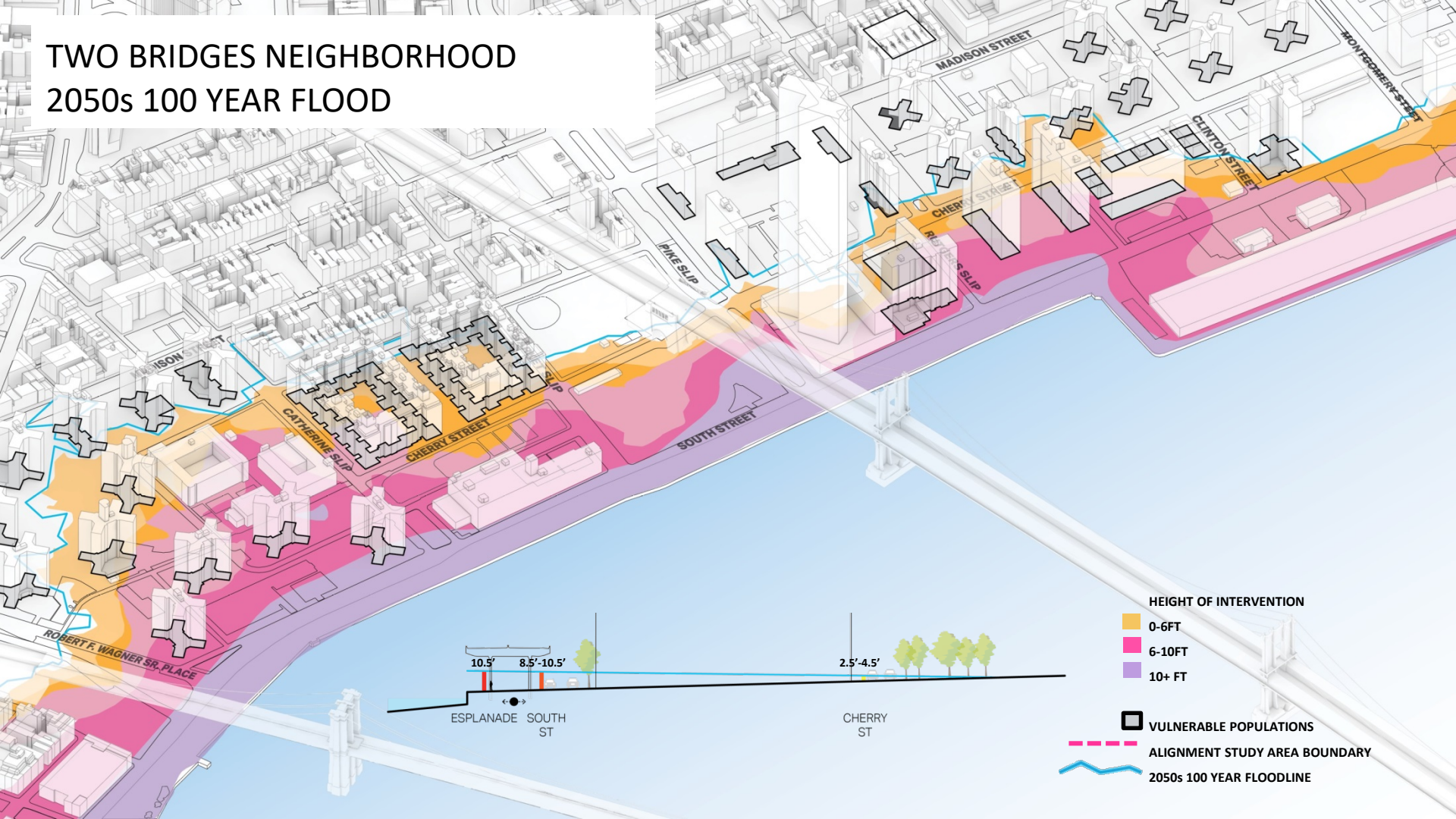
PUBLIC BENEFIT

DESIGN FLOOD ELEVATION COMPONENTS

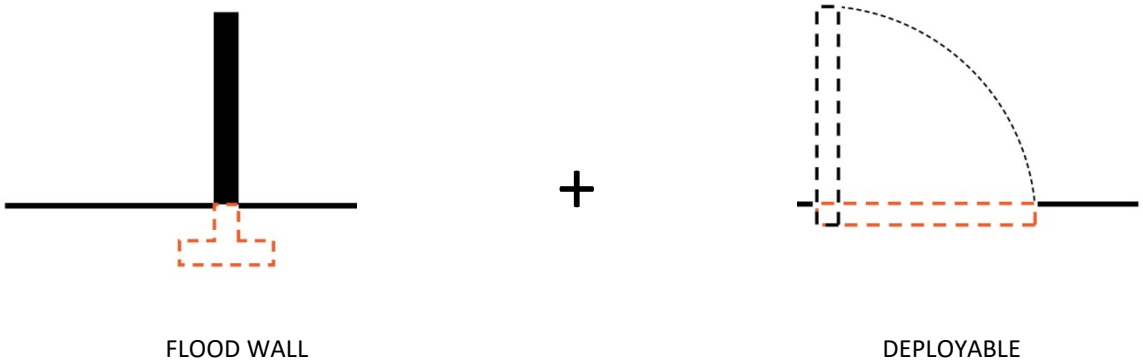


VERTICAL DATUM NAVD88

TWO BRIDGES NEIGHBORHOOD
2050s 100 YEAR FLOOD



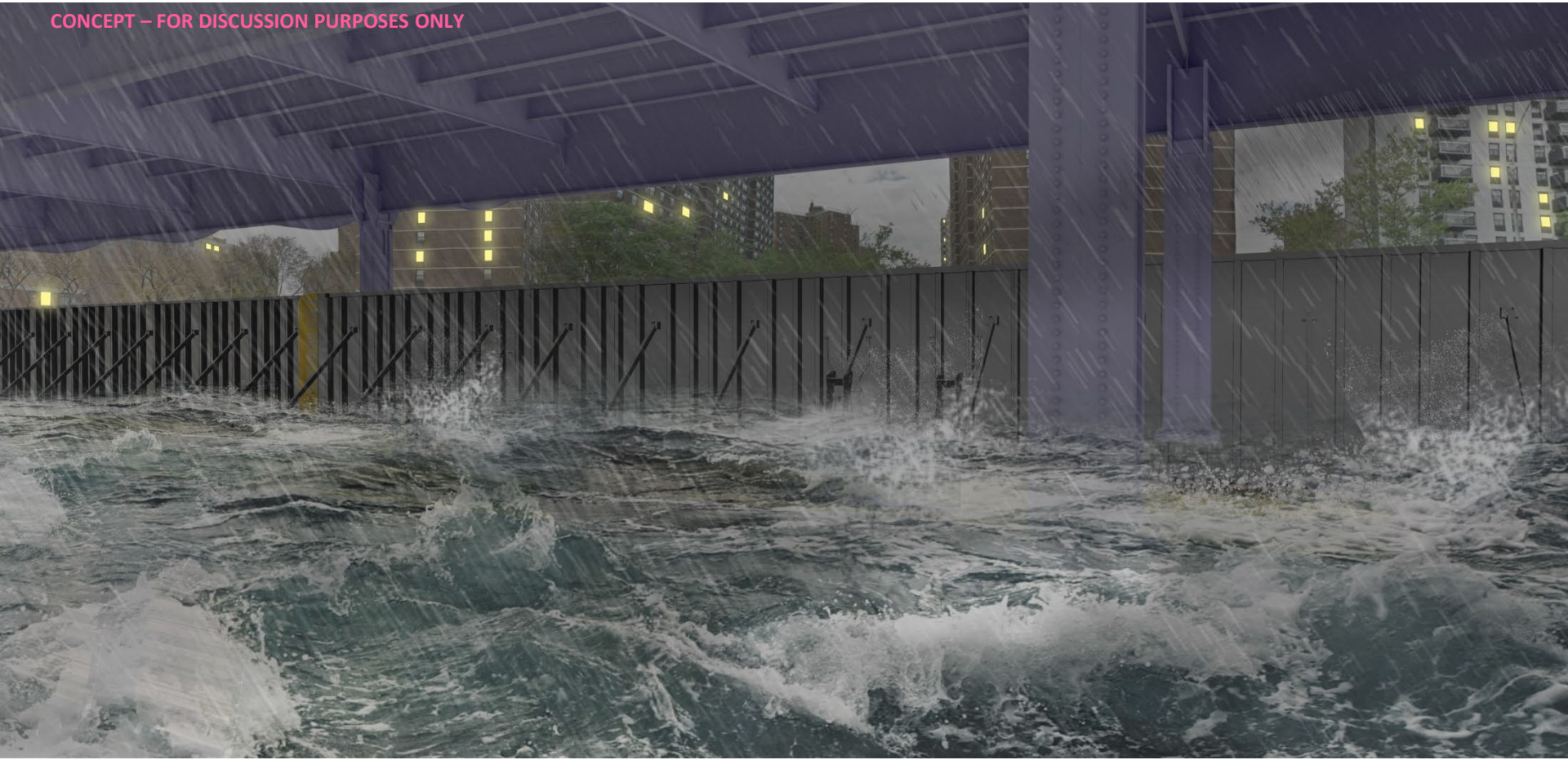
ADAPTING INFRASTRUCTURE | MAINTAIN WATERFRONT CONNECTIONS



FITNESS

FITNESS | STORM

CONCEPT – FOR DISCUSSION PURPOSES ONLY



NYC
Environmental
Protection

NYC Wastewater Resiliency Program

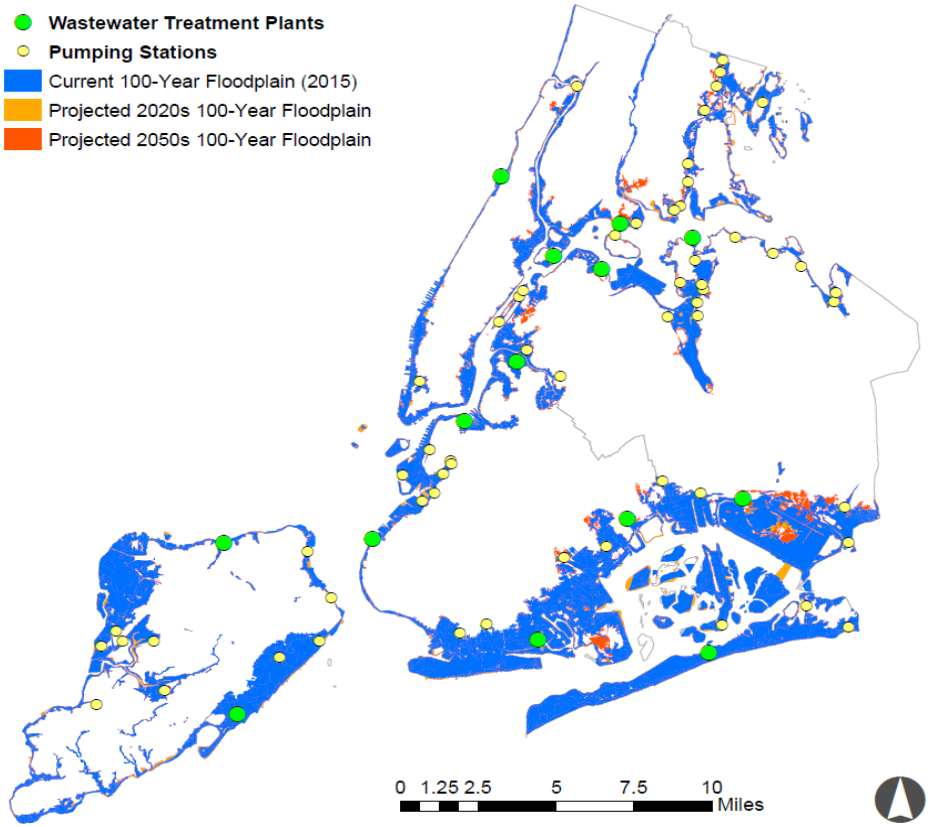
Purpose:: Harden, toughen, and repair wastewater infrastructure to protect public health and the environment

1. **SUPERSTORM SANDY RESPONSE**
   Replace Conduit and Wire that sustained disaster-related damage due to Hurricane Sandy.
2. **RESILIENCY IMPLEMENTATION**
   Implement Facility-specific protective measures based on projected flood levels for future events.

- **Upgrades at 13 Wastewater Treatment Plants and 18 Pumping Stations throughout NYC**
- **4 Design Firms and 23 Construction Contractors**
- **Multiple Funding Source management (e.g. FEMA, NY EFC/SMLP)**
- **Implementation of resiliency strategies while maintaining Wastewater Facility operations**

NYC Wastewater Resiliency | Program Overview

- **5+ years (2016-2021)**
- **$400M+ Total Program Value**
- **35 wastewater facilities** throughout New York City's **five boroughs**.
- **Implementing measures to help wastewater facilities be more resilient** and minimize disruptions to critical services during future storms.
- Design Guidelines developed to **protect critical equipment** at wastewater facilities to 100+ year Base Flood Elevations.
- DEP manages NYC's water supply and wastewater systems:
  - Supplying **one billion gallons of water** to nine million New Yorkers every day
  - Treating 1.3 billion gallons of wastewater each day
  - Operating 14 Wastewater plants and 18 Pumping Stations

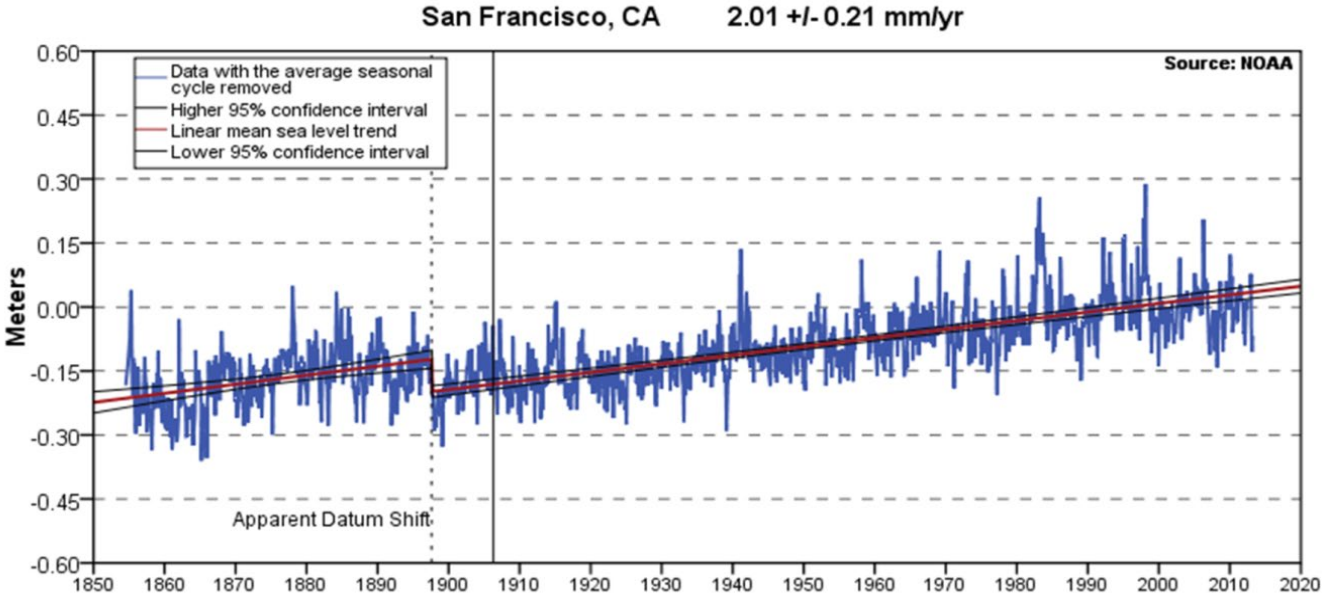


AECOM

San Francisco Public Utility Authority

Sea Level Rise (SLR) – Historical Data

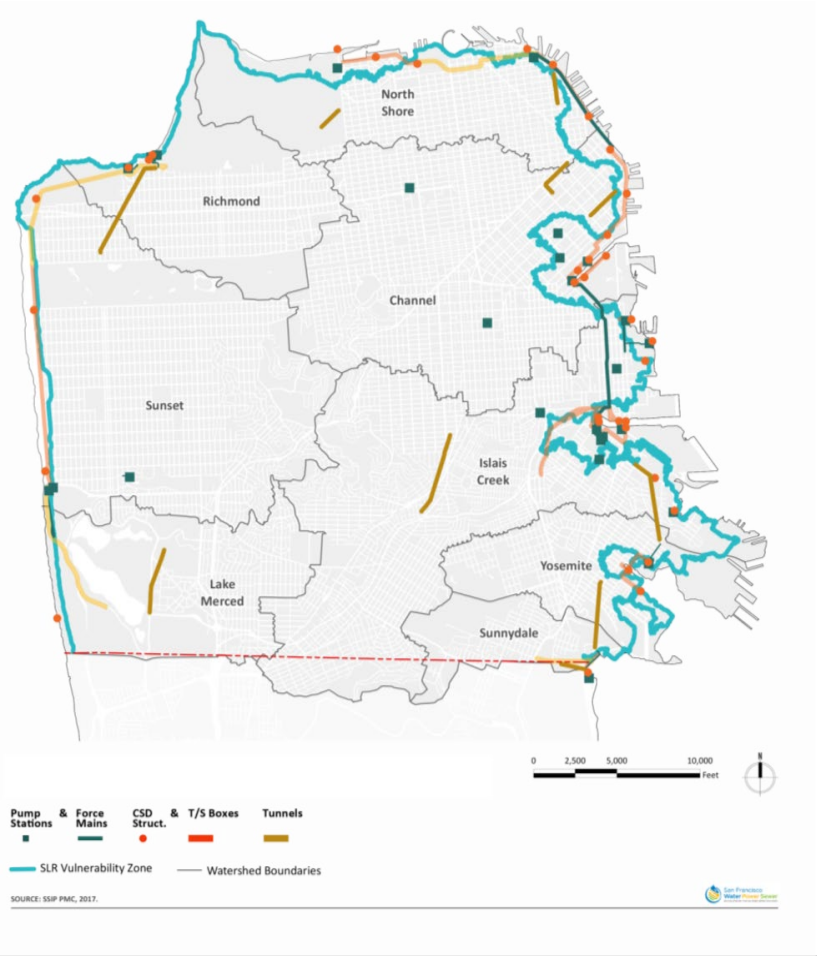
San Francisco Bay rising ~ 0.2 inches per year



Official, Adopted San Francisco Sea Level Rise Estimates

Year	Projections: Likely levels	Ranges: Unlikely but possible
2030	6 in	12 in
2050	11 in	24 in
2100	36 in	66 in

MHHW + 66” SLR + 100-Year Storm Surge



Overview Map of SFPUC Key Wastewater Enterprise Assets and Sea Level Rise Vulnerability Zone

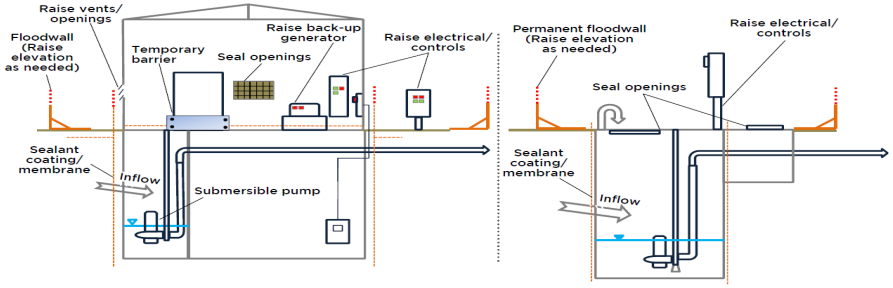
Flood Protection Strategies

Asset strategies:

- Raise key electrical and control components
- Raise and/or seal all flood pathways, including vents, louvers, vaults, windows, and conduit pathways
- Install submersible pumps and dry floodproof all water sensitive components to an elevation above potential future flood elevations
- Install wet floodproofing (e.g., temporary barriers to protect pump station from temporary flooding)

Regional strategies:

- Install permanent flood barriers (e.g., floodwalls or berms) along the shoreline or raise shoreline elevations near the asset to protect from flooding
- Coordinate with regional or city-wide sea level rise adaptation plans
- Coordinate with development and implementation of regional flood protection strategies (including shoreline management strategies from Ocean Beach Master Plan)



Above-Grade Station

Below-Grade Station

Triple Bottom Line Approach

TBL ALTERNATIVES COMPARISON SUMMARY

++	Significantly Positive
+	Positive
O	Neutral
-	Negative
--	Significantly Negative
N/A	Not Applicable

Social

- S1 System Resilience
- S2 Ratepayer Affordability
- S3 Bicycle & Pedestrian Environment
- S4 Odors
- S5 Recreation & Open Space Amenities
- S6 Employment
- S7 Cultural Resources
- S8 Noise
- S9 Construction Impacts

Environmental

- E1 Climate
- E2 Habitat
- E3 Water Use
- E4 Water Quality
- E5 Air Quality
- E6 Natural Resource Inputs

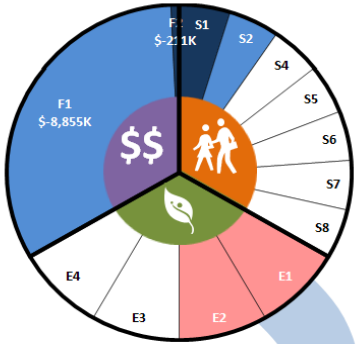
$$ Financial

- F1 Capital Costs
- F2 Operating and Maintenance Costs

Add/Remove NA | Update Results

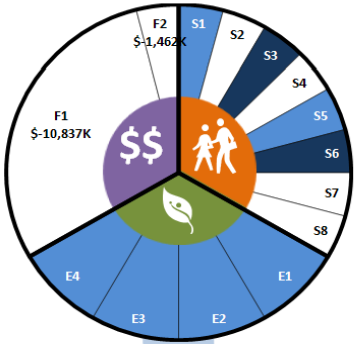
100 MGD Water Treatment Plant with 0 Green Infrastructure projects

Alt 1
Zero Green DMA Scenario



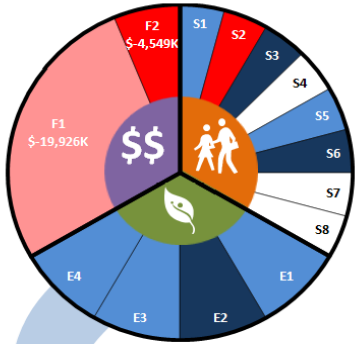
70 MGD Water Treatment Plant with 9 Green Infrastructure projects

Alt 2
100-acre Green DMA Scenario #2



50 MGD Water Treatment Plant with 19 Green Infrastructure projects

Alt 3
500-acre Green DMA Scenario



	Alt 1	Alt 2	Alt 3
CUMULATIVE BENEFITS SUMMARY			
Total CSD Volume Reduced (gals/yr)	138,000,000	139,452,091	209,993,918
Equivalent Annualized LCA NPV ($K)	($9,066)	($12,299)	($24,475)
Parks and Open Space Added or Improved (sq.ft)	0	188,496	802,568
NORMALIZED EFFICIENCY METRICS			
CSD Events Reduced Per million $ Annual Investment	0.44	0.24	0.08
CSD Reduction Per million $ Annual Investment	15,221,707	11,338,490	8,579,935
CSD Reduction Per Improved Area (gals/sf/yr)	0	740	262

More Favorable

Less Favorable

Sea Level Rise Resilience

Miami Beach, FL

AECOM

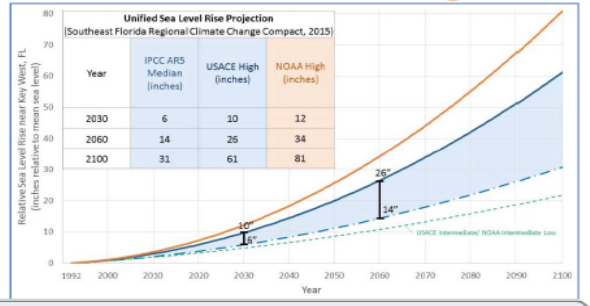
Sea Level Rise Challenges

- Higher tides
- Higher groundwater
- Increased flooding from tidal, ground & storm water
- Decreased effectiveness of aging infrastructure in corrosive conditions

Implementing Resilience in Miami Beach: Infrastructure Planning

SE FL Compact Guidance (2015)

- 2030 (short term) – low risk projects with short design life.
- 2060 (medium term) – moderate risk projects with design life < 50 years.
- 2100 (long term) – high risk and critical infrastructure projects not easily replaceable with design life > 50 years



Miami Beach Guidance

Asset type 1

- Short design life
- Low sensitivity to flooding
- High adaptive capacity
- Not critical system
- Plan for 2030-2060 (middle curve)

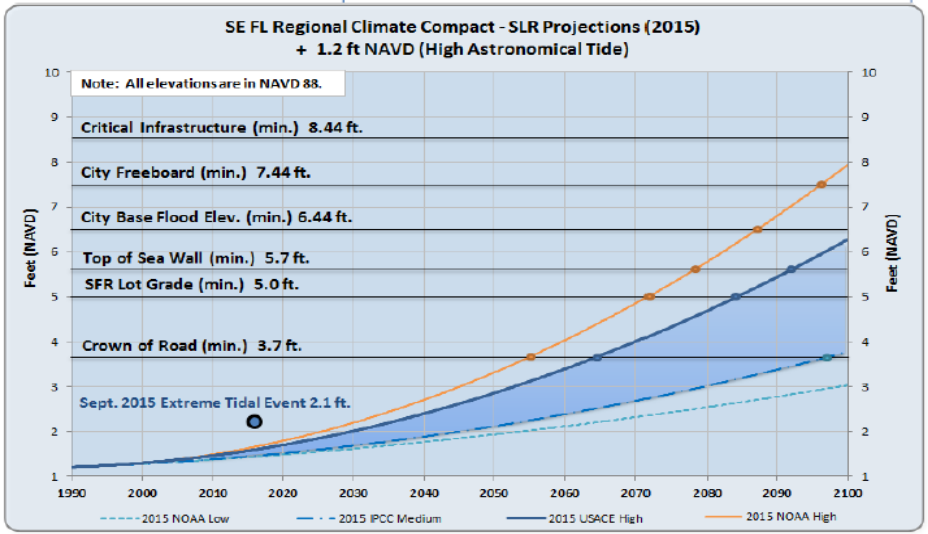
Asset type 2

- Medium-long design life
- Medium sensitivity to flooding
- Moderate adaptive capacity
- Important system
- Plan for 2060-2100 (middle curve)

Asset type 3

- Long design life
- High sensitivity to flooding
- Low adaptive capacity
- Critical system
- Plan for 2060-2100 (high curve)

Note: High Astronomical Tide, 1.2 feet NAVD, adopted by City Commission, Feb. 2014 for stormwater design.



Intent of this document: This document is intended to summarize the common vertical datums and SLR related guidance for new capital projects based on the Unified SLR Projections published by the SE FL Regional Climate Compact in 2015. This is not intended to be a design guide, but rather to relate potential SLR, tidal and surge flooding elevations to planning of future capital projects.

MIAMIBEACH RISING ABOVE

AECOM

Updated: April 10, 2017

Land Use Code Updates

AECOM

Miami Beach has adopted extensive land use amendments to guide future development to increase resilience and reduce flooding risk.

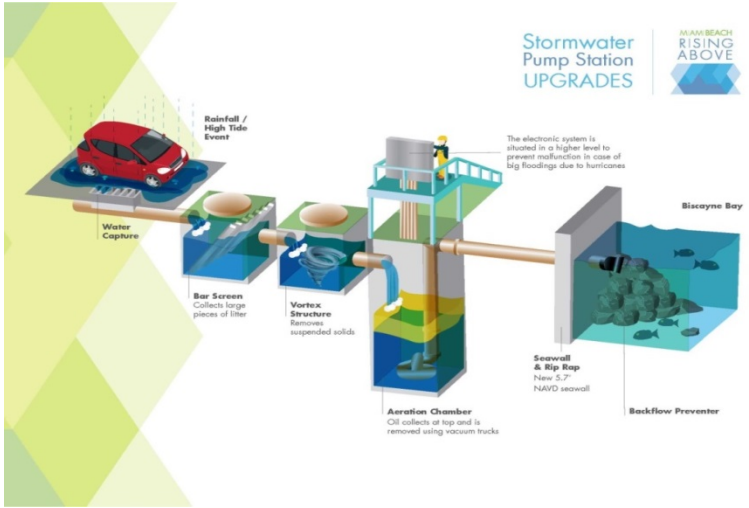
Ordinance Adopted	Summary
Feb 2014	Changes 0.5’ (NAVD) to 2.7’ (NAVD) for all tidal boundary conditions. Based on highest tidal events non-storm of 1.7’ (NAVD) .
Feb 2015	Establishes minimum elevation for crown of roads at 1’ higher to 3.7’ (NAVD) than the tail water elevation of 2.7’ (NAVD) for specific projects .
Jan 2016	Increases single-family front and side-yard set back amendments to increase green space.
May 2016	Amends Chapter 54 by establishing freeboard: a minimum 1’ and maximum 5’ above FEMA base flood elevation, or have enough headroom in to raise the floor in the future.
May 2016	Establishes a base flood elevation (BFE) of 8.0’ (NGVD) in areas that have a lower, 7.0‘, FEMA BFE.
Jun 2016	Amends Stormwater Management Master Plan to incorporate modifications to the standards for the construction of new roads, stormwater systems, and developments; which standards would incorporate higher elevations to reduce the risk of flooding; redefines the level of service and design storm; and defines minimum "future grade" and seawall heights.
Sep 2016	Amends Comprehensive Plan in order to improve the ability to mitigate the impacts of sea level rise and comply with Senate Bill 1094 by designating the city as an Adaptation Action Area.
Jul 2017	Amends RM-1 and RM-2 to include increased open space, reduced parking requirements, modifications to height, and yard elevations.
Jul 2017	Establishes sea level rise and resiliency review criteria within Land Development Regulations.
Jul 2017	Allows for buildings in Commercial and Town Center districts to be up to an additional 10’ of height, provided that the first floor has a minimum of 12’ from BFE plus maximum freeboard, to the top of the second floor slab. Also amends allowable height exceptions to incentivize sustainable roofing systems.

Adaptation Strategies

AECOM

Adaptation Strategies

AECOM



Smart Utility Standards

BOSTON

boston planning & development agency

AECOM

BOSTON SMART UTILITIES

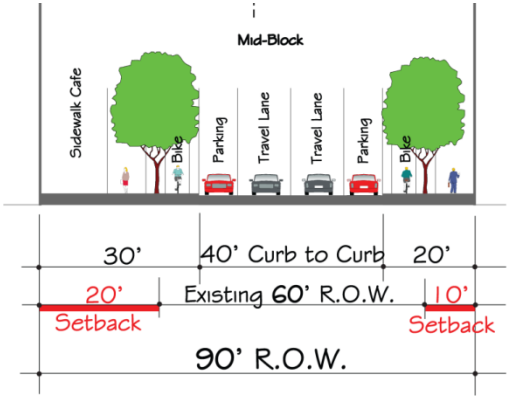
WHY SMART UTILITIES MATTER

- Increase community resilience
- Provide world-class utility services for residents and businesses
- Reduce costs for building owners and residents
- Reduce costs to build and maintain utilities and provide utilities with long-range capital planning insights
- Increase opportunities for multi-modal mobility
- Improve governing and financing strategies
- Improve collaboration between agencies and utility stakeholders

COMPLETE STREETS

PILOT PROJECT AREA

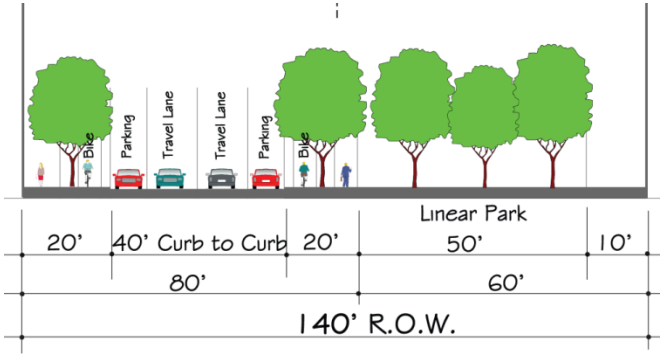
Dorchester Avenue - 90' ROW



Dorchester Avenue

Source: *PLAN South Boston, Dorchester Ave.*

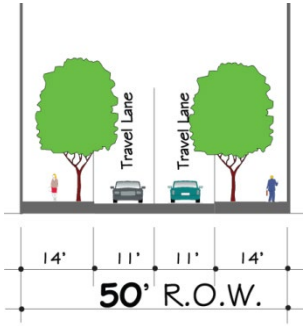
Ellery Street (new) – 140' ROW



Ellery Street (new)

Other Pilot Project Area Street Types Include:

- Preble Street – 70' ROW
- Boston Street – 70' ROW
- D Street – 80' ROW
- Southhampton Street – 90' ROW
- Old Colony Avenue – 90' ROW



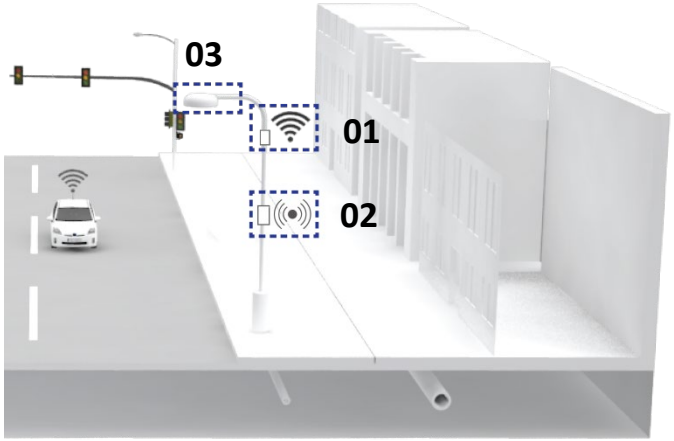
Typical East/West Street

boston planning & development agency AECOM

BOSTON SMART UTILITIES

5A. DESIGN GUIDELINES-TELECOM UTILIDOR & ADVANCED COMMUNICATIONS

Design & Equipment



01 Public Wi-Fi Access Point
02 Smart Sensors
03 Smart Streetlights

01 Public Wi-Fi Access Point:

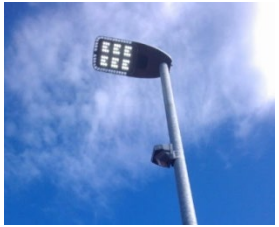
Access points are mounted on light poles and embedded in building facades. They require data connectivity and transmit Wi-Fi services to local residents and businesses, promoting equitable access to data services.

Photo: http://computer.howstuffworks.com/municipal-wifi2.htm

02 Smart Sensors:

Sensors detect changes in air quality, noise pollution, gunshot detection, and other key factors for a healthy urban environment, leading to more leveraged deployment of City resources.

Photo: https://www.utdallas.edu/news/2016/3/7-31941_Project-Aims-to-Make-Breathing-Easier-by-Mapping-A_story-wide.html



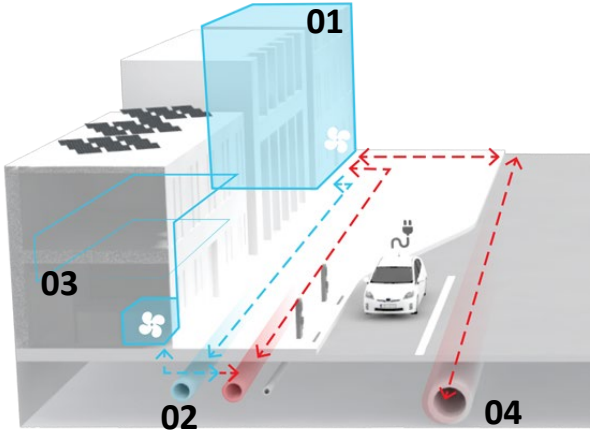
03 Smart Street Lights:

Street lighting is now designed to reduce energy consumption while maximizing safety for pedestrians and drivers. This includes retrofitting existing street lights with sensors and new streetlight units.

Photo: http://www.designboom.com/wp-content/uploads/2013/07/tvilight-smart-streetlight-shah-designboom-01.jpg

5B. DESIGN GUIDELINES – DISTRICT ENERGY MICROGRID

Design & Equipment



01 Central Energy Plant
- *-Energy Generation*
- *-Boilers / Chillers*
- *-Sewage Heat Exchange*
- *-Thermal / Electric Storage*

02 Hot & Cold Water Distribution

03 Energy Transfer Station

04 Sewage Heat Recovery

Central Energy Plant

Central Energy Plants are buildings that contain onsite power generation and microgrid switchgear. City governments like Philadelphia, San Diego and London have successfully developed infrastructure that anchor public spaces, like London's Greenwich Energy Center, a kinetic sculpture that also serves as a heat exhaust vent.

Photo: Bunhill CHP plant in Islington, London. "UNEP District Energy in Cities"

Hot and Cold Water Distribution

A network of underground pipes that deliver heating and cooling directly to buildings from low carbon, local energy source via steam, hot water and/or cold water.

Photo: district heating and cooling Handbook from International Energy Association

Energy Transfer Station replaces Boilers and Chillers [In-Building]

The Energy Transfer Station is a critical point in designing the interface between the building energy system and the district energy system. Examples are outlined in the resource below and are intended for use in the design of new building systems as well as for conversions of existing buildings. See IDEA Guidance: http://www.districtenergy.org/assets/CDEA/Best-Practice/IEA-District-Heating-and-Cooling-Connection-Handbook.pdf

Photo: https://www.comrongebrauchtefroster.de

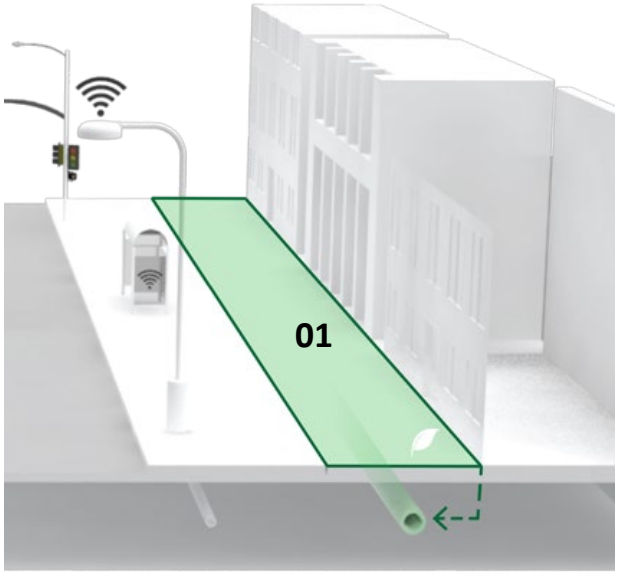
Sewage Heat Recovery

The Sewage Heat Recovery system captures heat from sewage via filters and heat pumps. The mature technologies have been deployed from the building to the district scale and are housed within the central energy plant.

Photo: http://www.greenenergyfutures.ca

5F. DESIGN GUIDELINES – GREEN INFRASTRUCTURE

Design & Equipment



01 Green Infrastructure/Permeable Pavement

01 Permeable Pavement

Permeable pavements allow stormwater runoff to infiltrate through the implemented material into the ground, where it can then be stored underground for gradual soil absorption. They are not for use in high-traffic areas and are most appropriate for greenscape and pedestrian zones. Many materials can be used including soft paving, porous unit pavers with open joints, or permeable concrete. It is typically laid with an infiltration bed and subgrade soil. Drainage characteristics of the underlying soils must be considered.

Photo: https://commons.wikimedia.org/wiki/File:Interlocking_stone.jpg

Bioretention Basins

Bioretention basins are vegetated depressions or shallow basins that capture and filter the stormwater runoff. They function by directing stormwater to the basin where it percolates through the system and can potentially be treated by a number of physical, chemical, and biological processes.

Photo: https://www.flickr.com/photos/8729782@N03/9753768921

Bioretention Planters

Bioretention planters are planted depressions within enclosed structures that can capture and slow the rate of runoff from surrounding paved surfaces and areas, while enhancing the streetscape. They combine engineered stormwater control with plantings that can improve water quality. The basic design includes structural walls and curbs, underdrains to keep water from building up in the soil, and an overflow pipe to control excess flow and prevent flooding. Drains and overflows are typically connected into nearby storm drains with open bottoms to allow for infiltration.

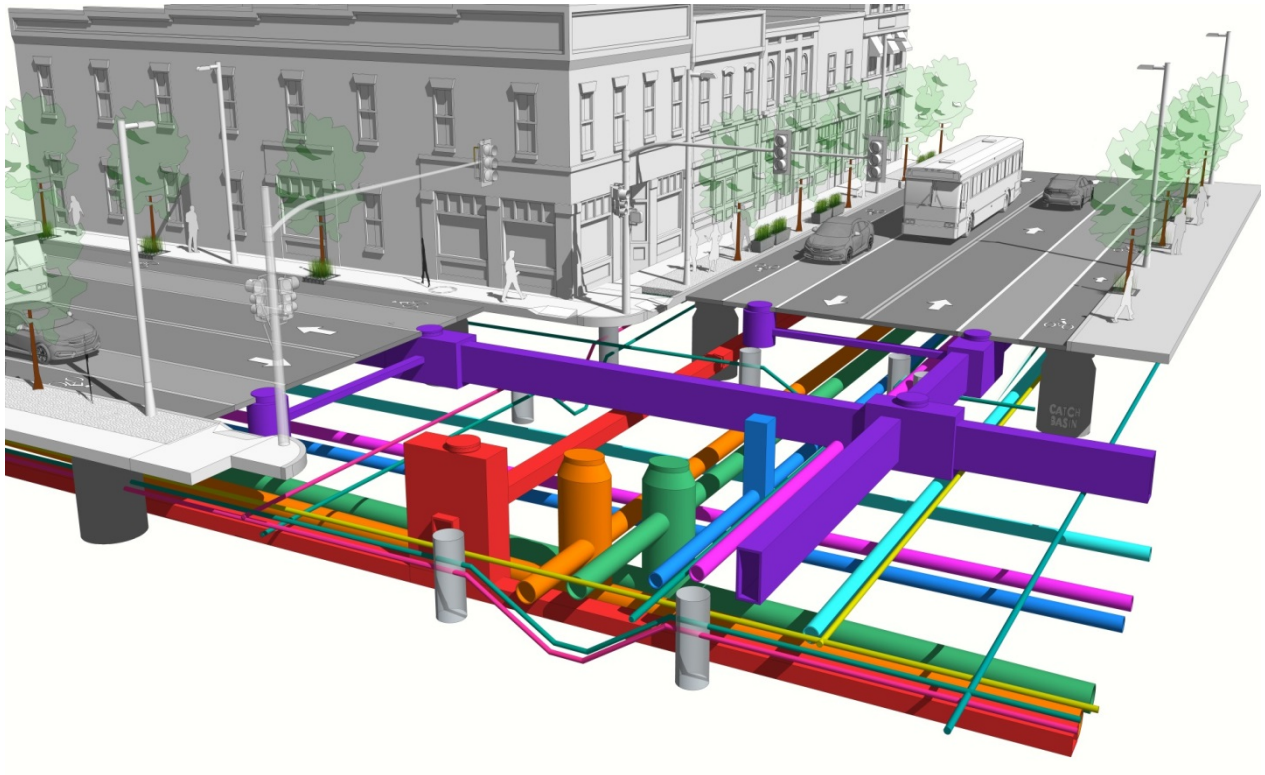
Photo: http://www.stormwaterpartners.com/lid/Techniques/bioretention.html

Downspout Disconnection

Downspout disconnections reroute drainage pipes from draining rainwater into the storm sewer and promote drainage into rain barrels, cisterns, and other permeable areas. They also, provide the ability to store stormwater or promote stormwater infiltration into the soil.

Photo: https://commons.wikimedia.org/wiki/File:2006NeighborsNewRG2.JPG

5H. DESIGN GUIDELINES - INTERSECTIONS



With the proper planning and coordination between stakeholders, Smart Utility Technologies can be successfully integrated into the existing utility-busy streets of Boston, even at the location for the most potential horizontal and vertical conflicts: Intersections.

Legend

- Electrical Duct Bank
- Sewer
- Storm Drainage
- Water
- Street Lighting
- Traffic Signal
- Gas
- Telecom Utilidor
- Smart Sensors
- District Chilled Water
- District Hot Water
- Biorentention Planter
- Permeable Pavement
- Infiltration Bed
- Bioretention Basin

Superstorm Sandy Storm Waves at Rockaway Beach, NY

Source: plaNYC: A Stronger, More Resilient New York, 2013

AECOM
Imagine it.
Delivered.