NEW JERSEY
NEW YORK
SAN FRANCISCO
MIAMI
BOSTON
REBUILD BY DESIGN
MEADOWLANDS
HURRICANE SANDY

1,700
HOMEOWNERS
SUSTAINED DAMAGE

3,500
RESIDENTS HAD TO BE EVACUATED
REBUILD BY DESIGN: COMPETITION & AWARD
U.S. DEPARTMENT OF HOUSING & URBAN DEVELOPMENT

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

EXISTING FLOODPLAIN

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

1. MAJOR STORM SURGE Flooding

2. 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
FLUVIAL PARK
CENTRAL HACKENSACK NORTH

• 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

APPLYING THE “KIT OF PARTS”

- BOARDWALK
- BERM
- PROPOSED TIDE GATE
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
Post-Sandy 2012
Post-Sandy 2012
Nor’easter 2018
Topography

PROJECT AREA BOUNDARY

LEGEND

PROJECT AREA BOUNDARY

15+ FT
10 - 15 FT
5 - 10 FT
0 - 5 FT
COMPREHENSIVE WATER MANAGEMENT STRATEGY
RESIST, DELAY, STORE, DISCHARGE

SOUTHWEST PARK EXPANSION
DSD TANKS
NORTHWEST RESILIENCY PARK
H5 PUMP STATION

LEGEND
RESIST
ALIGNMENT
PROJECT AREA BOUNDARY
MUNICIPALITY BOUNDARY
HIGH LEVEL STORM SEWER SYSTEM
DSD PROJECTS

RESIST - SOUTH
RESIST - NORTH
H1 PUMP STATION
HIGH LEVEL STORM SEWER SYSTEM
NORTHWEST RESILIENCY PARK
DSD TANKS
SOUTHWEST PARK EXPANSION
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
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

- FREEBOARD
- WAVE ACTION
- STORM SURGE
- SEA LEVEL RISE
- HEIGHT OF INTERVENTION (HOI)
- + 2.28 MEAN HIGH HIGH WATER
- + 0.0 NAVD88
TWO BRIDGES NEIGHBORHOOD
2050s 100 YEAR FLOOD

HEIGHT OF INTERVENTION
0-6FT
6-10FT
10+ FT

VULNERABLE POPULATIONS
ALIGNMENT STUDY AREA BOUNDARY
2050s 100 YEAR FLOODLINE

10.5' 8.5'-10.5' 2.5'-4.5'

ESPLANADE SOUTH ST CHERRY ST
ADAPTING INFRASTRUCTURE | MAINTAIN WATERFRONT CONNECTIONS

FLOOD WALL + DEPLOYABLE
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
Sea Level Rise (SLR) – Historical Data

San Francisco Bay rising ~ 0.2 inches per year

Source: NOAA
Official, Adopted San Francisco Sea Level Rise Estimates

<table>
<thead>
<tr>
<th>Year</th>
<th>Projections: Likely levels</th>
<th>Ranges: Unlikely but possible</th>
</tr>
</thead>
<tbody>
<tr>
<td>2030</td>
<td>6 in</td>
<td>12 in</td>
</tr>
<tr>
<td>2050</td>
<td>11 in</td>
<td>24 in</td>
</tr>
<tr>
<td>2100</td>
<td>36 in</td>
<td>66 in</td>
</tr>
</tbody>
</table>
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)
Triple Bottom Line Approach

### Alt 1: Zero Green DMA Scenario
- **E1:** Staffing
- **E2:** Energy
- **E3:** Water Use
- **E4:** Water Quality
- **E5:** Air Quality
- **E6:** Natural Resource Inputs

#### Financials
- **F1:** Capital Costs
- **F2:** Operating and Maintenance Costs

#### Cumulative Benefits Summary
- **Total CSD Volume Reduced (gals/yr):** 138,000,000
- **Equivalent Annualized LCA NPV ($K):** $9,066
- **Parks and Open Space Added or Improved (sq.ft):** 0
- **CSD Events Reduced Per million $ Annual Investment:** 0.44
- **CSD Reduction Per million $ Annual Investment:** 15,221,707
- **CSD Reduction Per Improved Area (gals/ft/yr):** 0

### Alt 2: 100-acre Green DMA Scenario #2
- **E1:** Staffing
- **E2:** Energy
- **E3:** Water Use
- **E4:** Water Quality
- **E5:** Air Quality
- **E6:** Natural Resource Inputs

#### Financials
- **F1:** Capital Costs
- **F2:** Operating and Maintenance Costs

#### Cumulative Benefits Summary
- **Total CSD Volume Reduced (gals/yr):** 139,452,091
- **Equivalent Annualized LCA NPV ($K):** $12,299
- **Parks and Open Space Added or Improved (sq.ft):** 0
- **CSD Events Reduced Per million $ Annual Investment:** 0.24
- **CSD Reduction Per million $ Annual Investment:** 11,338,490
- **CSD Reduction Per Improved Area (gals/ft/yr):** 740

### Alt 3: 500-acre Green DMA Scenario
- **E1:** Staffing
- **E2:** Energy
- **E3:** Water Use
- **E4:** Water Quality
- **E5:** Air Quality
- **E6:** Natural Resource Inputs

#### Financials
- **F1:** Capital Costs
- **F2:** Operating and Maintenance Costs

#### Cumulative Benefits Summary
- **Total CSD Volume Reduced (gals/yr):** 209,993,918
- **Equivalent Annualized LCA NPV ($K):** $24,475
- **Parks and Open Space Added or Improved (sq.ft):** 802,568
- **CSD Events Reduced Per million $ Annual Investment:** 0.08
- **CSD Reduction Per million $ Annual Investment:** 8,579,935
- **CSD Reduction Per Improved Area (gals/ft/yr):** 262
Sea Level Rise Resilience
Miami Beach, FL
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.

SE FL Regional Climate Compact - SLR Projections (2015)
+ 1.2 ft NAVD (High Astronomical Tide)

Intent of this document: This document is intended to summarize the common vertical datum 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.

Updated: April 10, 2017
## Land Use Code Updates

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

<table>
<thead>
<tr>
<th>Ordinance Adopted</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feb 2014</td>
<td>Changes 0.5’ (NAVD) to 2.7’ (NAVD) for all tidal boundary conditions. Based on highest tidal events non-storm of 1.7’ (NAVD).</td>
</tr>
<tr>
<td>Feb 2015</td>
<td>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.</td>
</tr>
<tr>
<td>Jan 2016</td>
<td>Increases single-family front and side-yard set back amendments to increase green space.</td>
</tr>
<tr>
<td>May 2016</td>
<td>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.</td>
</tr>
<tr>
<td>May 2016</td>
<td>Establishes a base flood elevation (BFE) of 8.0’ (NGVD) in areas that have a lower, 7.0’, FEMA BFE.</td>
</tr>
<tr>
<td>Jun 2016</td>
<td>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 &quot;future grade&quot; and seawall heights.</td>
</tr>
<tr>
<td>Sep 2016</td>
<td>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.</td>
</tr>
<tr>
<td>Jul 2017</td>
<td>Amends RM-1 and RM-2 to include increased open space, reduced parking requirements, modifications to height, and yard elevations.</td>
</tr>
<tr>
<td>Jul 2017</td>
<td>Establishes sea level rise and resiliency review criteria within Land Development Regulations.</td>
</tr>
<tr>
<td>Jul 2017</td>
<td>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.</td>
</tr>
</tbody>
</table>
Adaptation Strategies

**Before**

SEPTEMBER 2011

**After**

OCTOBER 2017
Adaptation Strategies
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

Ellery Street (new) – 140’ ROW

Other Pilot Project Area Street Types Include:

- Preble Street – 70’ ROW
- Boston Street – 70’ ROW
- D Street – 80’ ROW
- Southampton Street – 90’ ROW
- Old Colony Avenue – 90’ ROW

Typical East/West Street
Design & Equipment

**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.


**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.

5B. DESIGN GUIDELINES – DISTRICT ENERGY MICROGRID

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
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@N03/9753766821

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.
Resilient [ri-zil-yuhnt] adj.
1. Able to bounce back after change or adversity.
2. Capable of preparing for, responding to, and recovering from difficult conditions.

Syn.: TOUGH
See also: New York City
