Climate Change Impacts and Resiliency
Lessons Learned from Hurricane Sandy (and Hurricane Irene)

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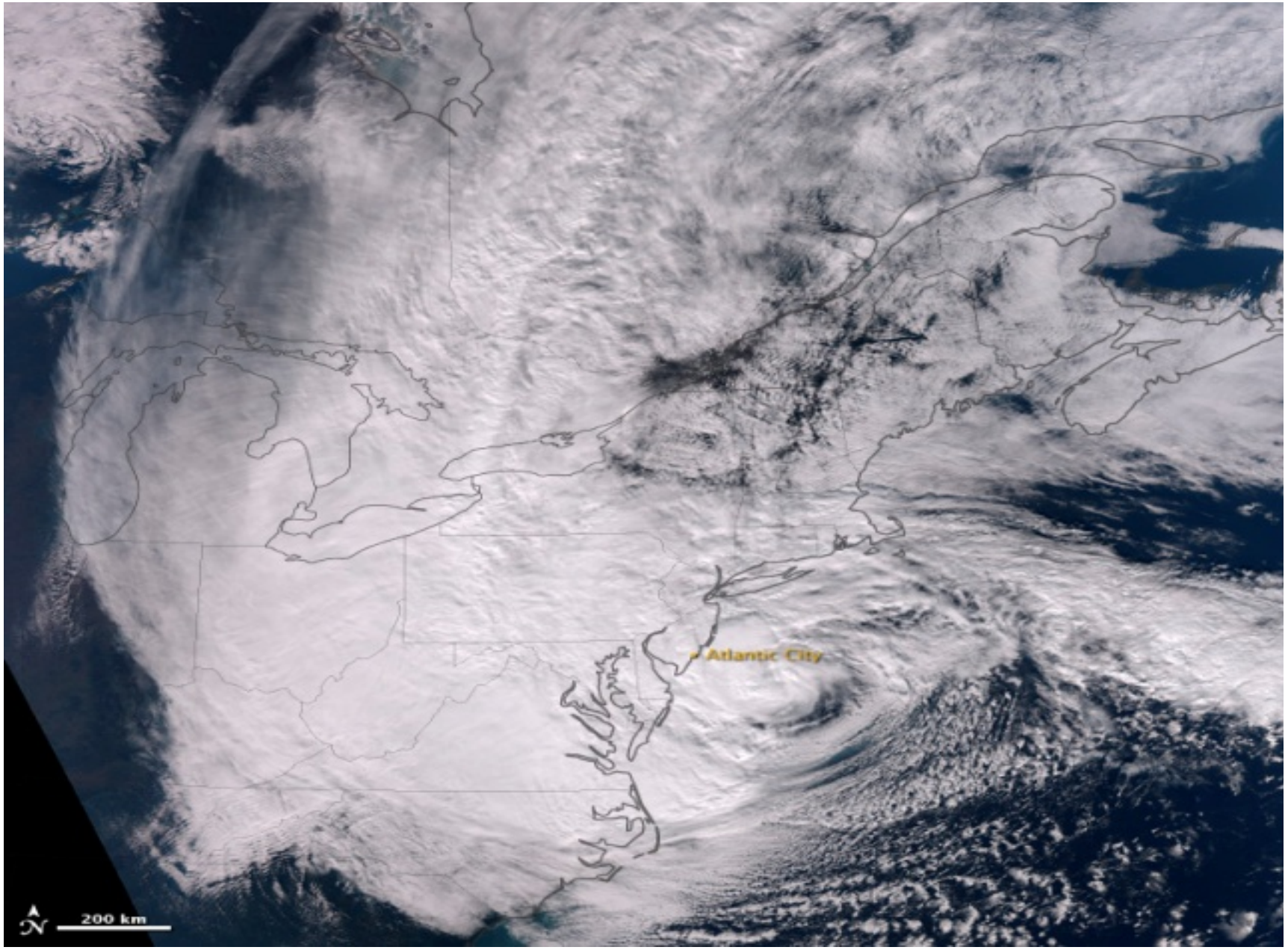
NYU Stern Urbanization Project Seminar

24 October 2013

Hurricane Sandy, 28 October 2012



Source: NOAA

Source: PlaNYC 2013

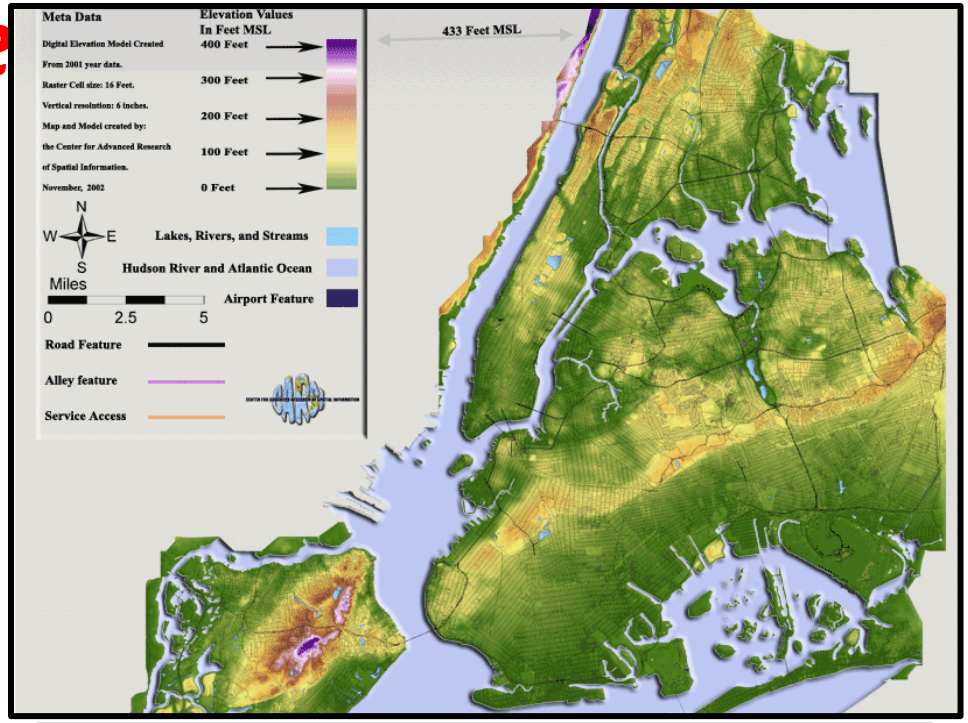
Hurricane Sandy revealed emerging vulnerabilities to climate change and opportunities for enhanced resiliency

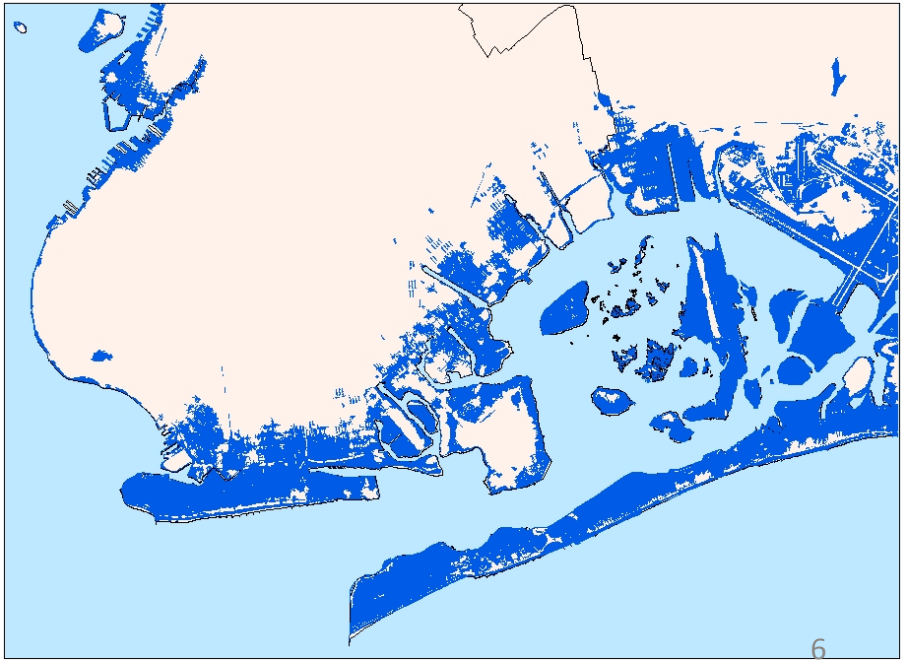
(photo source F. Montalto)

Hurricane Sandy Damage in Oakwood Neighborhood (Staten Island, NY)

What Does Hurricane Sandy Mean?

- New York City is prone to losses from weather-related disasters.
  - Top 10 in population vulnerable to coastal flooding
  - Second only to Miami in assets exposed to coastal flooding
- What did it reveal about exposure and vulnerability?; What does it mean about disaster risk reduction and climate change adaptation?; Will it signal a change in policy?

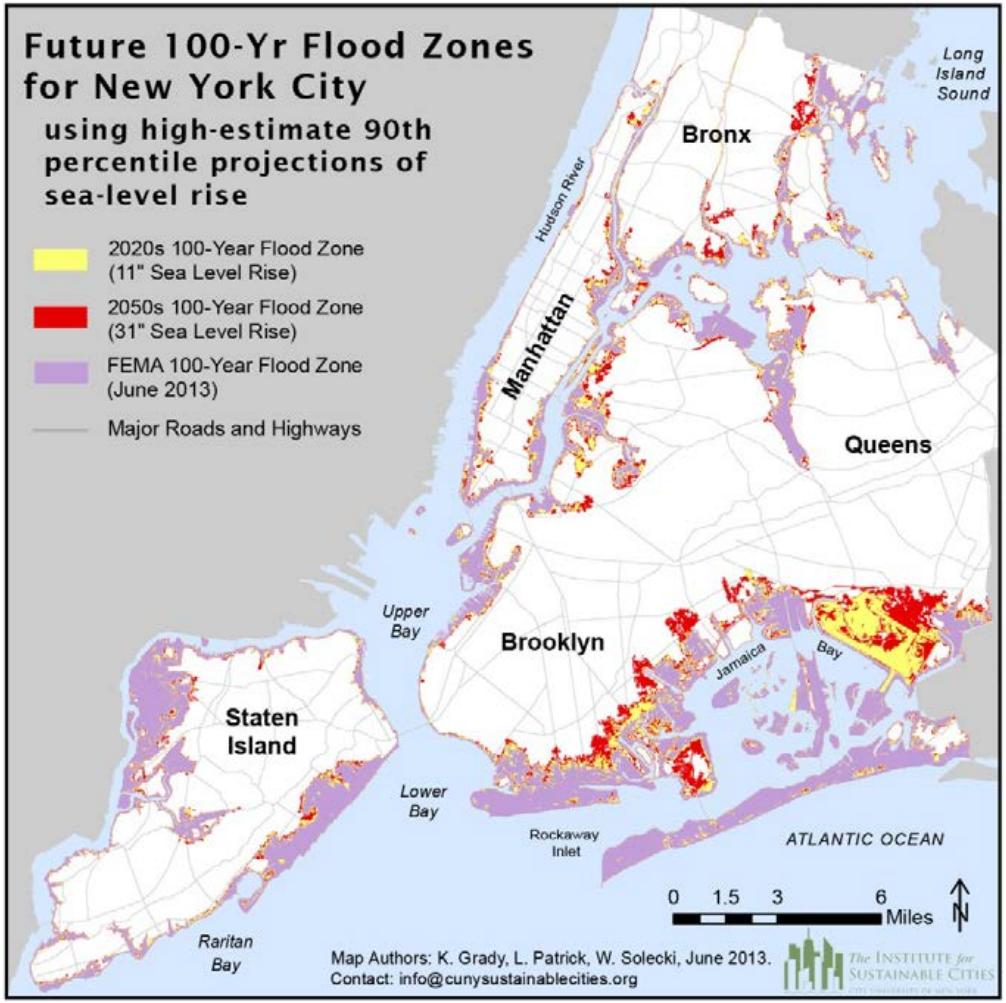




Observed Inundation – Hurricane Sandy

Impacts and Associated Vulnerabilities

Urban Lifelines and Infrastructure System Failures

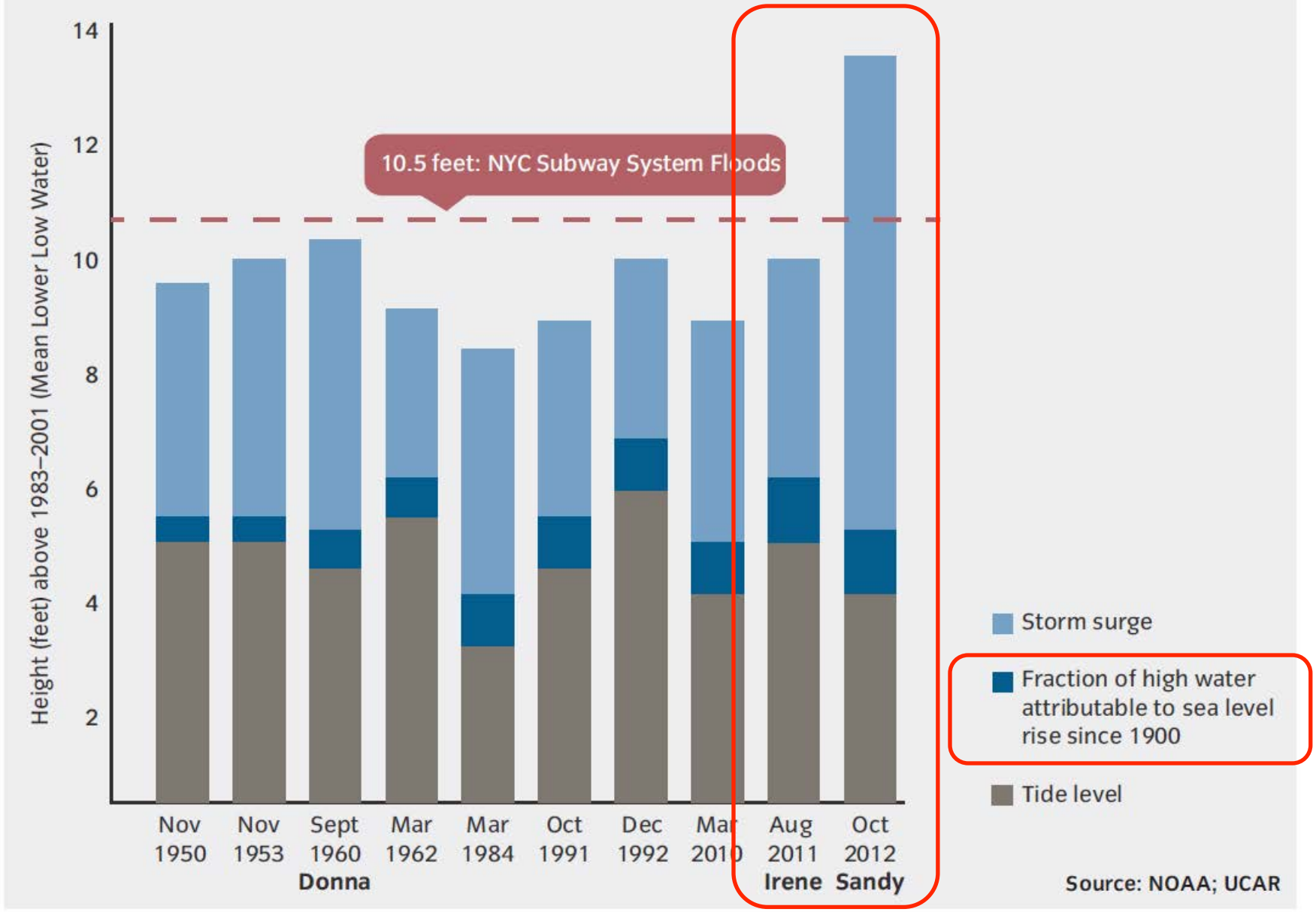


- Water Supply
- Electricity
- Transportation
- Gasoline Supply
- Pharmacy – Drug Supply

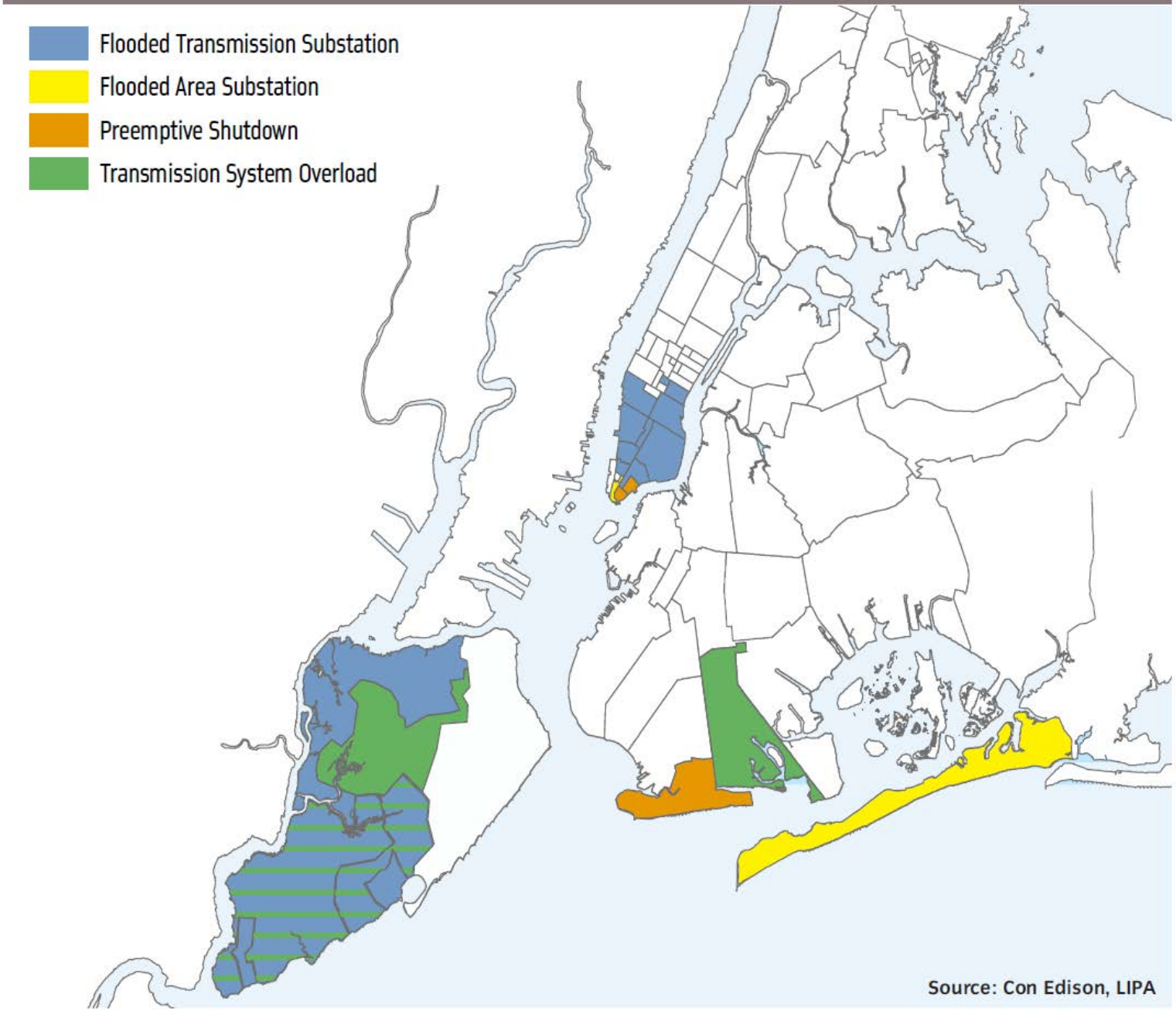
General Observations about Impacts and Vulnerabilities

- Cascading system impacts
- Uneven geography – not all on the coast, but most impactful on coast
- Role of ecosystem protection opportunities – lost and found – e.g. wetlands
- Highly complex systems require significant redundancy and context specific vulnerabilities – e.g. health care system
- Data rich assessment – smart city context yielding critical data – challenge is how to use it
- A lot more impact and vulnerability work to be done

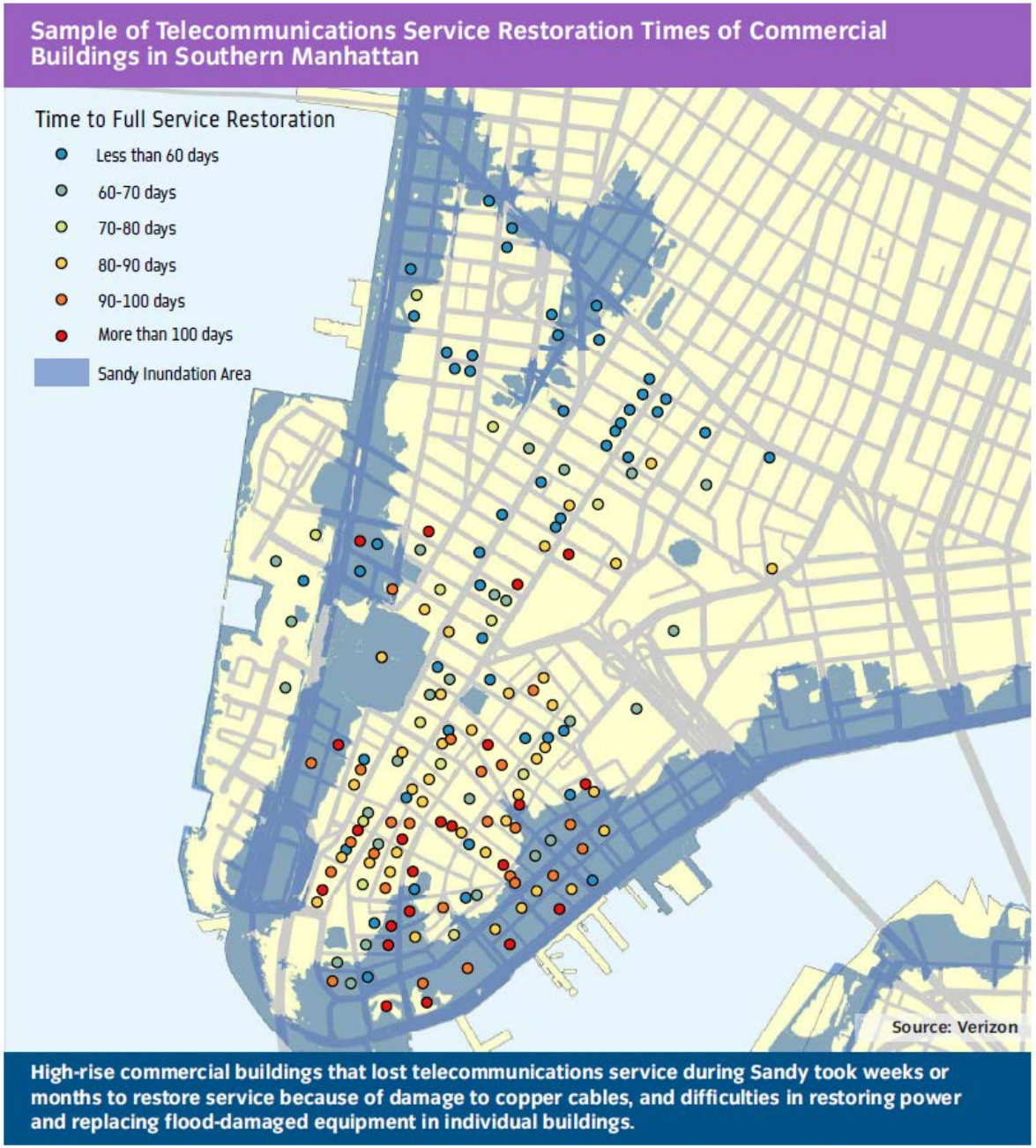
High-Water Events in Lower Manhattan



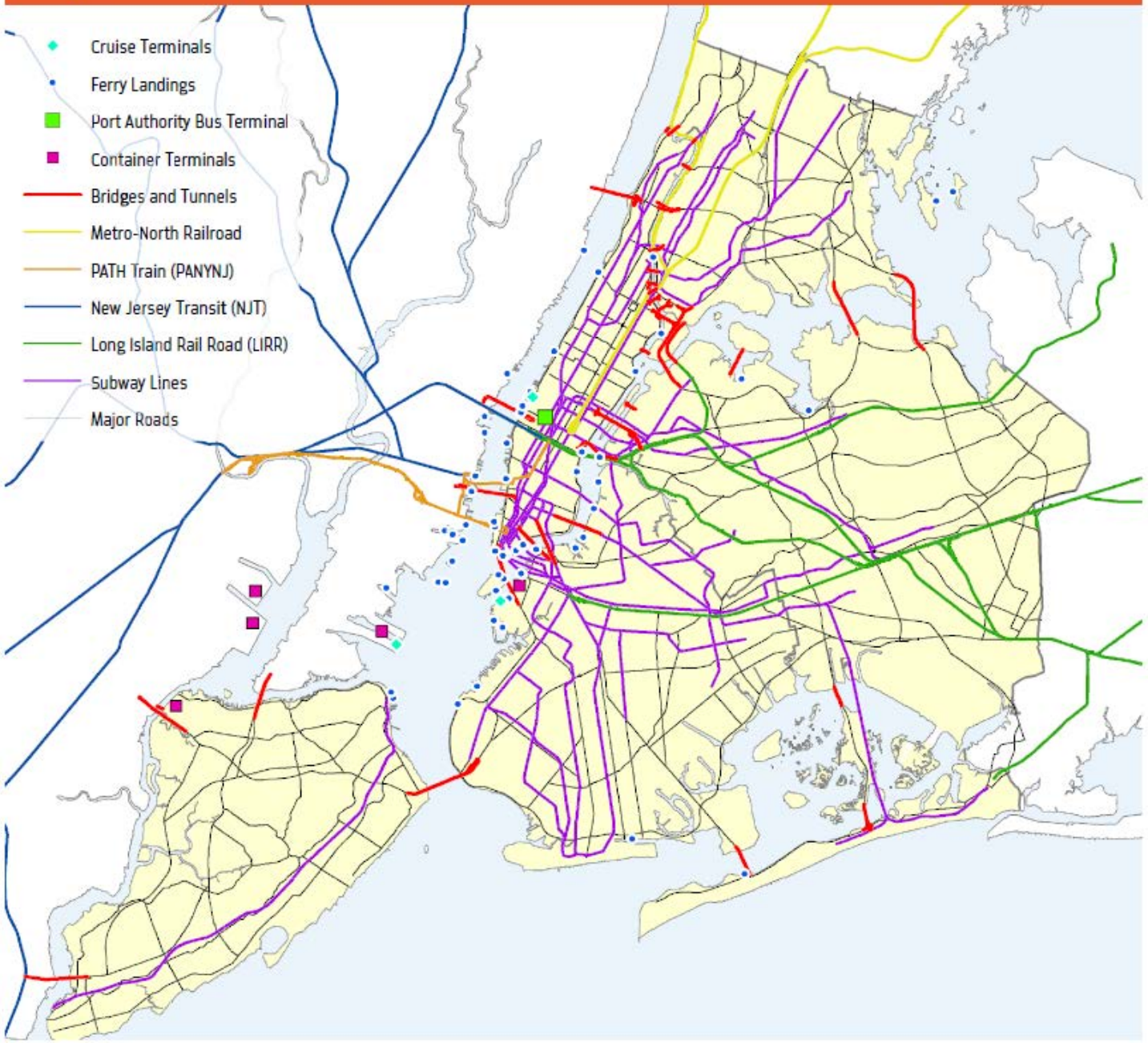
Electric Network Shutdowns During Sandy by Cause



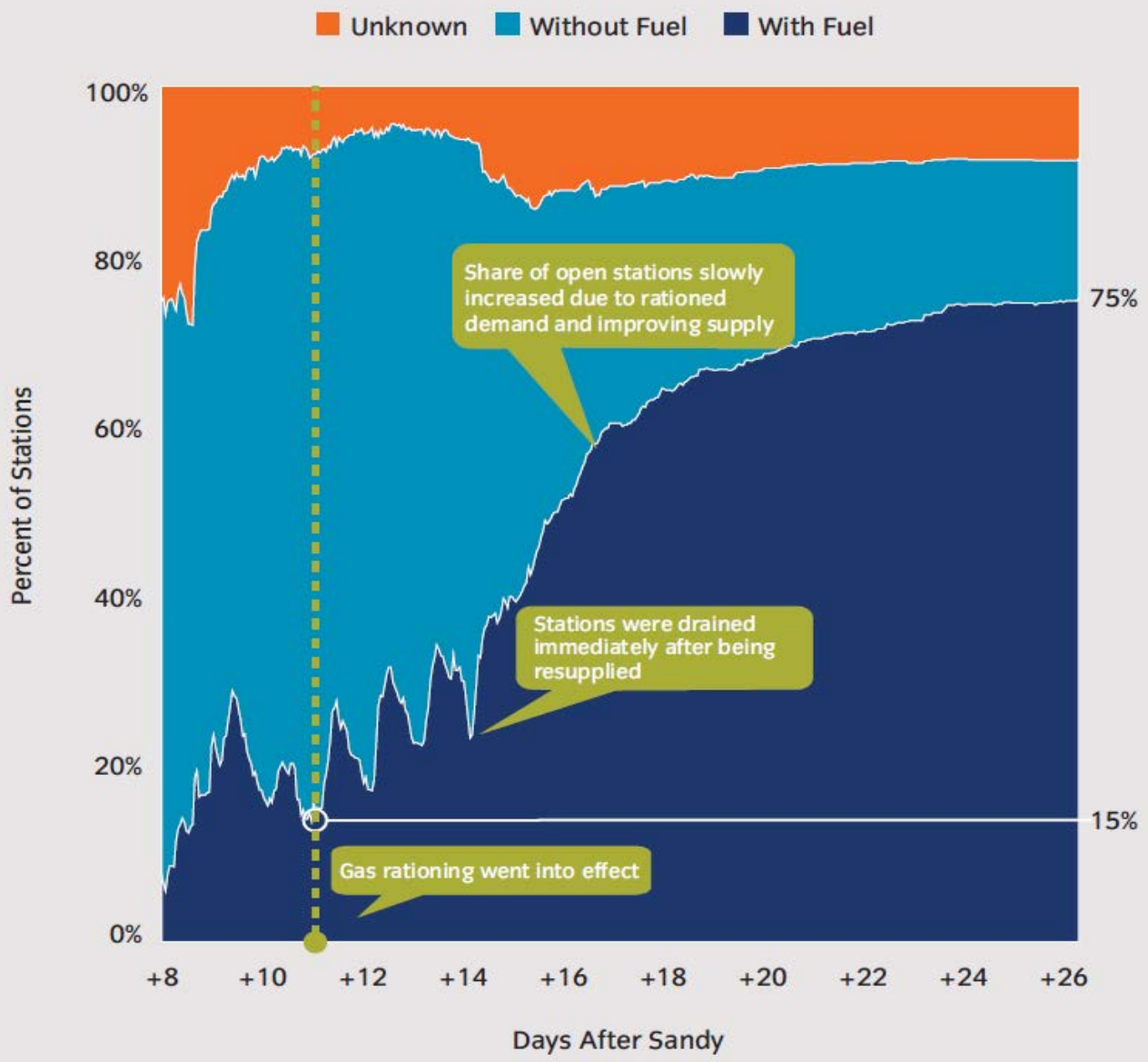
Telecommunications



Regional Transportation Network

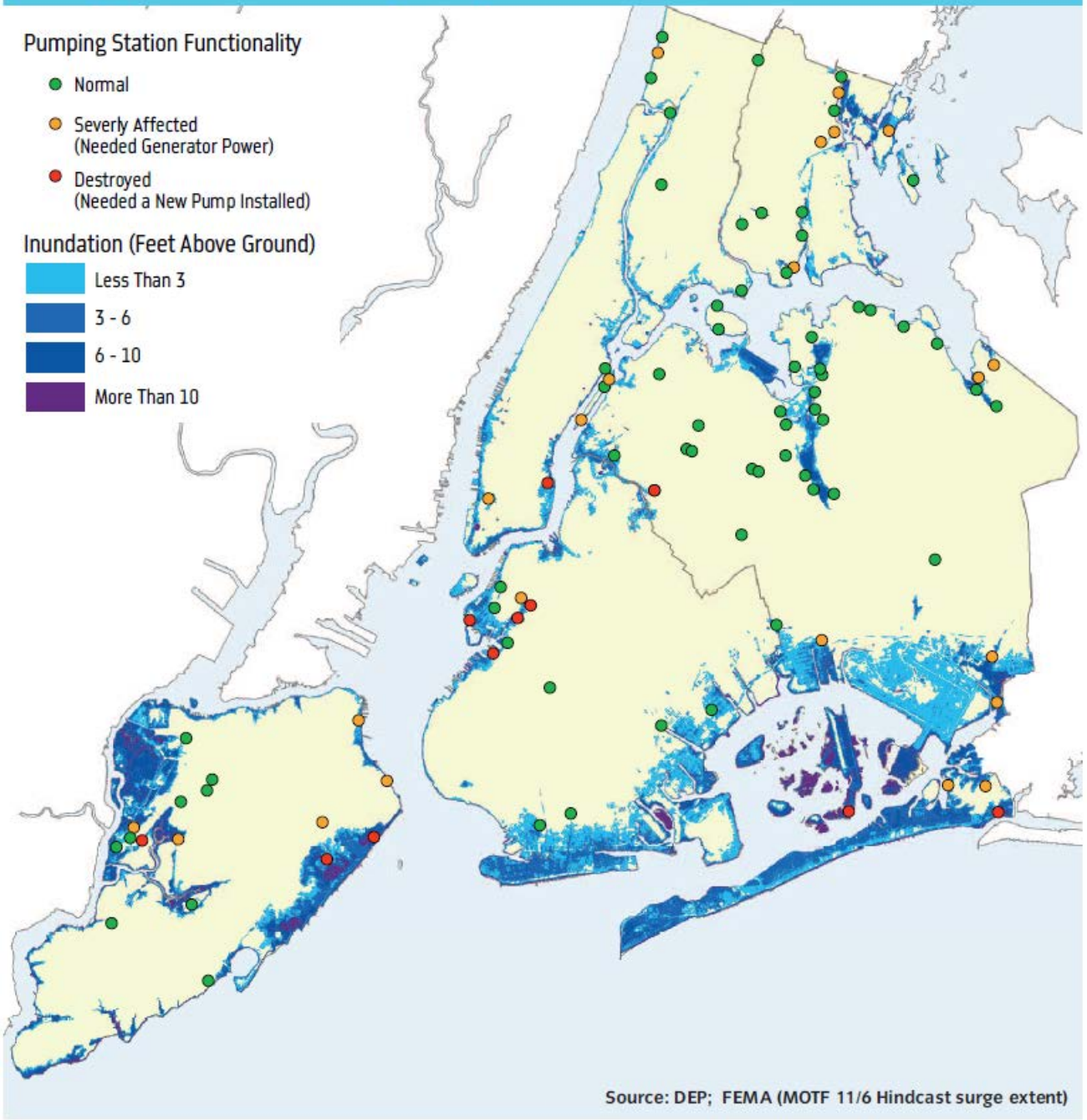


New York City Gas Stations by Point-in-Time Operational Status

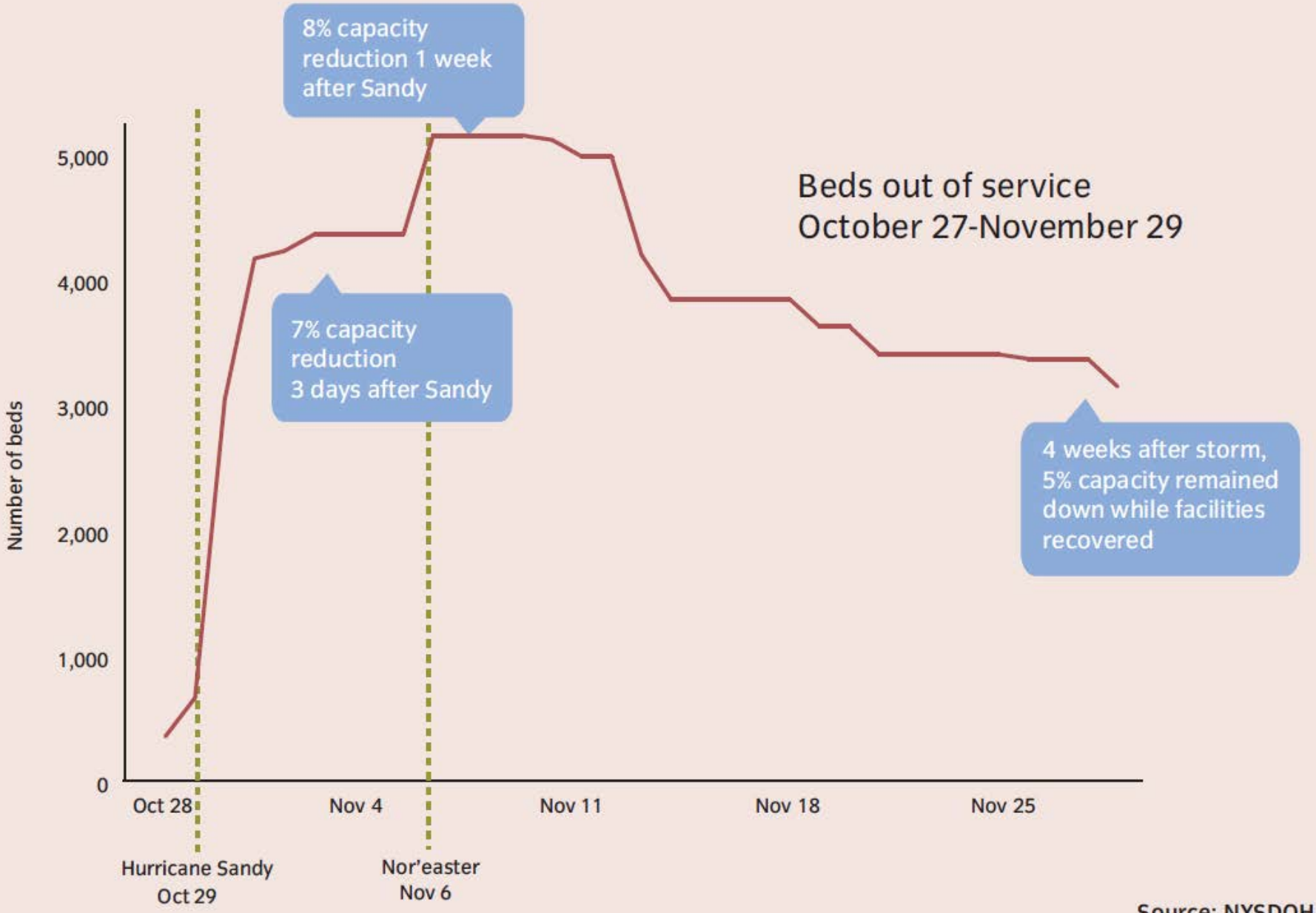


Source: Gasbuddy.com

Pumping Stations Affected By Sandy

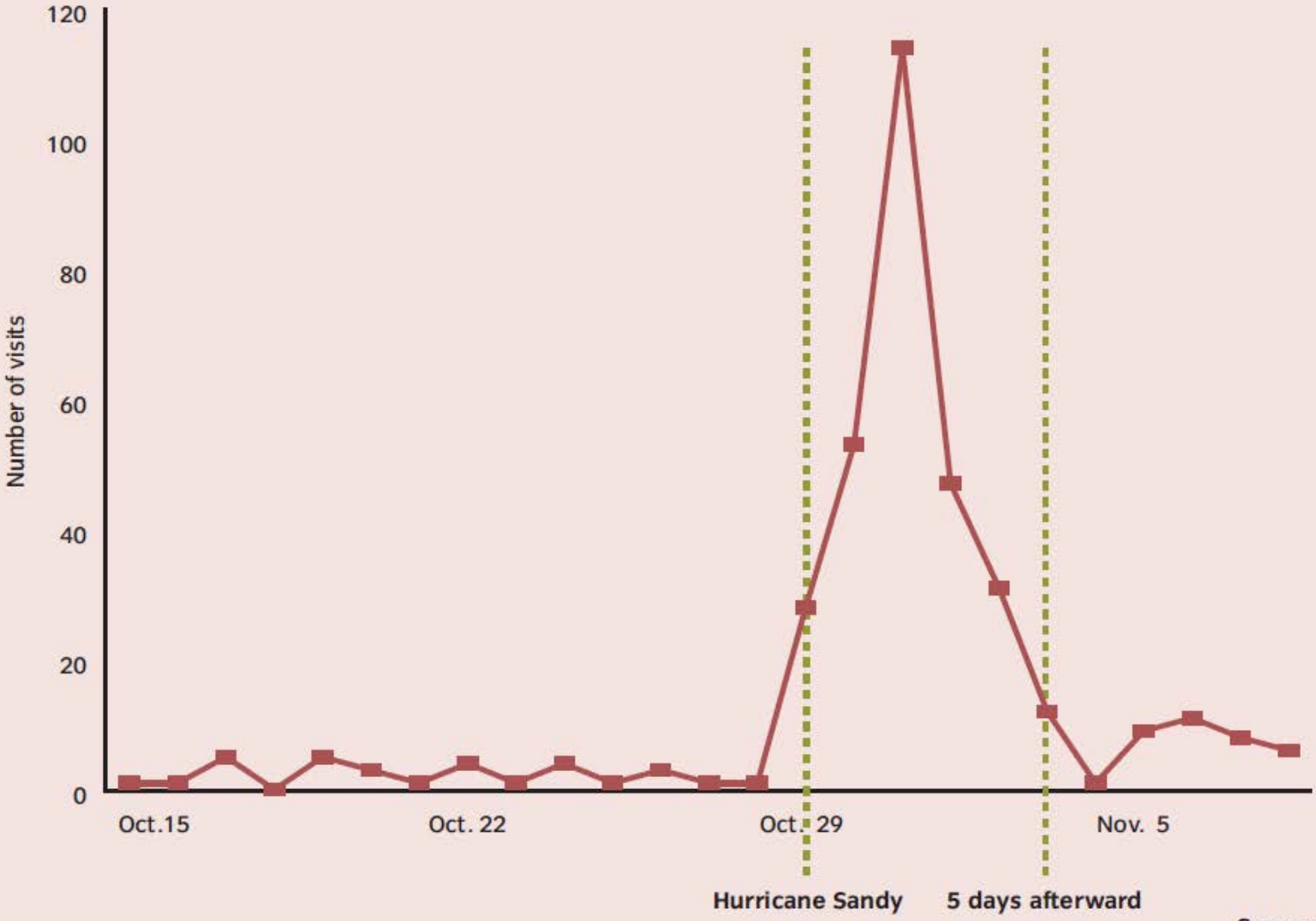


Citywide Bed Capacity Reductions in Nursing Homes and Adult Care Facilities



Source: NYSDOH

Citywide Emergency Department Visits Needing Dialysis



Source: DOHMH

Key Questions

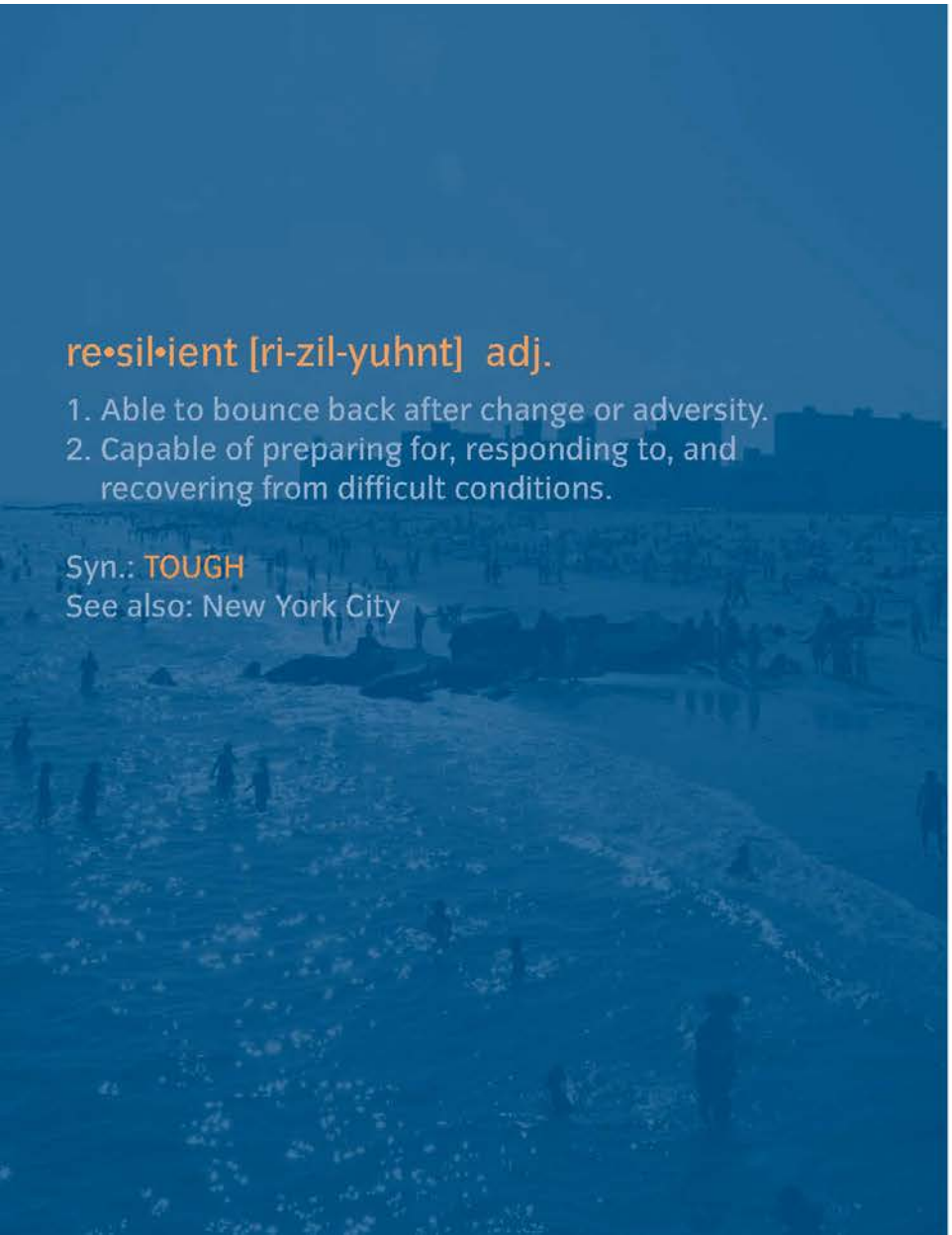
- The question is being asked whether climate change impacts will be like other urban environment-related crises
- Does Hurricane Sandy represent a tipping point for public policy.
- What is the connection between societal resilience, infrastructure resilience, community resilience?
- What is the connection between resilience, transition, and transformation?

Disaster Response and How Might Hurricane Sandy Points to Wider Transitions and Transformations

- *After a disaster, response typically* is focused on addressing failures and cost-benefit calculations in the context of future risk probability
- Hurricane Sandy response also is often discussed in the context of climate change
- Movement from disaster recovery to disaster rebuilding and resilience
- Change in conceptualization of extreme events
  - From discrete acute events to events as part of a chronic process
  - Looking into future dynamics as much as the present and past

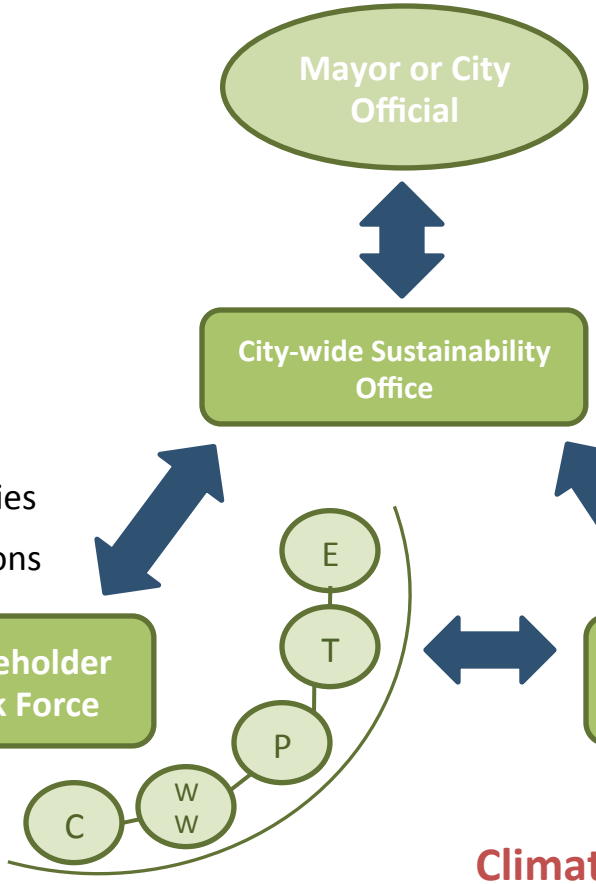
PlaNYC 2013 – Released 11 June 2013

Preface of PlaNYC 2013



This report is dedicated to the 43 New Yorkers who lost their lives during Sandy, and to the loved ones they left behind. It is also offered in recognition of those whose homes, businesses, and communities were damaged during the storm and who are working to rebuild. The City stands in solidarity with all of them as it makes plans to strengthen New York so that future climate events do not have the same devastating effects.

New York City Climate Adaptation Process



High-Level Buy-In

Coordinating Role

Critical Infrastructure

Stakeholders

- City Agencies
- Regional Authorities
- Private Corporations

Expert Knowledge Providers

- University scholars and private sector experts
- Social, biological, and physical scientists
- Legal and insurance experts
- Risk management professionals

Climate Risk Information

Integration across Sector-specific Working Groups

- Energy (E)
- Transportation (T)
- Policy (P)
- Water & Waste (WW)
- Communications (C)

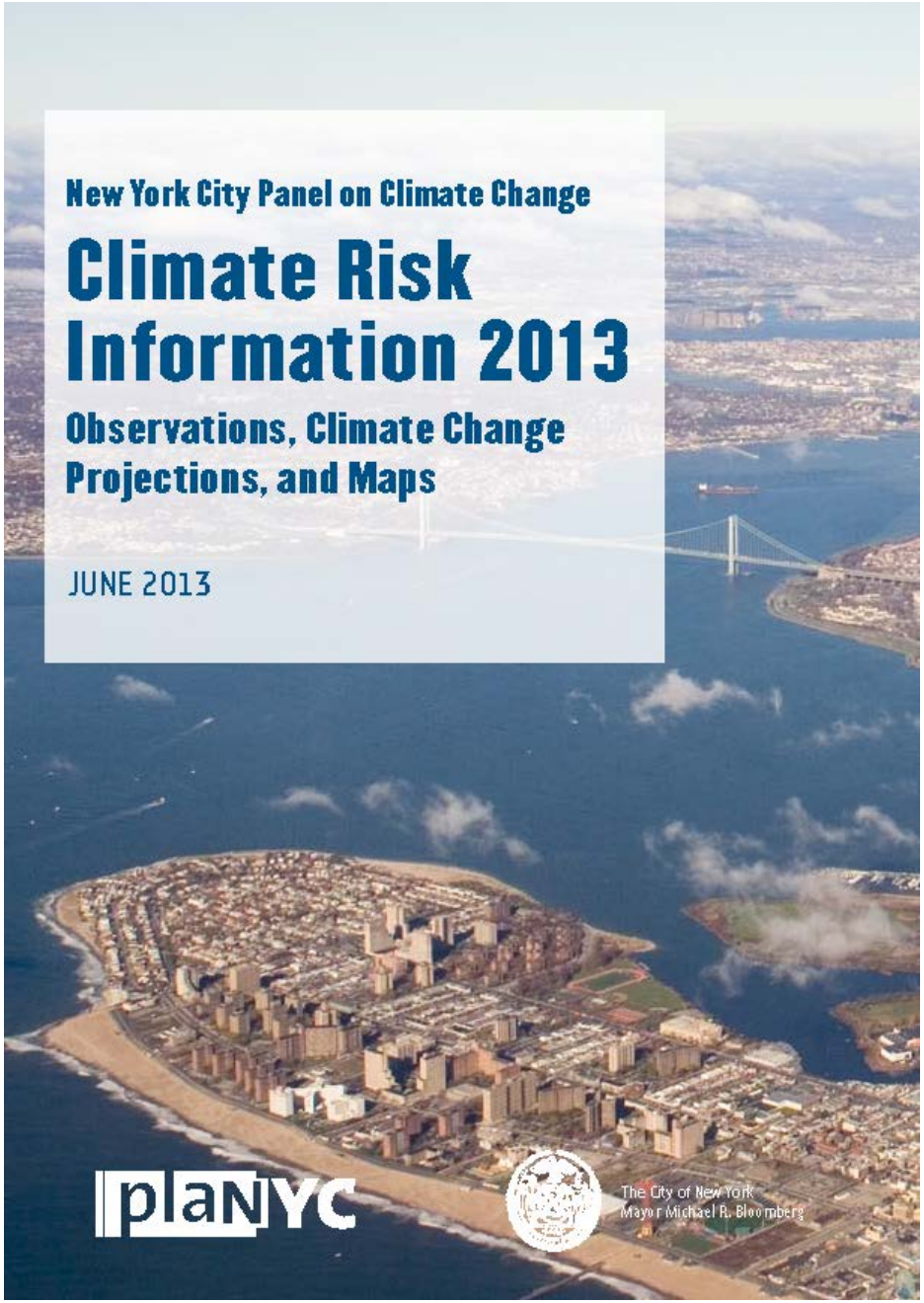
Adaptation Assessment Guidelines

Climate Protection Levels

Source: NPCC, 2010

NYC Special Initiative for Rebuilding and Resiliency

- Addresses how to rebuild New York City to be more resilient in the wake of Sandy but with a long-term focus on:
  - 1) how to rebuild locally; and
  - 2) how to improve citywide infrastructure and building resilience
- A comprehensive report in June 2013 addresses these challenges by investigating three key questions:
  - What happened during and after Sandy and why?
  - What is the likely risk to NYC as the climate changes and the threat of future storms and severe weather increases?
  - What to do in the coastal neighborhoods and citywide infrastructure

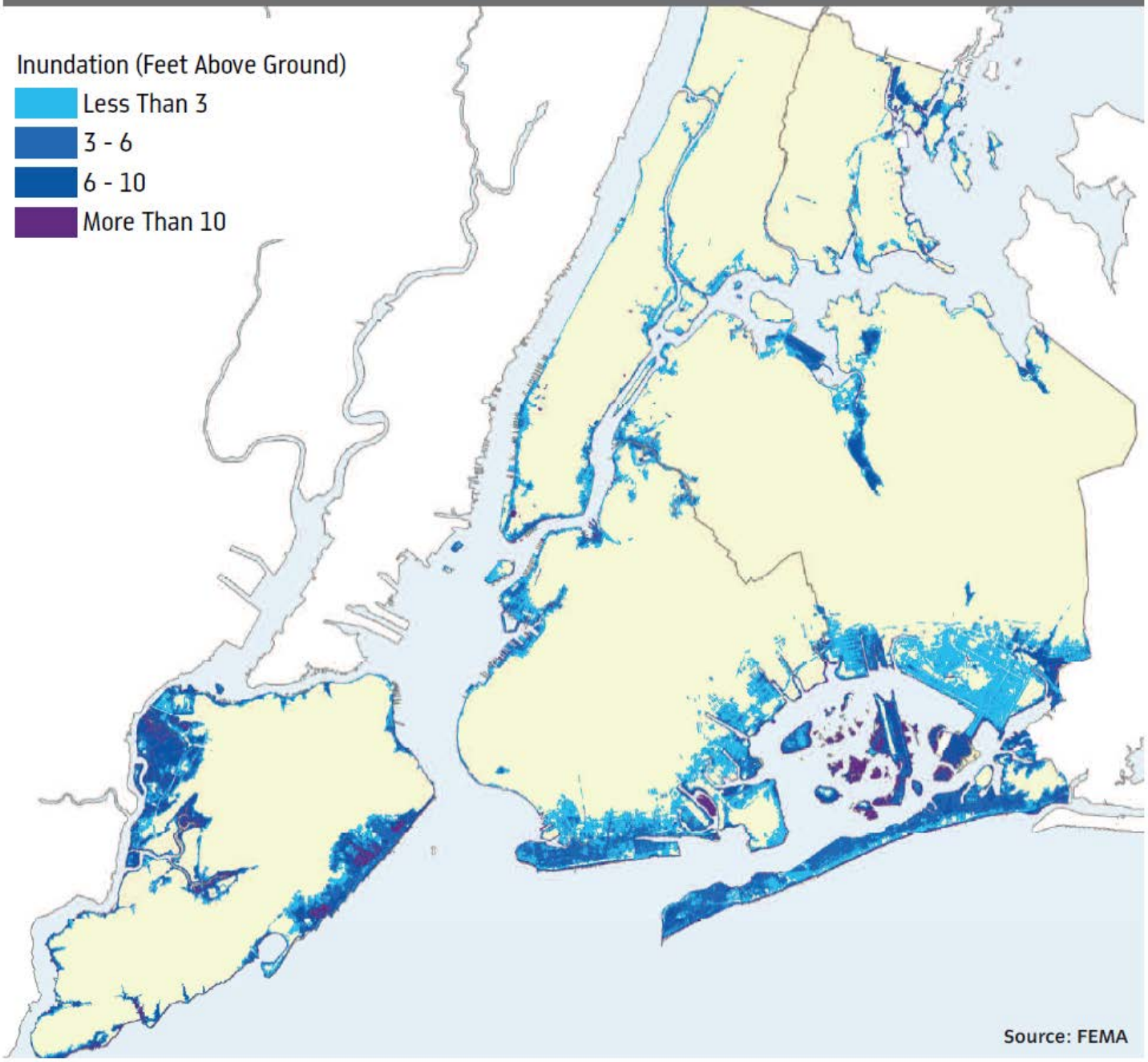


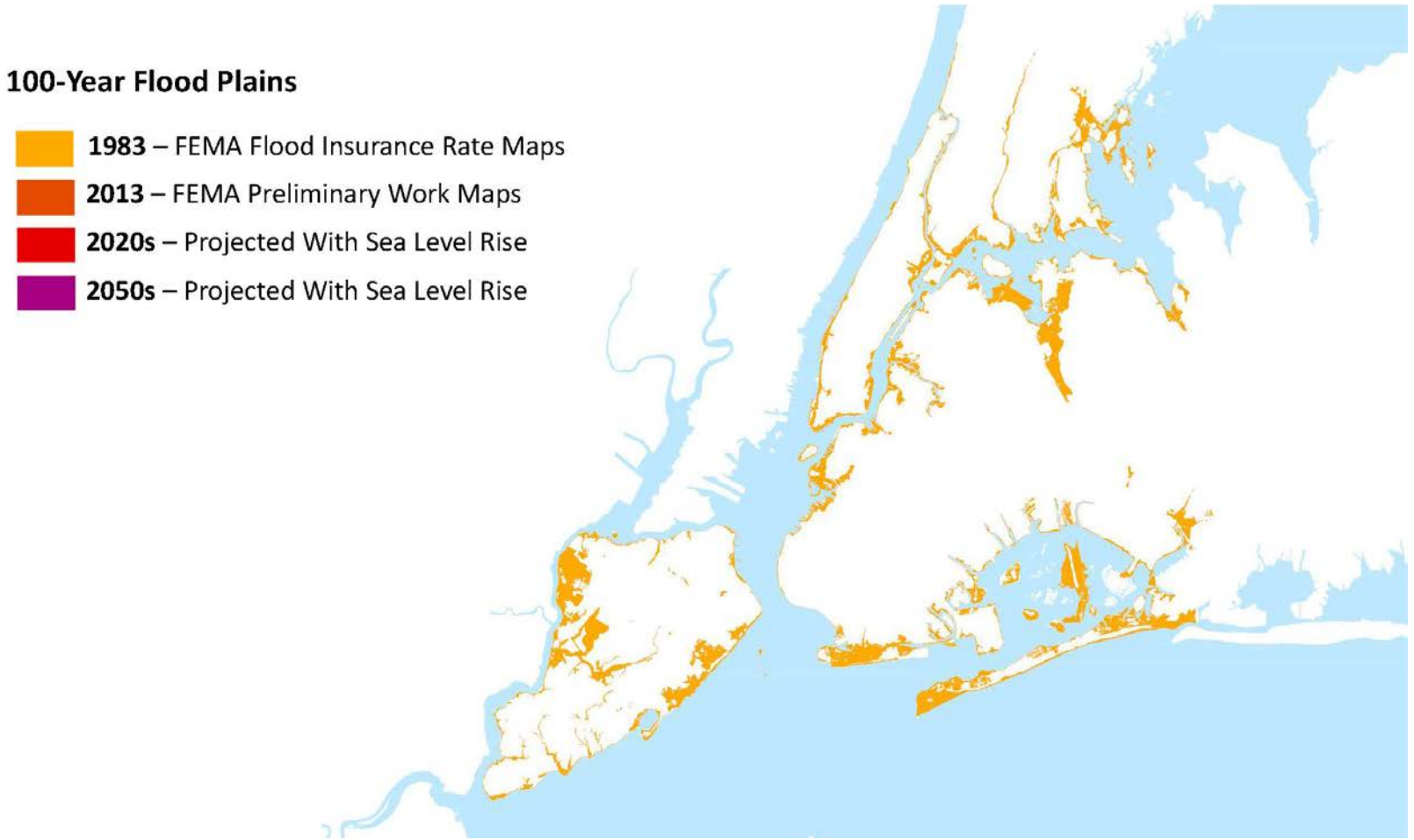
Released 11 June 2013;
available at CUNY Institute for Sustainable Cities (CISC) website – www.cunysustainablecities.org

Provides the updated climate science information and foundation for PlaNYC 2013

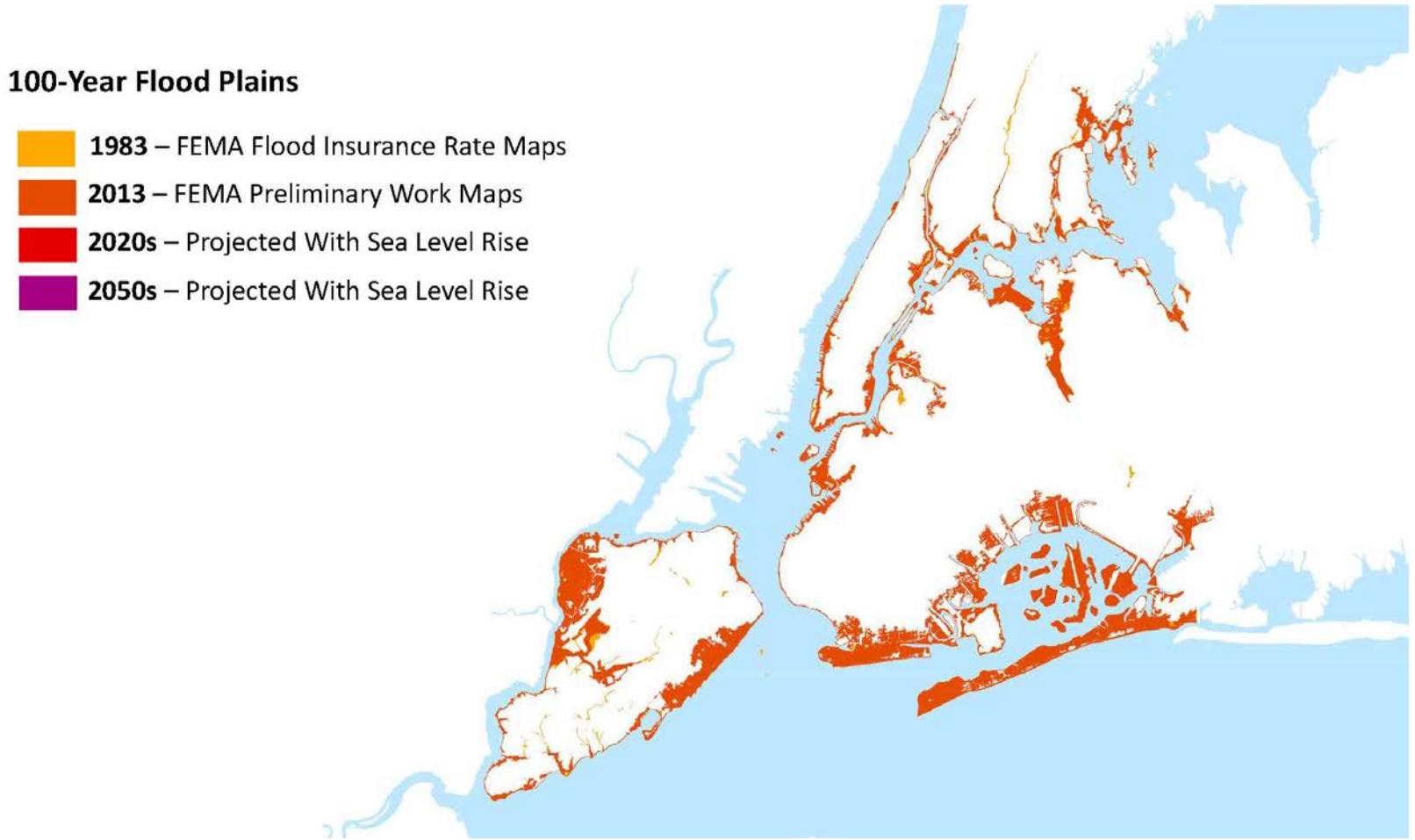
Storm Surge – Now and Future

Sandy Inundation





Source: PlaNYC 2013



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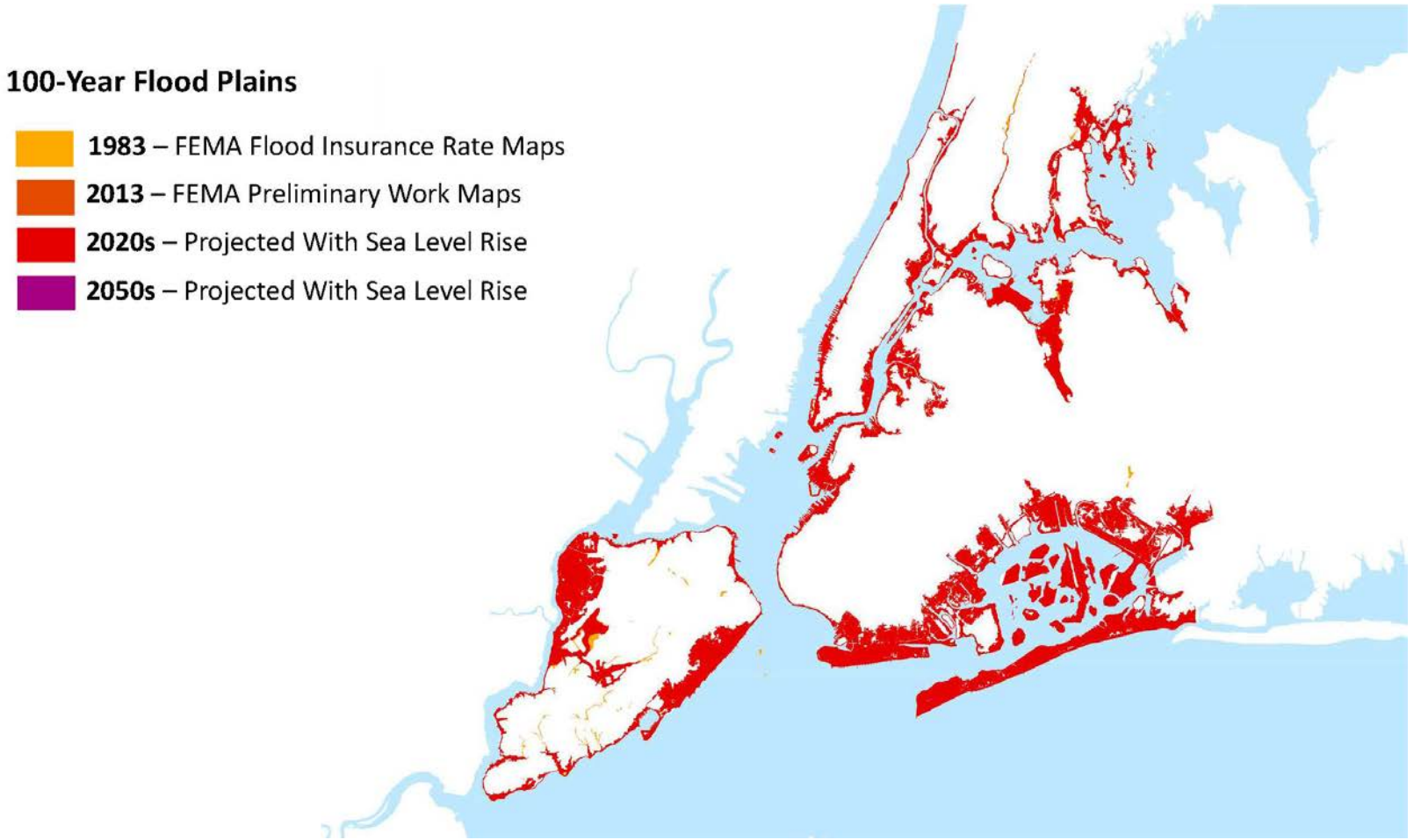

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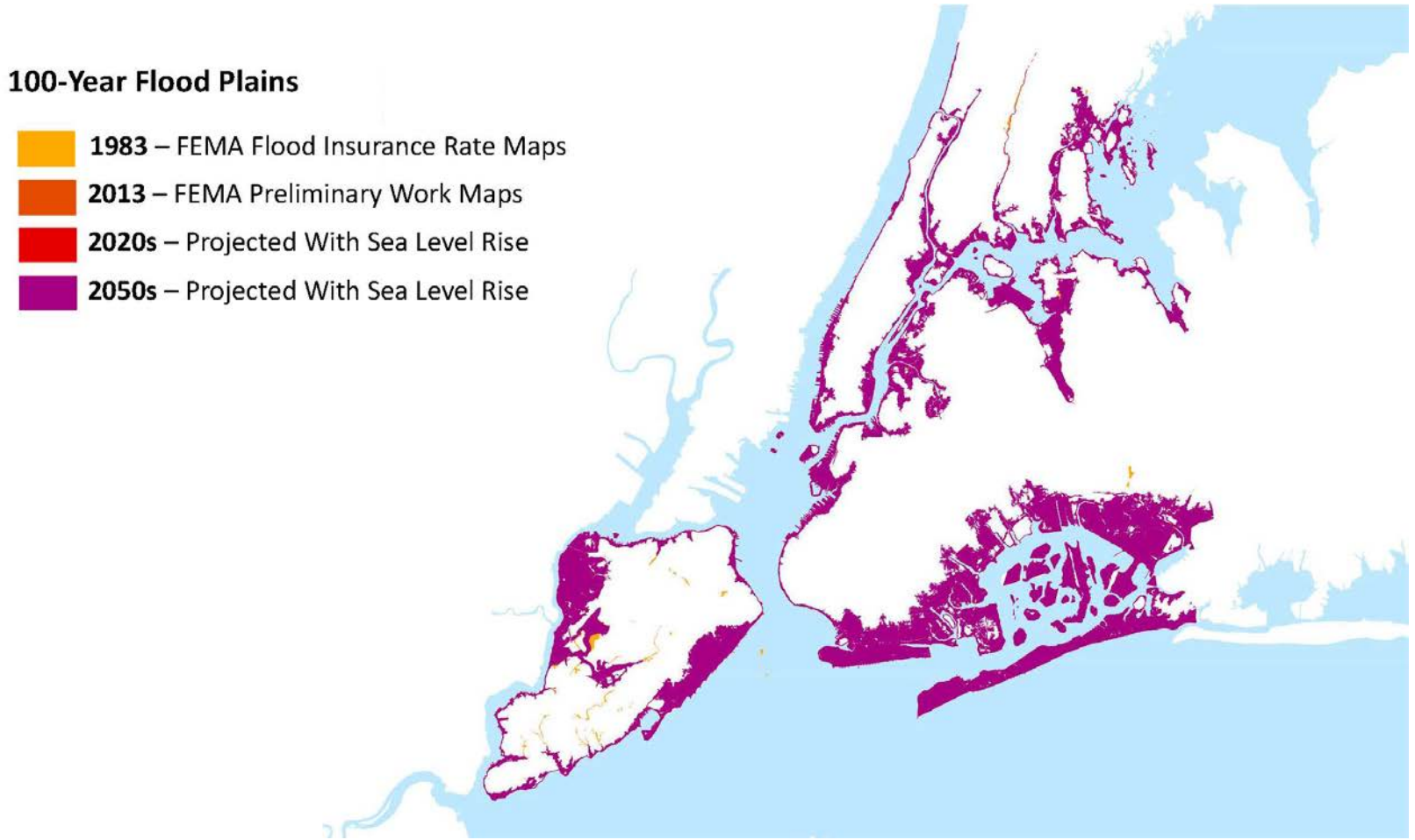
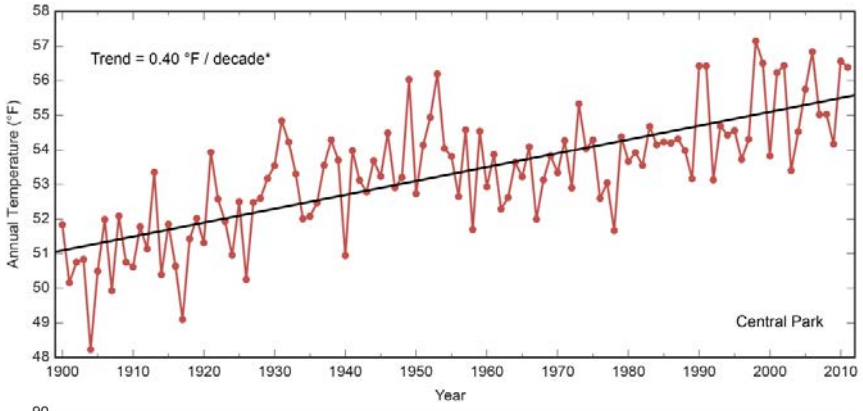
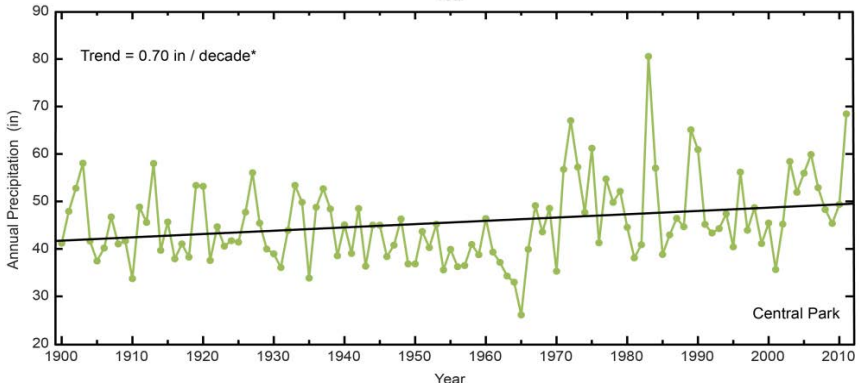
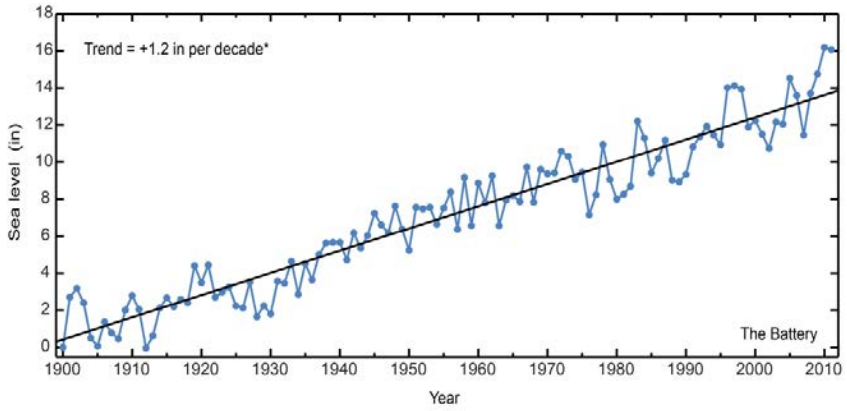


Source: PlaNYC 2013

NPCC2 Observed Trends







* All trends significant at the 99% level

Temperature

Mean annual temperature in New York City has increased 4.4°F from 1900 to 2011.

Precipitation

Mean annual precipitation has increased 7.7 inches from 1900 to 2011 (a change of 1.4 percent per decade). Year-to-year precipitation variability was greater from 1956 to 2011 than from 1900 to 1955.

Sea Level

Sea level in New York City (at the Battery) has risen 1.1 feet since 1900.

Extreme Events

Very difficult to determine trends on local scales

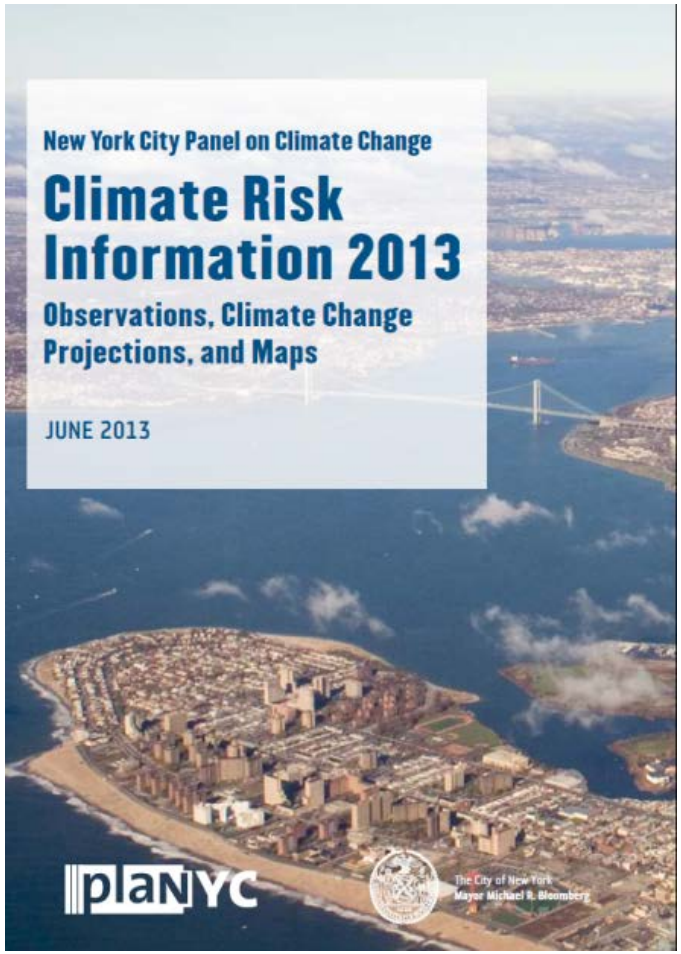
75% increase in heaviest rain events in Northeast in last 50 yrs

Increase in strength of hurricanes and in number of the most intense hurricanes in North Atlantic since early 1980s

Key Findings for Future Projected Changes

Recently released climate change projections…

- illustrate a broad-based acceleration of climate change in coming decades
- show significant climate risks for New York City, especially heat waves, extreme precipitation events, and coastal flooding
- valid for New York City ***and*** the metropolitan region
- Compared to 2009 projections:
  - No dramatic shifts or changes with respect to any one specific climate risk metric or variable
  - Small increases in some variables and timeslices



Mean Annual Changes

The projections show accelerating change and broad consistency with previous NPCC projections

Air temperature[1] Baseline (1971-2000): 54° F	Low-estimate (10th percentile)	Middle range (25th to 75th percentile)	High-estimate (90th percentile)
2020s	+ 1.5°F	+ 2.0°F to 2.8°F	+ 3.2°F
2050s	+ 3.1°F	+ 4.1°F to 5.7°F	+ 6.6°F
Precipitation[1] Baseline (1971-2000): 50.1 inches	**Low-estimate (10th percentile)**	**Middle range (25th to 75th percentile)**	**High-estimate (90th percentile)**
2020s	-1 percent	+ 1 to + 8 percent	+ 11 percent
2050s	+ 1 percent	+ 4 to + 11 percent	+ 13 percent

[1] Based on 35 GCMs and 2 Representative Concentration Pathways. Baseline data from NOAA National Climatic Data Center (NCDC) United States Historical Climatology Network (USHCN), Version 2 (Menne et al., 2009). 30-year mean values from model-based outcomes.

Extreme Events

			2020s			2050s		
		Baseline (1971-2000)	Low-estimate	Middle range	High-estimate	Low-estimate	Middle range	High-estimate
Heat waves[1] [2] and cold weather events	Number of days/ year with maximum temperature at or above 90°F	18	24	26 to 31	33	32	39 to 52	57
	Number of heat waves/year	2	3	3 to 4	4	4	5 to 7	7
	Average heat wave duration (in days)	4	5	5 to 5	5	5	5 to 6	6
	Number of days/ year with minimum temperature at or below 32°F	72	50	52 to 58	60	37	42 to 48	52
Intense Precipitation[1]	Number of days/ year with rainfall at or above 2 inches	3	3	3 to 4	5	3	4 to 4	5

[1]Based on 35 GCMs and two Representative Concentration Pathways. Baseline data are from the NOAA NCDC USHCN, Version 2 (Menne et al., 2009). 30-year mean values from model-based outcomes.

[2]Heat waves are defined as three more consecutive days with maximum temperatures at or above 90°F.

Extreme Events

The NPCC developed qualitative projections where future changes are too uncertain to provide local quantitative projections

	Spatial Scale of Projection	Direction of Change by 2050s	Likelihood[1]	Sources
Tropical Cyclones				
Total number	North Atlantic Basin	Unknown	--	--
Number of intense hurricanes	North Atlantic Basin	Increase	More likely than not	USGCRP, 2013; IPCC, 2012
Extreme hurricane winds	North Atlantic Basin	Increase	More likely than not	USGCRP, 2013; IPCC, 2012
Intense hurricane precipitation	North Atlantic Basin	Increase	More likely than not	USGCRP, 2013; IPCC, 2012
Nor'easters	NYC area	Unknown	--	IPCC 2012; Colle et al. 2013

Number of intense hurricanes in the North Atlantic Basin will more likely than not increase

[1] Probability of occurrence and likelihood defined as (IPCC, 2007): Virtually certain; >99% probability of occurrence, Extremely likely; >95% probability of occurrence, Very likely; >90% probability of occurrence, Likely; >66% probability of occurrence, More likely than not; >50% probability of occurrence, About as likely as not; 33 to 66% probability of occurrence.

Sea Level Rise Projections

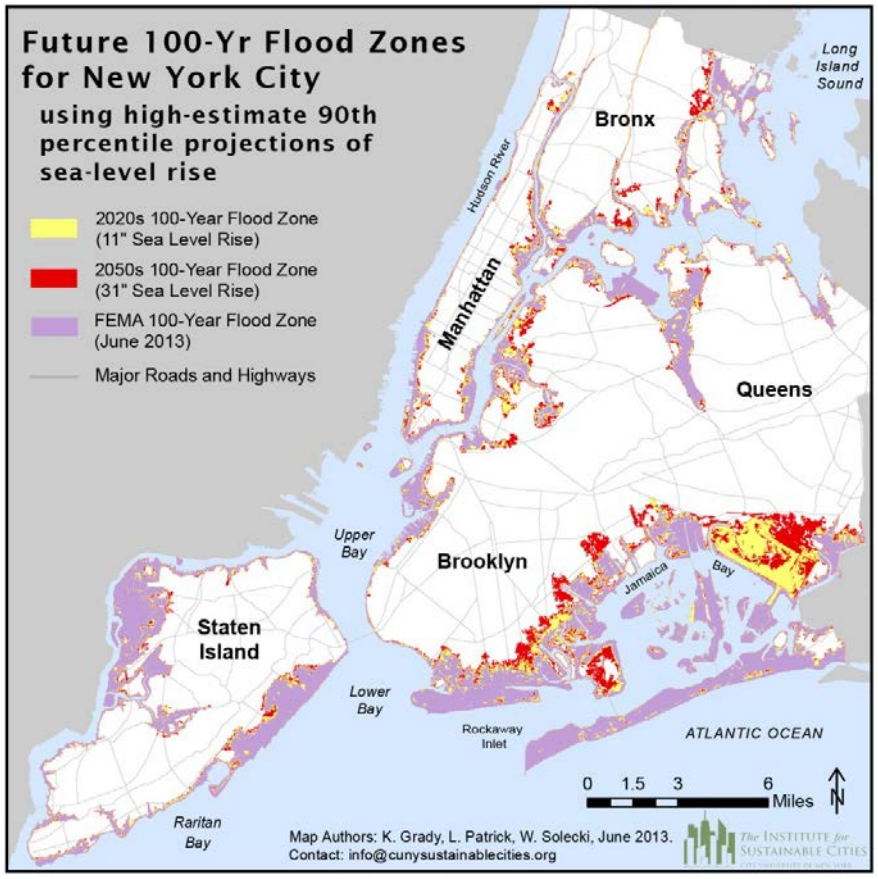
Newly-released sea level rise projections account for processes not well reflected in global climate models, including the possibility of rapid ice loss

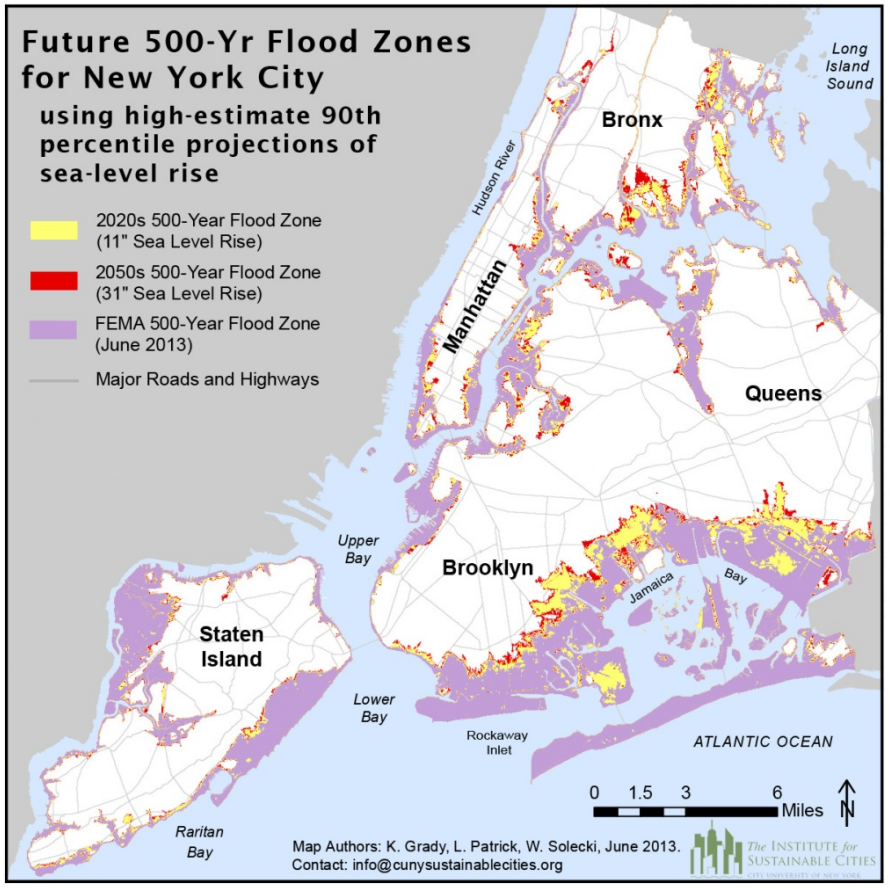
- High estimate projections are higher than the Panel's 2009 "Rapid-ice melt" Scenario
- Sea level rise for New York City is projected to exceed the global average

Sea level rise[1] Baseline (2000-2004) 0 inches	Low-estimate (10th percentile)	Middle range (25th to 75th percentile)	High-estimate (90th percentile)
2020s	2 inches	4 to 8 inches	11 inches
2050s	7 inches	11 to 24 inches	31 inches

[1] Based on 24 GCMs and 2 Representative Concentration Pathways.

Future Coastal Flood Risk Maps – Became a Critical Component of SIRR





The potential areas that could be impacted by the 100-year and 500-year floods in the 2020s and 2050s based on projections of the high-estimate 90th percentile sea level rise scenario

Post Hurricane Sandy Adaptation
Emerging Challenges and Opportunities

- Baseline climate science data (and modeling if possible)
- Rapid assessment strategy of impacts, vulnerabilities, opportunities for increased resiliency
- Long term goal (e.g. resilience) as frame for action
- Interagency cooperative (within govt. and across governments)
- Integrate new risk and hazard measures (in conjunction with traditional measures – e.g. 1% maps)
- Climate protection levels – access codes, standards, and regulations, and monitoring and indicators for climate change robustness
- System perspective – for identifying tipping points/cascade impacts and vulnerabilities
- Climate science data and mapping uncertainties (besides cost uncertainties)
- Greater transparency of data analysis and data interpretation
- Promote greater post extreme event learning – pushing open the policy window

Conclusions: Connections to Resiliency and Resilience Practice

- Timing of impacts
- Rate of change
- Emergent vulnerabilities
- Risk, uncertainties, cost curves
- Actionable science – relevant to engineering world
- Uneven distribution of impacts and vulnerabilities
- Urban system complexity – opportunity and challenge
- Defining indicators and monitoring schemes


Thank you – wsolecki@hunter.cuny.edu