Safeguarding Vital Wastewater Infrastructure: A Strategic Risk and Triple-Bottom Line Adaptation Framework

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Climate Change Planning

Since 2007, NYCDEP has been proactively investigating the impacts of climate change on its infrastructure…

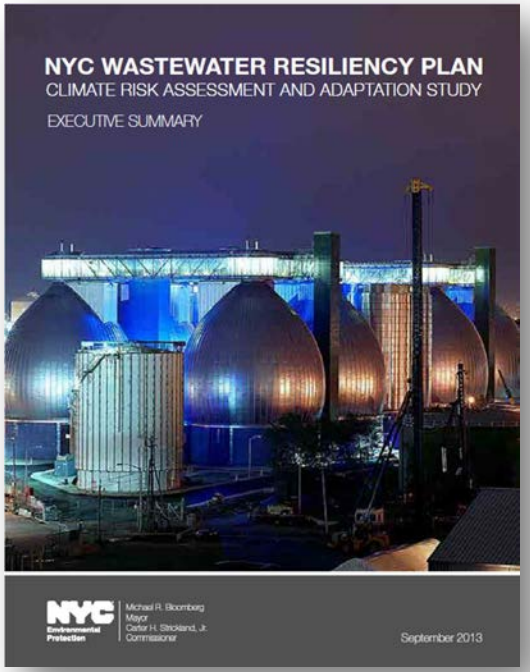
Goal of the Study

Provide a roadmap to

enhance the flood resiliency of DEP wastewater infrastructure

considering existing vulnerabilities, cost, and level of protection

- Give a sense of the options and level of effort
- Support funding applications
- Provide preliminary analysis for future design projects

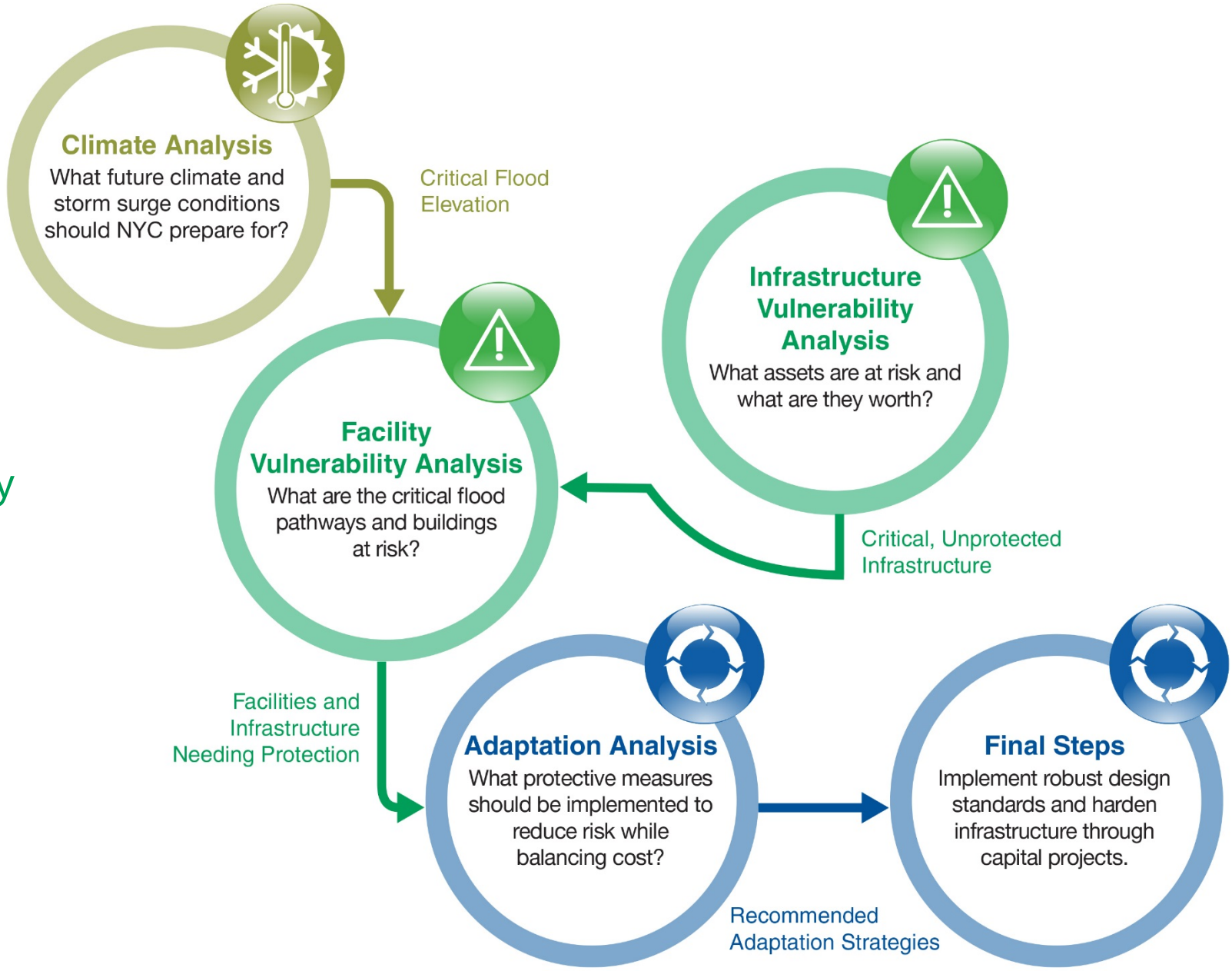


Study Framework

Phase 1
Climate Analysis

Phase 2
Vulnerability Analysis

Phase 3
Adaptation Analysis



Phase 1: Climate Analysis

Establish the Design Flood Elevation

Design Flood Elevation = **Current Surge Projections** + **Future Sea Level Rise**

- We chose 100 year ABFE + 30” Sea Level Rise (from NPCC) as a conservative level

- FEMA
- USGS
- State and Municipal

- IPCC
- NPCC
- Local research institutions

NPCC Seal Level Rise Projections:

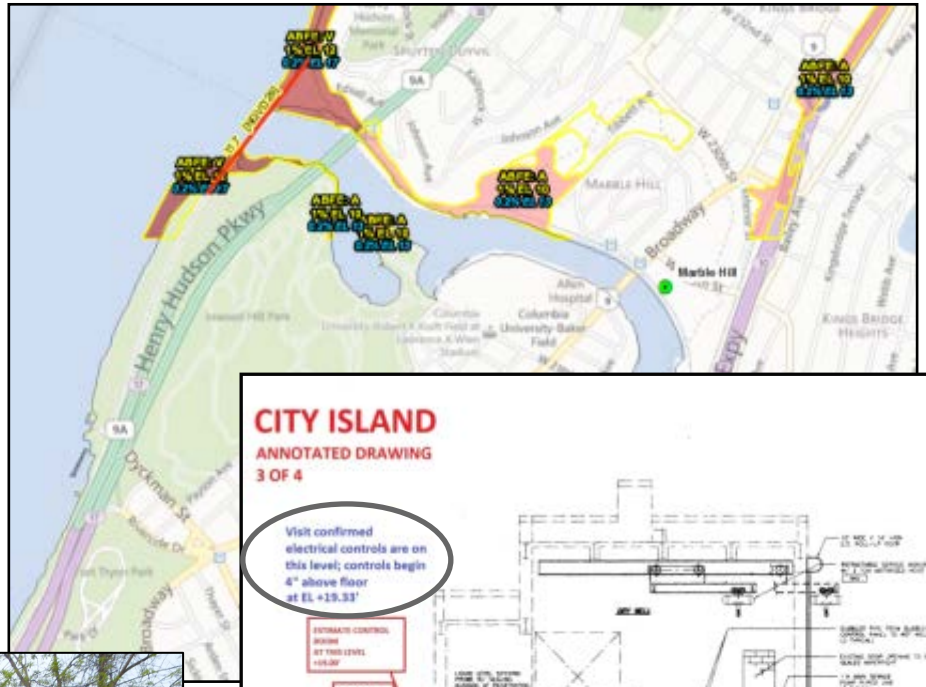
Sea Level Rise Baseline (2000 – 2004)	Low-estimate (10th percentile)	Middle range (25th to 75th percentile)	High-estimate (90th percentile)
2020s	+ 2 in	+ 4 in to 8 in	+ 10 in
2050s	+ 8 in	+ 11 in to 21 in	+ 30 in
2080s	+ 13 in	+ 18 in to 39 in	+ 58 in
2100	+ 15 in	+ 22 in to 50 in	+ 75 in

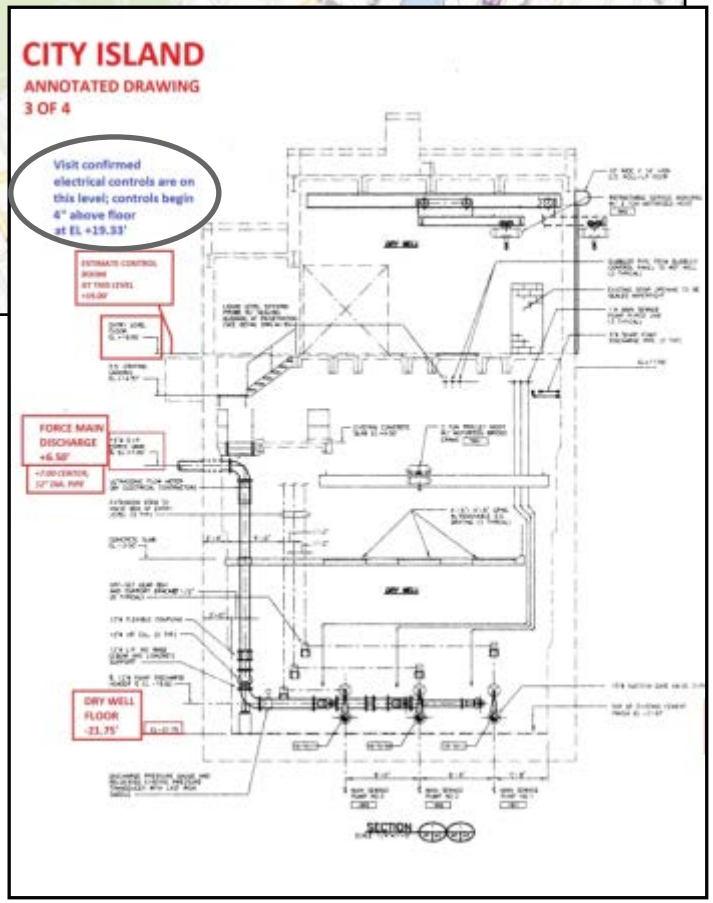
WWTP Assigned Flood Elevations

WWTP Name	Sandy	FEMA 100-yr ABFE + 30 inches SLR		
	NAVD88 (ft)	NAVD88 (ft)	Local Datum (ft)	
26th Ward	12.6	13.5	12.9	Brooklyn-Sewer
Bowery Bay	11.6	15.5	13.9	Queens
Coney Island	10.1	15.5	14.0	Brooklyn-Highway
Hunts Point	10.2	17.5	16.0	Bronx
Jamaica	None	13.5	11.9	Queens
Newtown Creek	10.0	13.5	12.0	Brooklyn-Highway
North River	9.7	12.5	10.8	Manhattan
Port Richmond	12.1	14.5	12.4	Staten Island
Oakwood Beach	13.1	16.5	14.4	Staten Island
Owls Head	13.5	14.5	13.0	Brooklyn-Highway
Red Hook	11.7	14.5	13.0	Brooklyn-Highway
Rockaway	11.4	14.5	12.9	Queens
Tallman Island	10.1	15.5	13.9	Queens
Wards Island	10.7	17.5	15.8	Manhattan

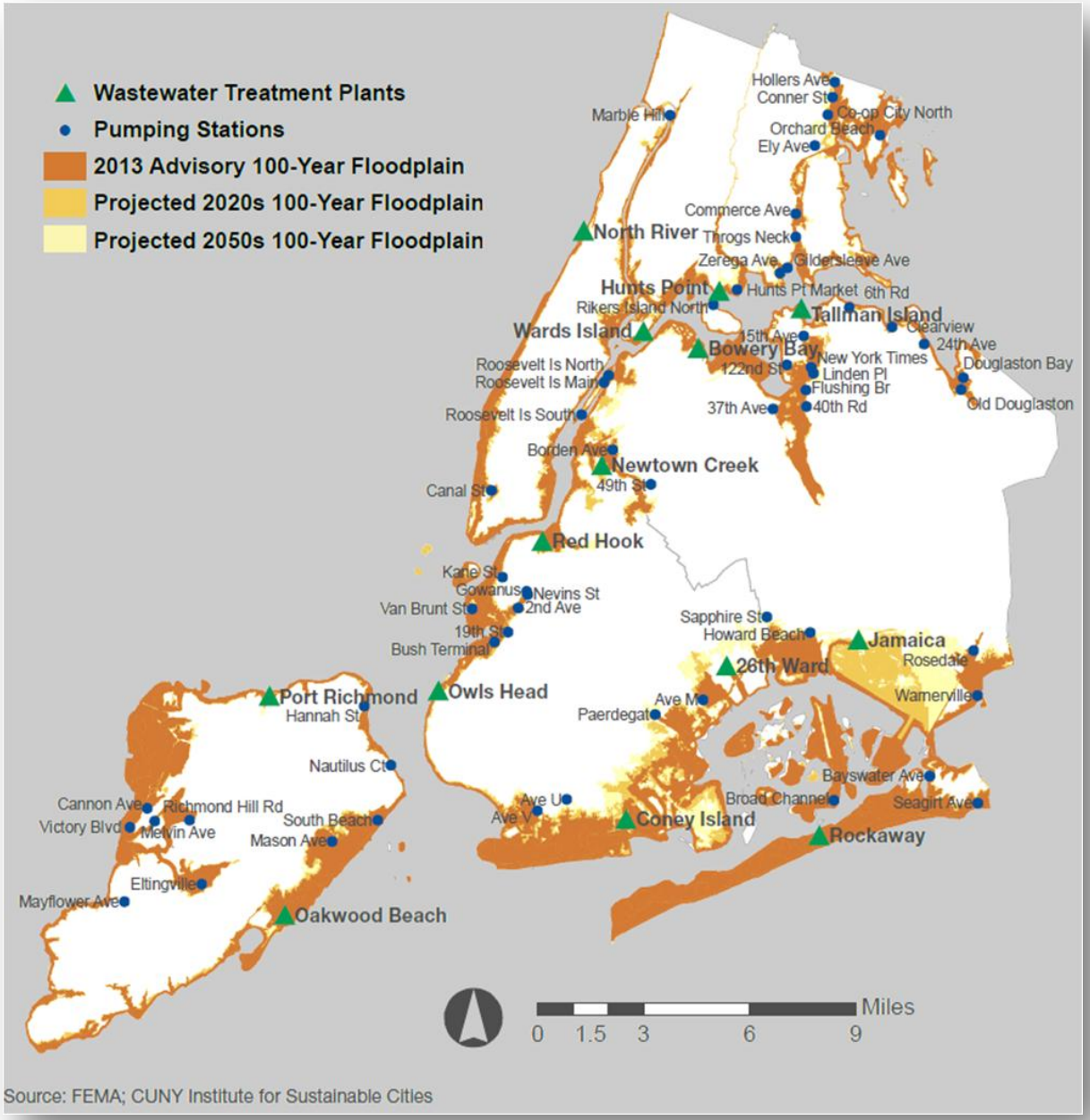
Phase 2: Vulnerability Analysis

- Establish logical breakdown of facilities
- FEMA floodplain and terrain analysis
- Staff interviews and facility walkthroughs documenting pathways and assets
- Drawings to compare threshold/asset elevations with flood elevations
- Impacts and criticalities





Vulnerability Results

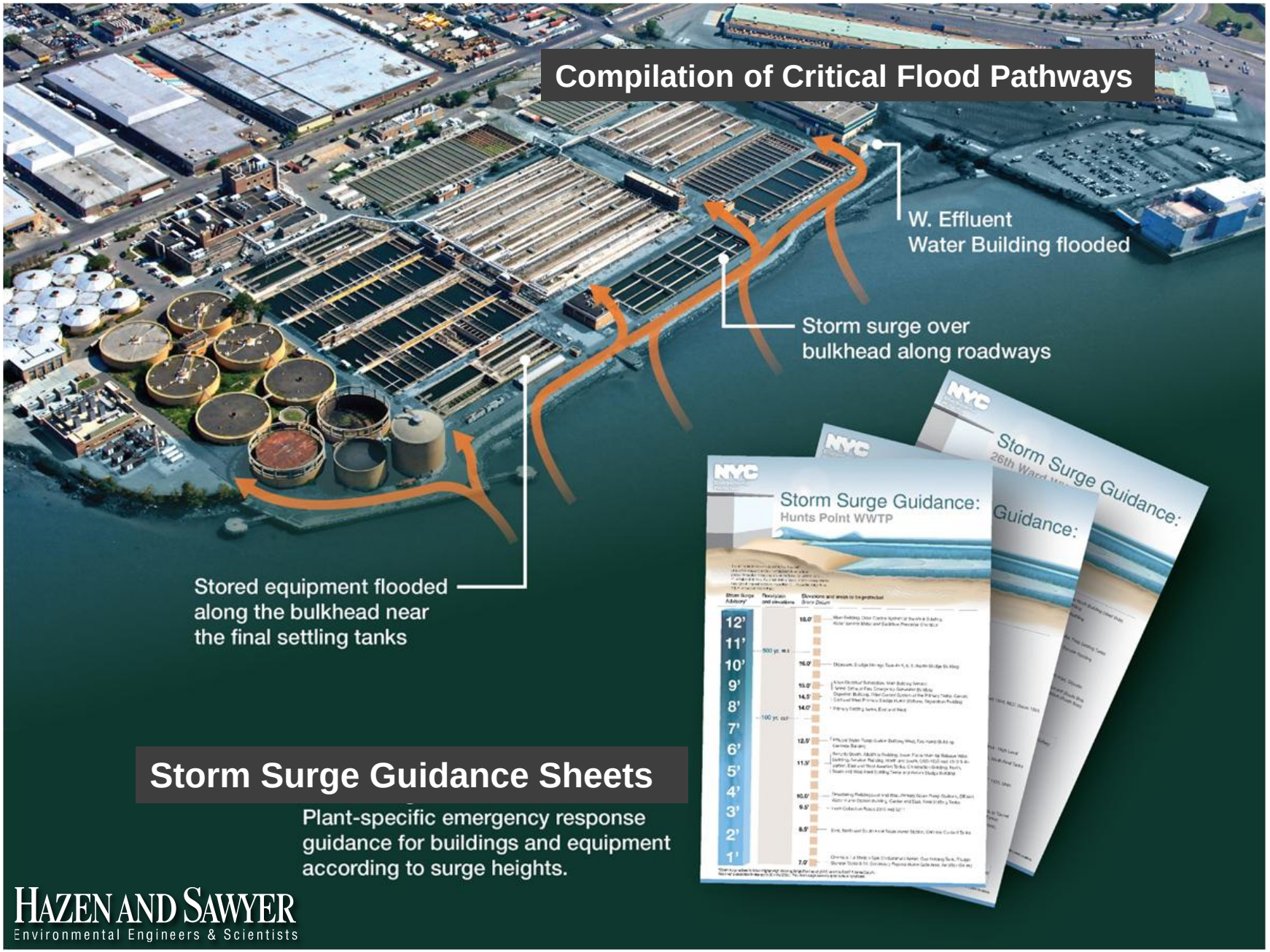


- All 14 wastewater treatment plants and 60% of pumping stations are at risk.

Vulnerability Costs

Impacts Beaches?	WWTP	Locations At Risk w/ Primary	TOTAL	
			Asset Quantity	No Action Cost
Y	Hunts Point	19	3,804	$201.4 M
Y	Coney Island	6	1,204	$84.9 M
Y	Rockaway	8	689	$49.3 M
Y	26th Ward	5	1,244	$82.4 M
Y	Oakwood Beach	5	353	$21.0 M
Y	Jamaica	0	1	$1.7 M
	Tier 1 TOTAL	**43**	**7,295**	**$440.7 M**
N	Bowery Bay	15	1,215	$112.6 M
N	North River	1	2,251	$94.1 M
N	Red Hook	7	1,281	$67.4 M
N	Owls Head	9	762	$48.4 M
N	Port Richmond	5	536	$54.8 M
N	Tallman Island	5	773	$45.2 M
N	Newtown Creek	5	382	$28.8 M
N	Wards Island	1	46	$8.7 M
	14 Plant TOTAL	**91**	**14,541**	**$901 M**

Storm Surge Guidance Resources



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Environmental Engineers & Scientists

Phase 3: Adaptation Analysis

Asset Level

Building Level

Adaptation Strategy	Resiliency/Effectiveness	Cost
 **Elevate Equipment** on pads or platforms, to a higher floor, to the roof, or to a new elevated building.		$$$$
 **Flood-Proof Equipment** by replacing pumps with submersible pumps and installing watertight boxes around electrical equipment.		$$$
 **Install Static Barrier** across critical flood pathways or around critical areas.		$$$
 **Seal Building** with water-tight doors and windows, elevating vents and secondary entrances for access during a flood event.		$$
 **Sandbag Temporarily** around doorways, vents, and windows before a surge event.		$
 **Install Backup Power** via generators nearby or a plug for a portable generator.	*Does not protect equipment but facilitates rapid service recovery.*	$$$

- Potential access and hydraulic limitations
- Expensive unless replacement done at end of pump service life
- Temporary stop logs or permanent berms / wall around area/site.
- Not feasible for roll-up doors. Requires secondary elevated access / egress
- Not suitable for flood depths greater than 4'. Requires storage provisions.

Assign Feasibility & Cost for each Strategy/Location

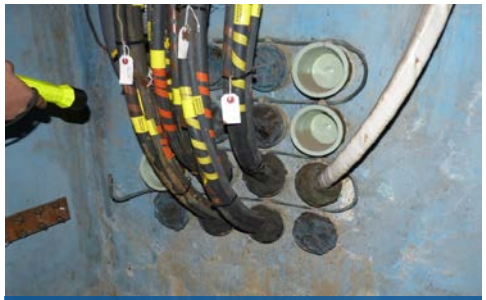
Rollup Doors

Doorways & Windows

Areaways

Tunnels

Grates



Electrical Conduits and Manholes

Others: open process tanks, outfalls, storm drains and plant drains, wet well, temporary building material, and interconnected buildings

Develop Adaptation Selection Criteria

➢ Keep in mind:

- Typically, the more protection, the higher the cost
- Assess the level of risk acceptable for each level of criticality

For Example:

High Criticality:

- Flood-proof or elevate critical assets where possible
- If not all critical assets can be protected or there is more than 15% risk remaining across the location, provide a building level strategy

Moderate Criticality:

- Provide the most cost-effective mix of strategies (lowest CBR)

Low Criticality:

- Provide the most cost-effective mix of strategies, however if none of the strategies have a CBR lower than 1, opt to Do Nothing

Develop Adaptation Selection Criteria

➢ Keep in mind:

- Typically, the more protection, the higher the cost
- Assess the level of risk acceptable for each level of criticality

For Example:

How do we calculate these values?

High Criticality:

- Flood-proof or elevate critical assets where possible
- If not all critical assets can be protected or there is more than **15% risk remaining** across the location, provide a building level strategy

Moderate Criticality:

- Provide the most cost-effective mix of strategies (lowest **CBR**)

Low Criticality:

- Provide the most cost-effective mix of strategies, however if none of the strategies have a **CBR** lower than 1, opt to Do Nothing

Perform Calculations and Selection Process

$$\textbf{CBR} = \frac{\text{COST}}{\text{BENEFIT}} = \frac{\text{Cost of Implementing Adaptation Strategy}}{\textbf{Risk Avoided} \text{ with Implementation of Strategy}}$$

- Like insurance companies, we use risk calculations. Although we cannot predict the future, we can estimate what we **expect to pay out** based on 3 factors:
  1. Probability of flooding
  2. Likelihood that the strategy will withstand a flood
  3. Potential damage

- **Risk Avoided =** (1) Risk without Protection **-** (2) Risk with Protection

Perform Calculations and Selection Process

1 Annual Risk without Strategy Implementation

= No Action Damage Cost x Annual Probability of Flood Event

Post Storm Clean-Up and In-Kind Asset Replacement

Annual Probability of 100-year storm = 0.01

This risk is incurred every year, so bring this value (A) to **present value**:

$$PV = A * \frac{(1+i)^n - 1}{i * (1+i)^n}$$

n = 50 years
i = 0.03

Perform Calculations and Selection Process

2 Annual Risk with Strategy Implementation

= No Action Damage Cost x Annual Probability of Flood Event x ***Probability of Strategy Failure during Flood Event***

Strategy	Probability of Failure	Explanation of Probability of Failure
No-Action	100%	
Building-Level Strategies		
Sandbagging	15%	Human element, may overtop
Seal Building	10%	Difficult to detect all building penetrations
Install Temporary Barrier	10%	Minor leakage through stop log access, difficult to detect all building penetrations
Construct Static Barrier	5%	Minor leakage through stop log access, Blowout
Asset-Level Strategies		
Floodproof Equipment	5%	May exceed rated pressure, Seals weaken over time
Elevate Equipment	< 1%	If elevated to 100-yr flood height, only risk from larger storms

Perform Calculations and Selection Process

- **Risk Avoided**

  = PV of Risk without Strategy **–** PV of Risk with Strategy

  1 2

$$\textbf{CBR} = \frac{\text{COST}}{\text{BENEFIT}} = \frac{\text{Cost of Implementing Adaptation Strategy}}{\text{Risk Avoided with Implementation of Strategy}}$$

- **Risk Remaining**

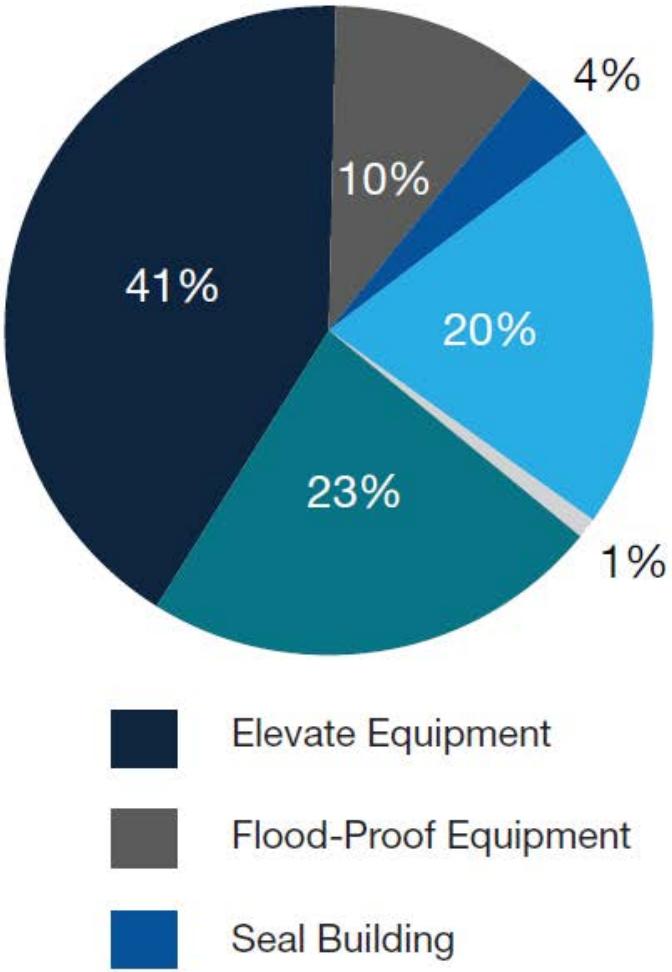
  = PV of Risk with Strategy / PV of Risk without Strategy

Review Selections at Plant and Planning Level

- Remember to not get lost in the weeds.
  - Internal pathways and inter-connections between buildings
  - Power system and plant as a whole
  - Programmatic changes, safe spaces, access
  - Adaptive management
- Leverage existing and planned capital projects
- Account for long-term change
  - Are the recommendations adaptable for future conditions?
  - What type of continued research/actions are needed in the future to ensure continued resilience?

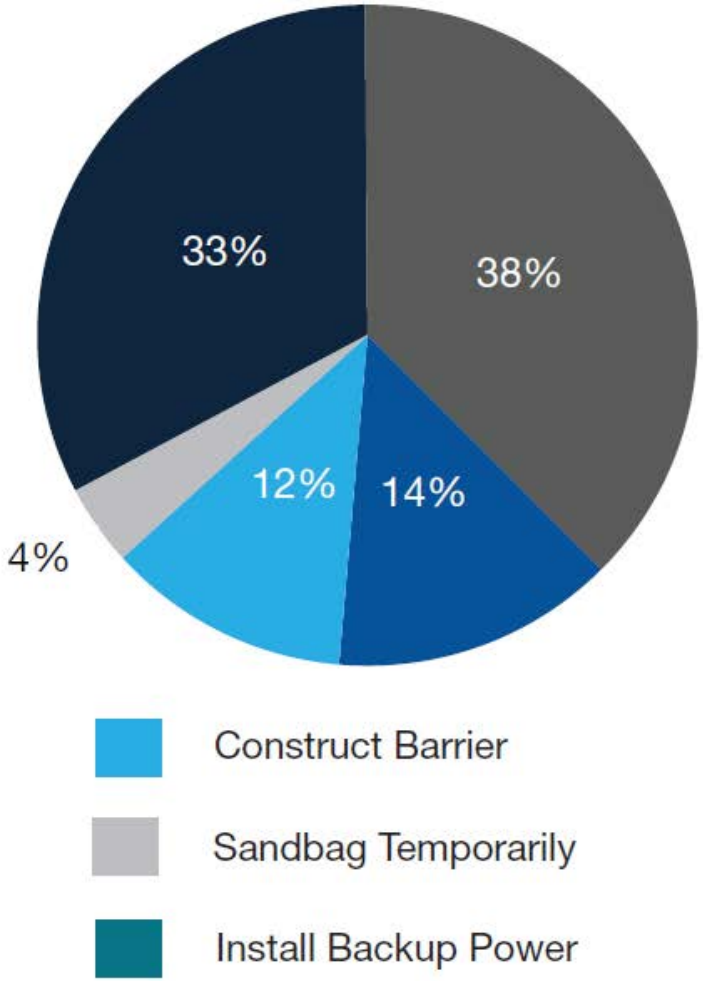
Recommended Adaptation Strategy Allocations

Pumping Stations

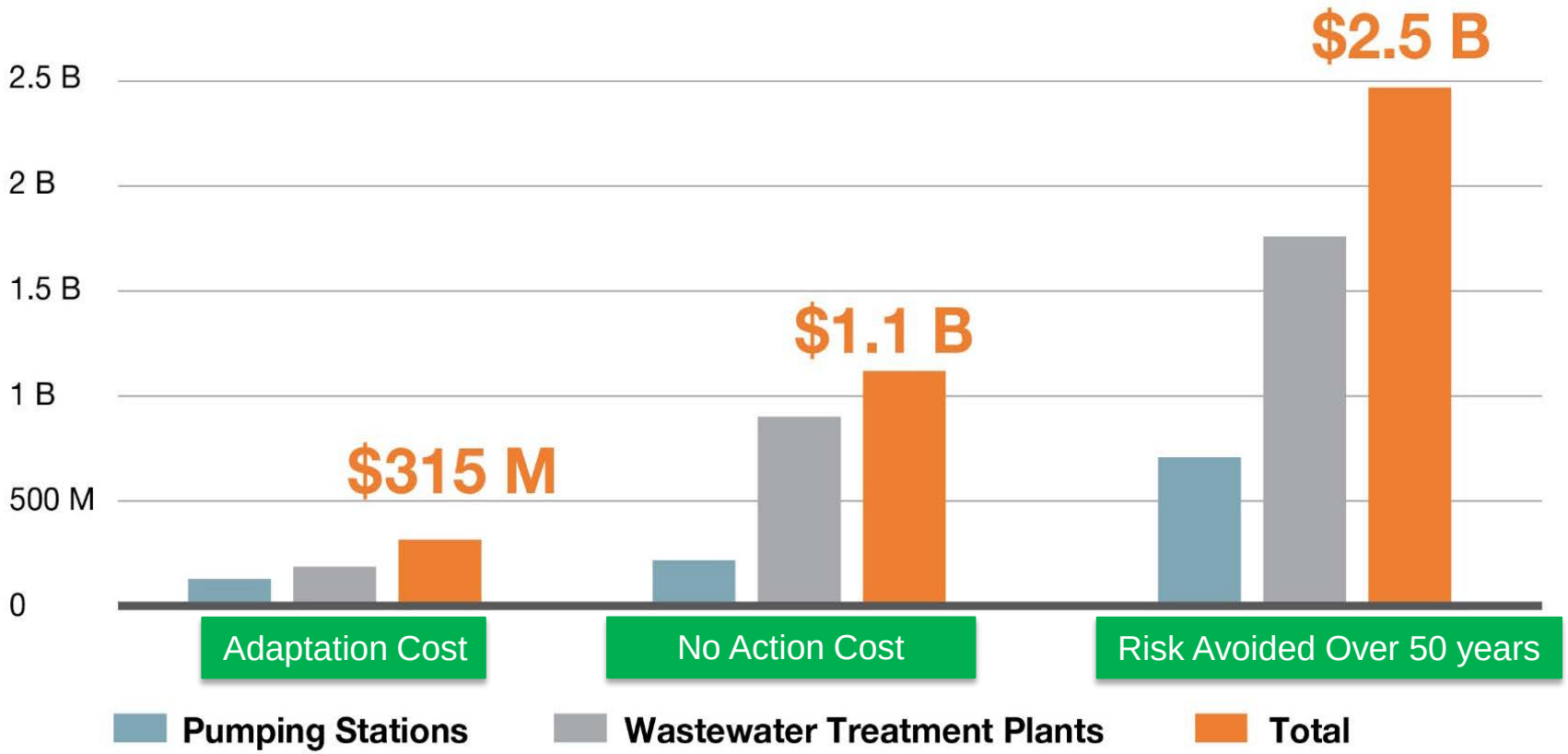


Wastewater Treatment Plants

Note: All facilities are already equipped with backup power generators



Summary of Costs



Investing **$315 Million** in strategic fortification can safeguard **$1.1 Billion** of vital infrastructure and save the city **$2.5 Billion** in emergency response costs over the next 50 years.

All estimates are based on AACE Level 5 Cost Estimate guidelines as noted in the NYCDEP BEDC Cost Estimating Manual.

Prioritization Approach

Prioritization considered against seven metrics:

1. Historical Frequency of Flooding
2. Historical Loss of Power
3. PS Tied in with Other PS (Daisy Chained or Grouped)

Operational Metrics

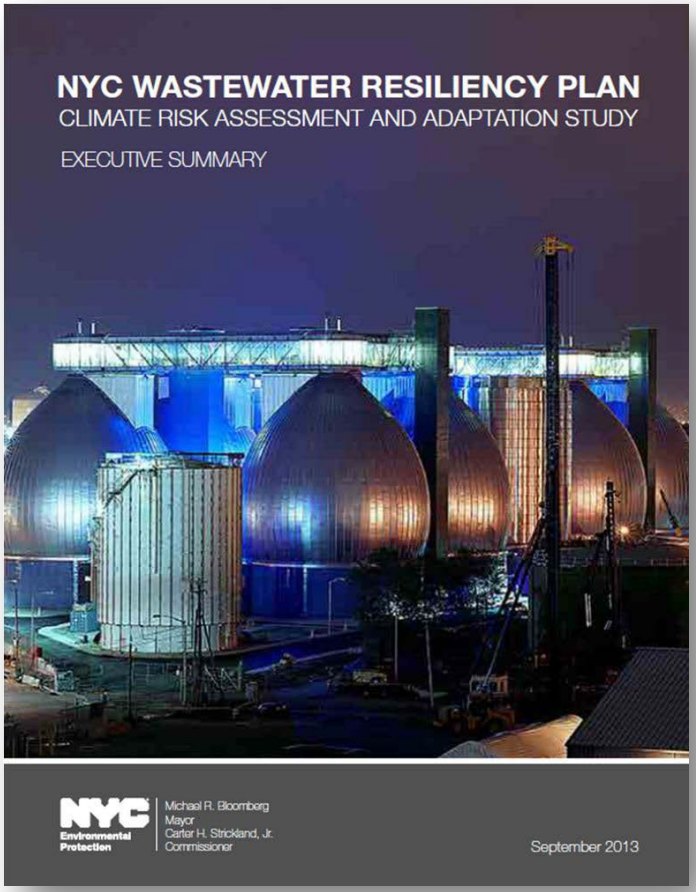
4. Tributary Area Population Impacted
5. Number of Critical Facilities Impacted
6. Beaches Impacted

Vulnerability Metrics

7. Included in DEP's 10 year Capital Plan

Other Metrics

Questions?



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