Coastal Adaptation by Design

Northeastern Legislative Climate
and Energy Summit

Andlinger Center for Energy and Environment
Princeton University
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Guy Nordenson
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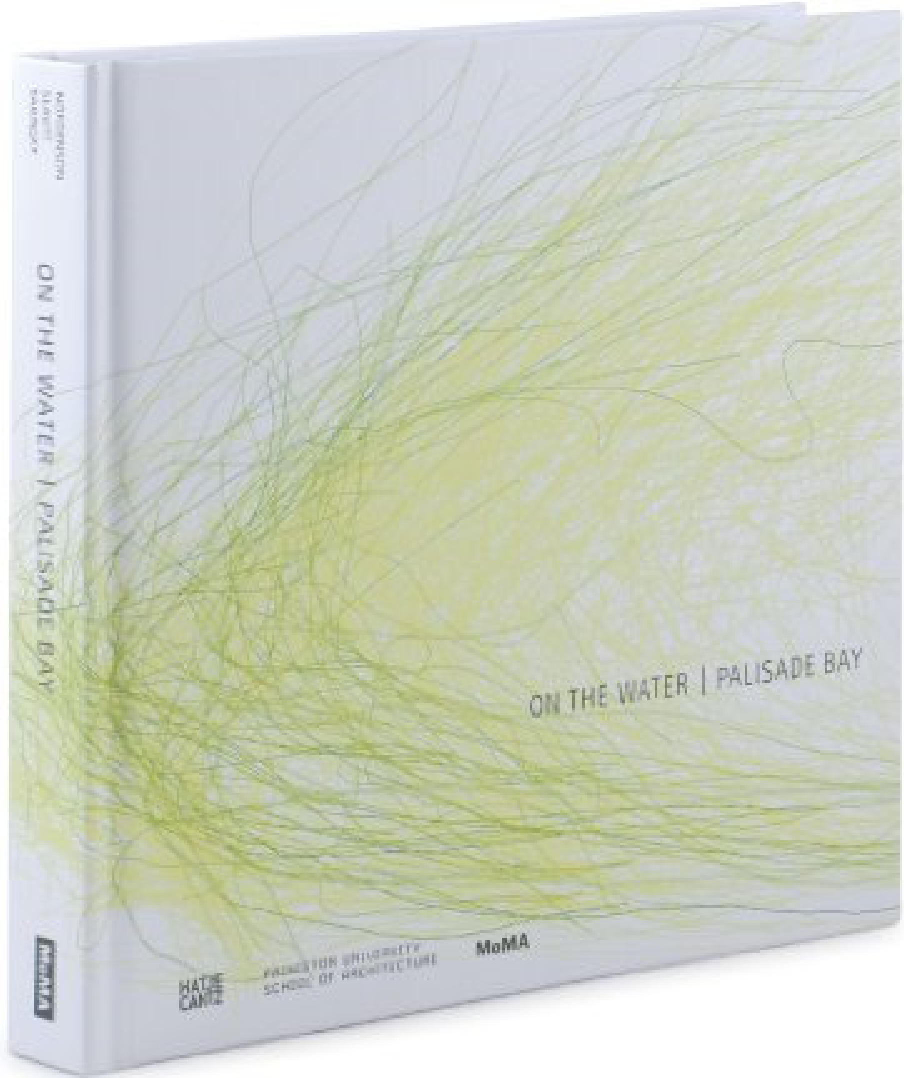
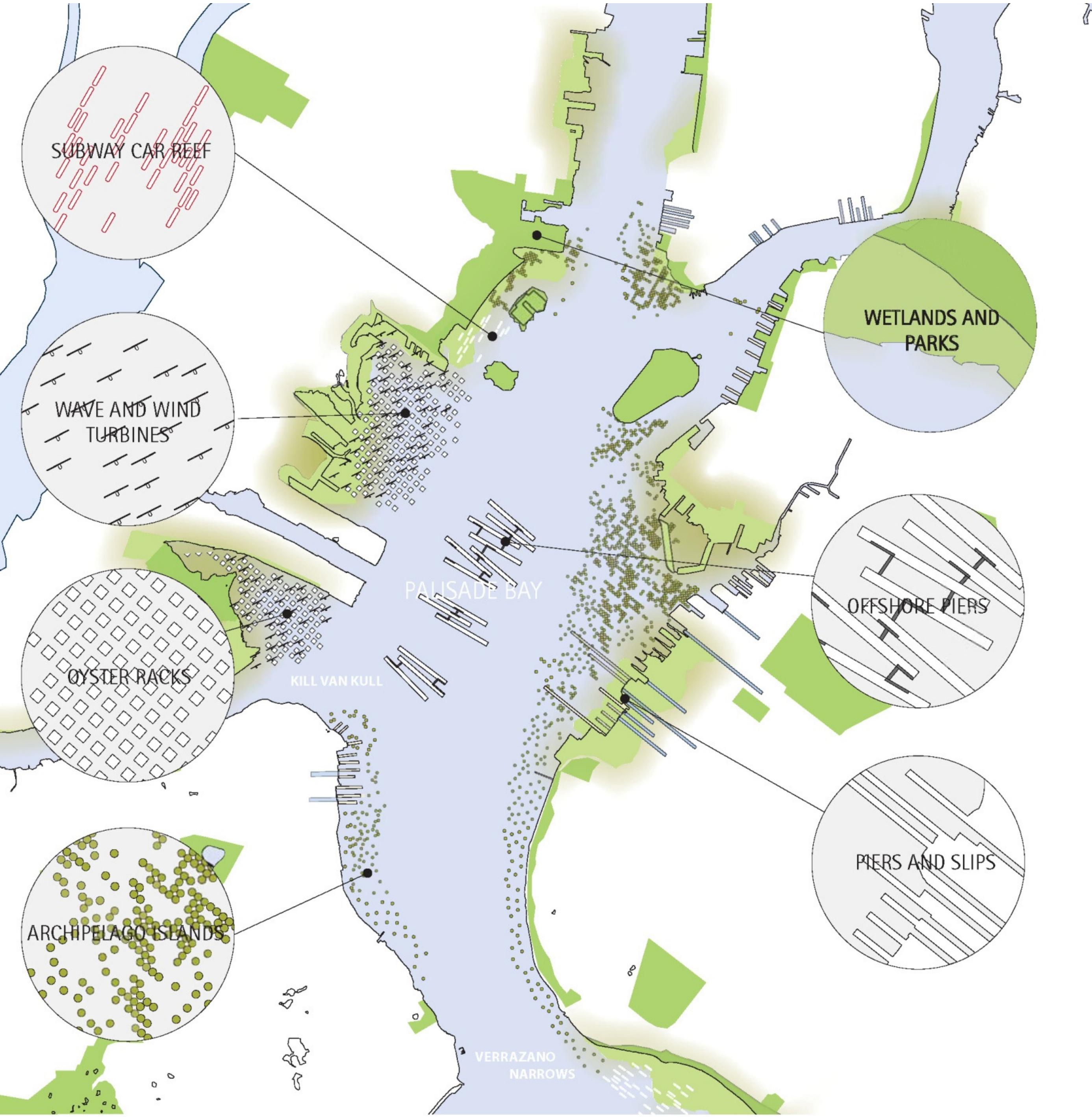
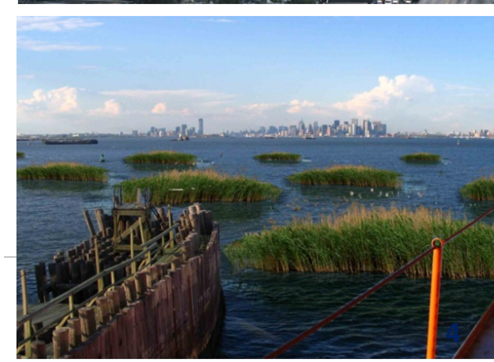
1 On the Water | Palisade Bay _2010

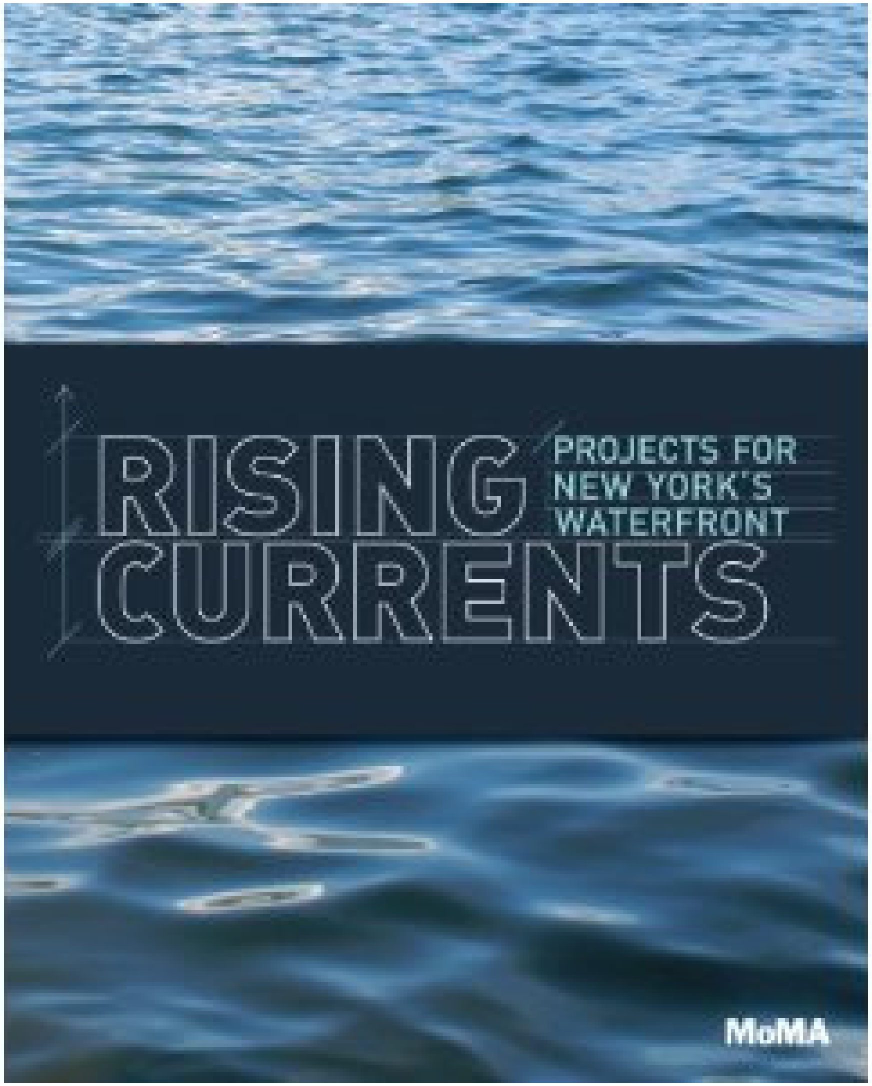


On the Water | Palisade Bay


SUBWAY CAR REEF
WAVE AND WIND TURBINES
OYSTER RACKS
ARCHIPELAGO ISLANDS
WETLANDS AND PARKS
OFFSHORE PIERS
PIERS AND SLIPS
PALISADE BAY
KILL VAN KULL
VERRAZANO NARROWS



2 MoMA Rising Currents _2010



Rising Currents

3a Post Hurricane Sandy Policies _2013

NYS 2100 COMMISSION

Recommendations to Improve the Strength and Resilience of the Empire State's Infrastructure

infrastructure techniques intended to retain and absorb stormwater at the surface have the benefit of reducing the strain on storm sewer capacity by reducing the volume of stormwater that enters the piped system.

From an economic standpoint, natural solutions require lower maintenance and management costs when compared to traditional built infrastructure. Analyses performed by McKinsey, Swiss Re, and the Rockefeller Foundation have shown that reef and wetland management and restoration can be among the most cost-effective approaches for hazard mitigation.[8] The authors of the Palisade Bay proposal sought to show how various types of natural protective infrastructure can be placed in the New York and New Jersey Upper Harbor (Figure L-08). The Museum of Modern Art "Rising Currents" workshop and exhibition further developed this approach through five detailed designs for the NY Harbor.

These approaches, however, also have limitations. While they reduce damage and erosion due to waves, they do not serve to protect against stillwater flooding, for example. They also may not be appropriate in some urban areas or preclude competing land uses. As such, feasibility analyses must evaluate how to integrate natural solutions with repairs to existing hard shoreline defenses such as riprap, bulkheads, levees, and berms as well as newly created hard defenses. Measures should also include land use and zoning appropriate for achieving risk reduction in New York City. More importantly, the comprehensive package should not impair any existing or contemplated commercial and navigational interests.

The Commission recommends the State conduct a detailed feasibility study to explore how the five major types of natural infrastructure presented on the next page should be used as parts of a Harbor resilience strategy. In particular, the analysis should include the following.

Beaches and dunes: Identify how to expand and protect barrier islands, beaches,

Figure L-10: Proposed natural protective infrastructure from On the Water | Palisade Bay by Guy Nordenson, Catherine Seavitt and Adam Yarinsky. The designers who participated in the workshop suggested that a dense network of piers, islands, wetlands and oyster beds could project out into New York Harbor from the waterfronts on all sides, breaking up storm surges. An additional archipelago of small fingerlike islands could be built in the center of the harbor, and old subway cars could be dumped into the water to form reefs. (Guy Nordenson et al, 2010)

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Rendering from *On the Water: Palisade Bay* of potential storm surge barrier islands in Upper New York Harbor.

Research and Innovation

The challenges of climate change lead us to re-examine traditional approaches to coastal management and to seek new, creative solutions to supplement the range of available adaptation strategies. The *On The Water: Palisade Bay* project by Guy Nordenson, Catherine Seavitt, and Adam Yarinsky, which considered potential interventions to attenuate storm surge in Upper New York Harbor, was an important step in exploring alternative approaches. The subsequent "Rising Currents: Projects for New York's Waterfront" exhibition at the Museum of Modern Art further illustrated potential strategies.

Clearly, more information will be needed. This includes the creation of a comprehensive inventory of adaptation strategies—including innovative strategies—with possible applicability to New York City. It will be important to establish partnerships among practitioners of many disciplines—including planning, engineering, design, marine biology, and ecology—to develop and test new coastal interventions that have the potential to promote a safe city and sound ecology within a changing environment. Studies that provide information on the benefits and drawbacks of emerging strategies will be helpful as part of this effort. Pilot projects that gather empirical data on the effectiveness and ecological value of alternative strategies will also be valuable.

Integrating Resilience Into Planning

Everyone from government to homeowners to insurance companies will need to consider the implications of climate change and sea level rise and make decisions about resilience strategies. It will be important to integrate resilience considerations into planning on a continuing basis. This will provide opportunities for ongoing adaptation. For instance, much of the city's waterfront infrastructure—such as bulkheads, docks, roads, and bridges—will need to be rebuilt or renovated as a matter of course before the most pronounced effects of sea level rise are expected to be felt. Incorporating consideration of climate-change projections into the design specifications for such structures and into long-term capital plans will ensure that flood risks and sea level rise are taken into account when new facilities are built, and existing ones upgraded.

Whether it's piloting inventive solutions or simply replacing existing bulkheads, the maintenance and improvement of the waterfront will require a predictable process for the review and issuance of permits for in-water construction (for further discussion see section of *Vision 2020* on government oversight, beginning on page 96). Establishing guidelines and standards for the design of waterfront infrastructure can facilitate the protection of development areas while minimizing ecological damage and maximizing ecological benefits.

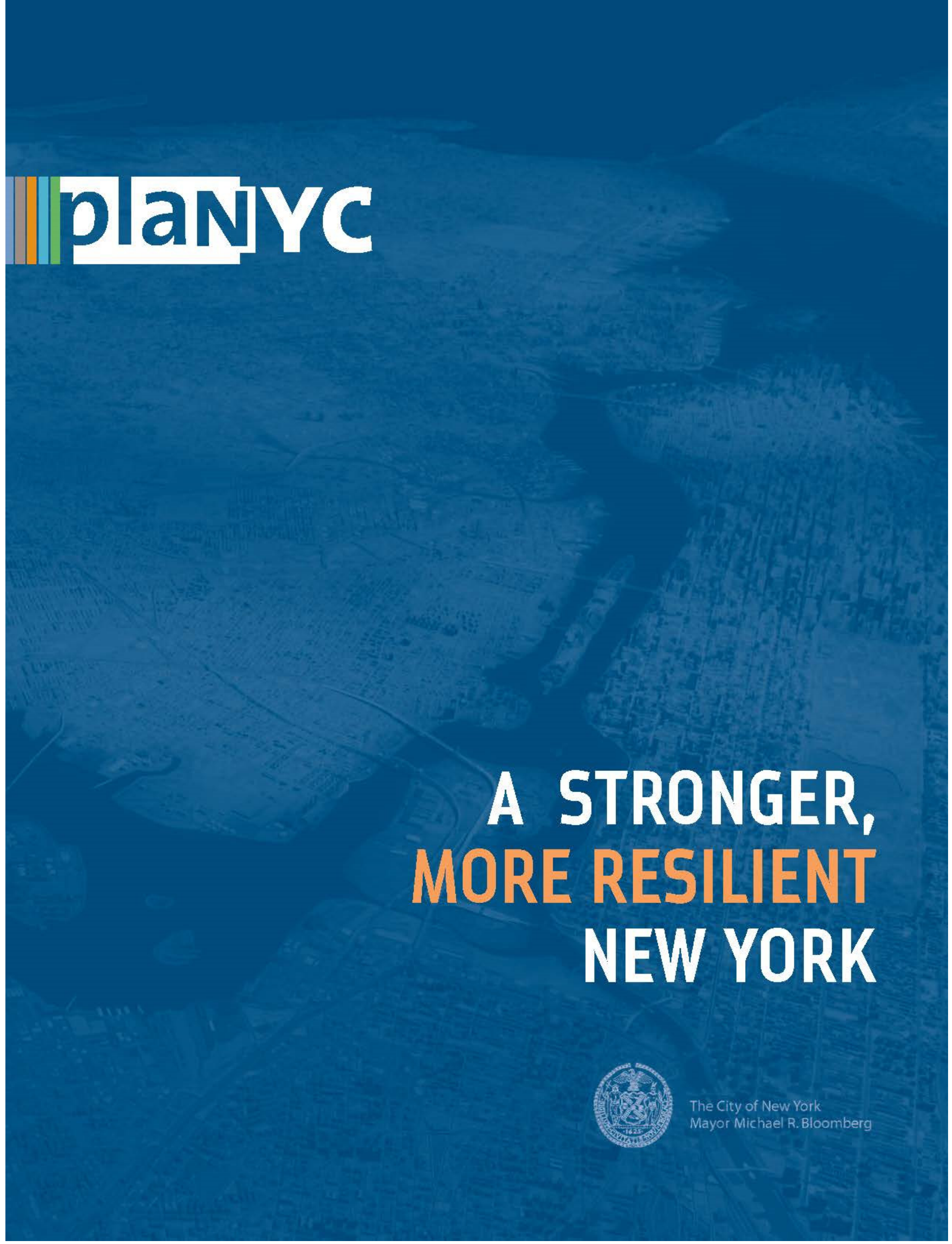
EVALUATION OF STRATEGIES

With a waterfront as big and as diverse as New York's, there can be no one-size-fits-all solution for climate change. It is important to identify a range of potential strategies to increase the city's resilience. In very limited, less-developed portions of the city, controlled retreat from coastal land may be an option; in others, accommodation strategies may be sufficient; and in yet others, enhanced protection of shorelines will be necessary. In all these cases, decisions about shoreline management must consider the full range of costs and benefits and take into account both ecological and economic development goals. Opportunities to leverage other resources or provide co-benefits—such as augmenting a berm alongside a highway that could also serve as a levee—should be considered.

Evaluating these strategies is challenging. There is inherent unpredictability in storm events and the risks they present, as well as some uncertainty in climate projections. In addition, it is difficult to predict future changes that may result from storm events, or from erosion and accretion of shorelines, or the secondary effects of such changes. There are also many unknowns about the possible effects of many of the strategies mentioned above. In the future, scientific modeling, empirical research, and pilot projects can yield better information. Improved scientific understanding will be important in the evaluation of potential adaptive strategies.

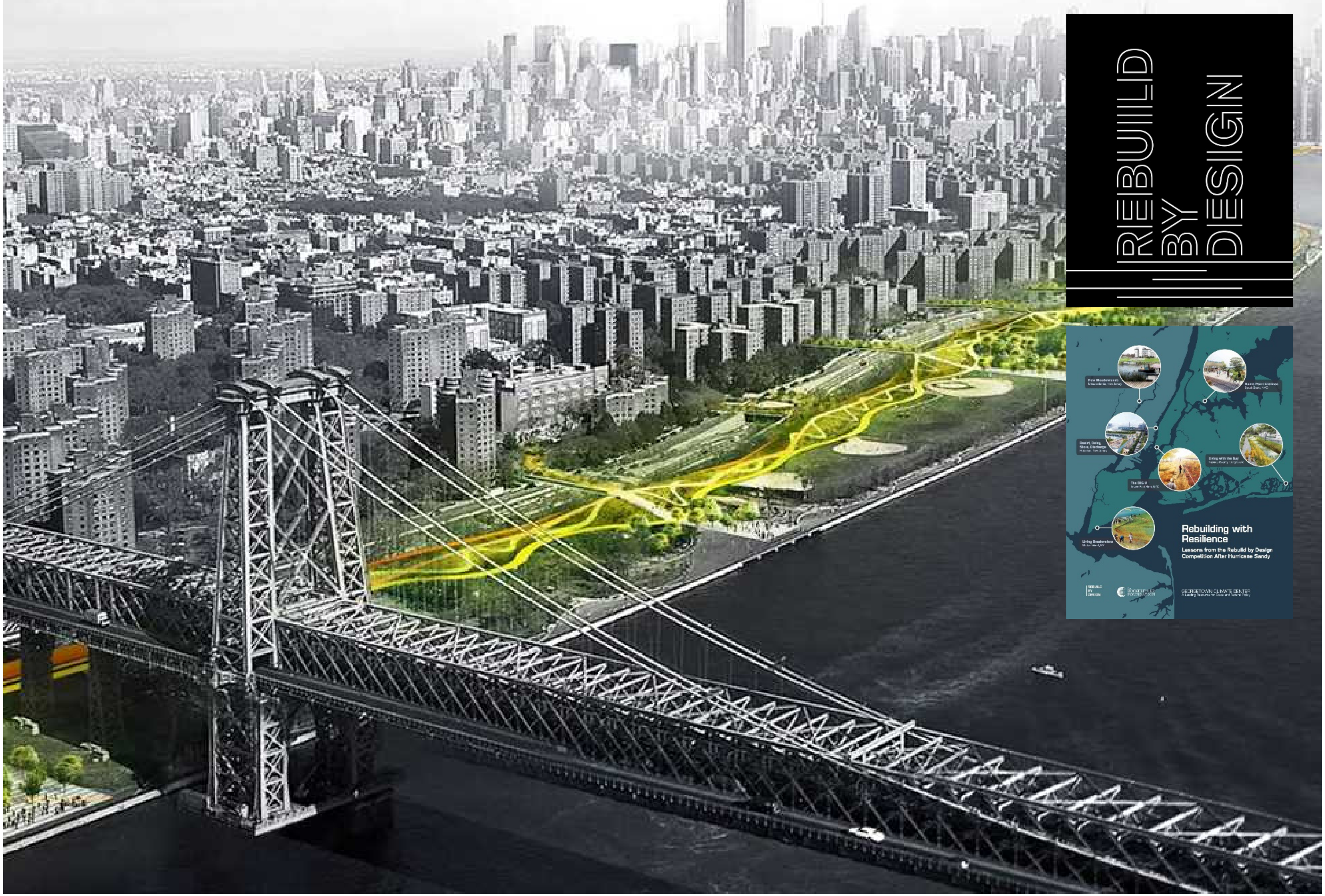
There are, however, actions that can be explored now to build resilience. These include allowances and potential requirements for more stringent flood protection of buildings in flood-vulnerable areas; updating FEMA flood maps to accurately reflect current topography; the periodic updating of emergency-response plans; improvements to the coastal permitting processes necessary to undertake adaptation; and public education about climate-related risks and opportunities to address them.

Measures to increase the city's resilience must consider a number of goals, including economic development, public access, and ecological health. Strategies should be promoted that produce co-benefits or advance other desirable ends. Building resilience can be an impetus for transforming the waterfront in ways that can make the city not only more climate-resilient, but also more healthy, prosperous, and livable.


planYC
A STRONGER,
MORE RESILIENT
NEW YORK
The City of New York
Mayor Michael R. Bloomberg

Comprehensive Coastal Protection Plan | Full-Build Recommendations
Increase Coastal Edge Elevations
Beach Nourishment
1 Coney Island, Brooklyn
2 Rockaway Peninsula, Queens
3 East and South Shores, Staten Island
A Orchard Beach, Bronx
Armor Stone (Revetments)
4 Coney Island Creek, Brooklyn
5 Annadale, Staten Island
B South Shore, Staten Island
Bulkheads
6 Citywide Program
7 Belt Parkway, Brooklyn
8 Beach Channel Drive, Queens
Tide Gates / Drainage Devices
9 Oakwood Beach, Staten Island
10 Flushing Meadows, Queens
C Coney Island Creek, Brooklyn
D Mill Creek, Staten Island
Minimize Upland Wave Zones
Dunes
11 Rockaway Peninsula, Queens
12 Breezy Point, Queens
E Coney Island, Brooklyn
Offshore Breakwaters
13 Great Kills Harbor, Staten Island
F South Shore, Staten Island
G Rockaway Extension
H City Island, Bronx
Wetlands, Living Shorelines and Reefs
14 Howard Beach, Queens
15 Tottenville, Staten Island
16 Plumb Beach, Brooklyn
17 Brant Point, Queens
I Jamaica Bay
J Bay Ridge Flats
K Saw Mill Creek, Staten Island
Groins
18 Sea Gate, Brooklyn
Protect Against Storm Surge
Integrated Flood Protection System
19 Hunts Point, Bronx
20 East Harlem, Manhattan
21 Lower Manhattan / Lower East Side
22 Hospital Row, Manhattan
23 Red Hook, Brooklyn
L Brooklyn-Queens Waterfront
M West Midtown, Manhattan
Floodwalls / Levees
24 East Shore, Staten Island
25 Farragut Substation, Brooklyn
N Astoria Generating Station, Queens
Local Storm Surge Barrier
26 Newtown Creek
O Rockaway Inlet
P Gowanus Canal, Brooklyn
Multi-purpose Levee
Q Lower Manhattan
Phase 1 Initiatives
Additional Full-Build Recommendations
Note: Though all projects indicated on this map are recommended in the full-build scenario, not all are individually labeled in the key.
51 A STRONGER, MORE RESILIENT NEW YORK
CHAPTER 3 | COASTAL PROTECTION 52

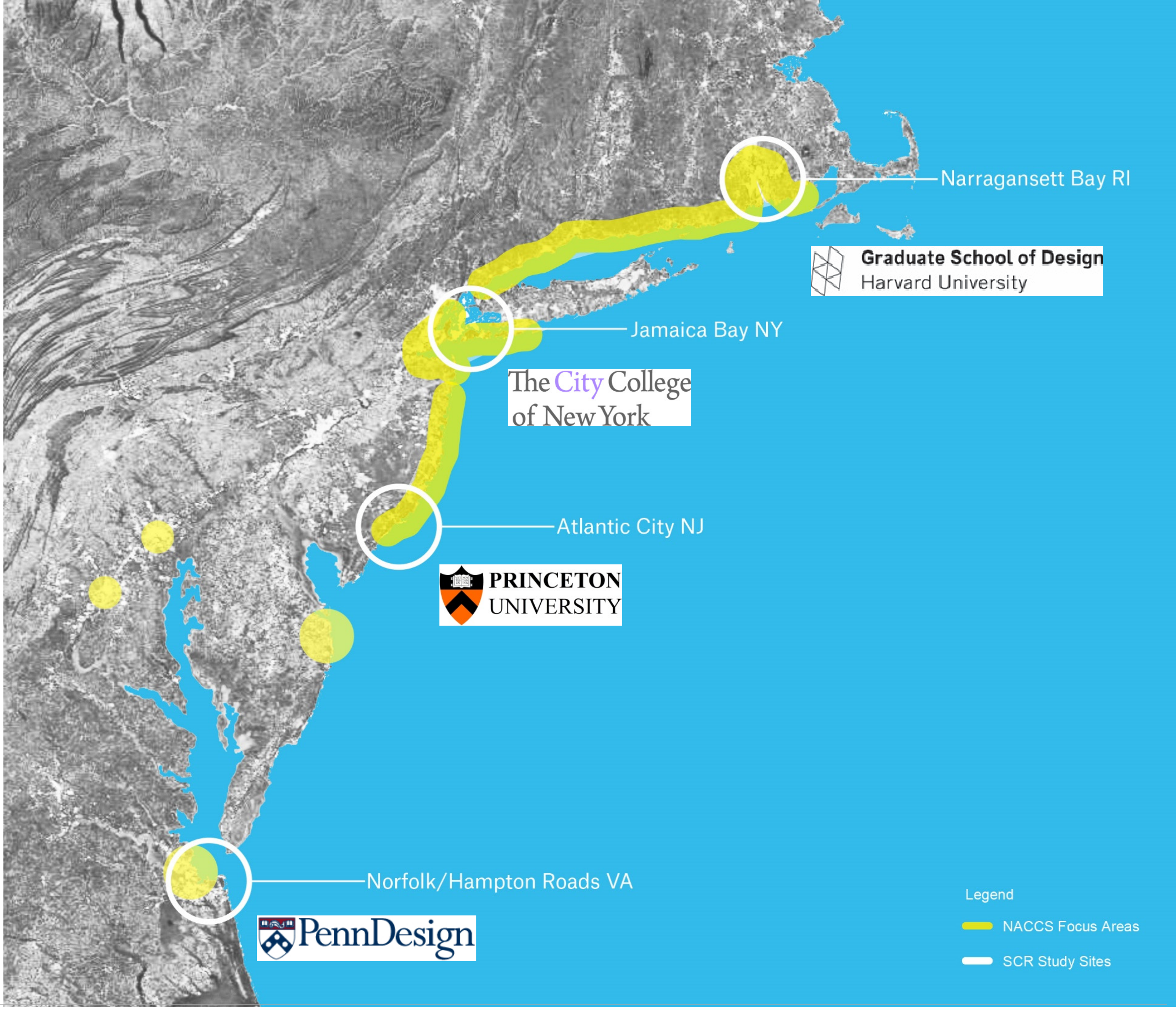
3b Rebuild by Design _2013



3c Structures of Coastal Resilience _2015

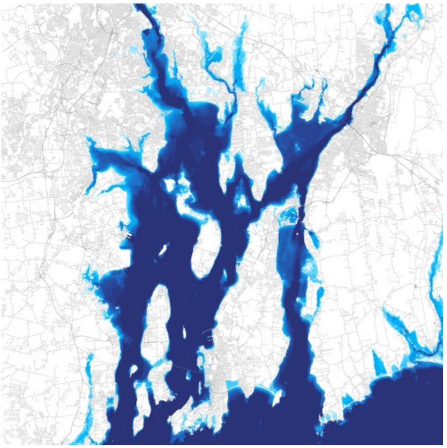
THE ROCKEFELLER FOUNDATION
PRINCETON UNIVERSITY
Graduate School of Design Harvard University
The City College of New York
PennDesign

SCR

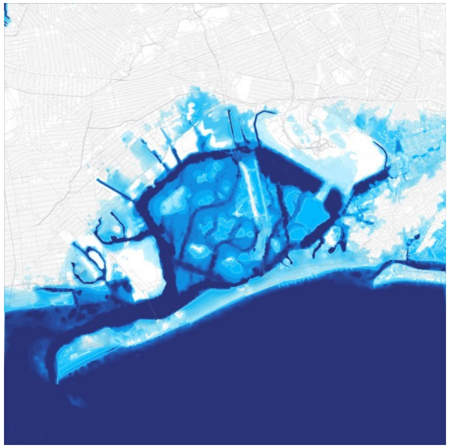


Narragansett Bay RI
Graduate School of Design
Harvard University
Jamaica Bay NY
The City College of New York
Atlantic City NJ
PRINCETON UNIVERSITY
Norfolk/Hampton Roads VA
PennDesign
Legend
NACCS Focus Areas
SCR Study Sites

Storm Surge Flood Mapping for Four Sites

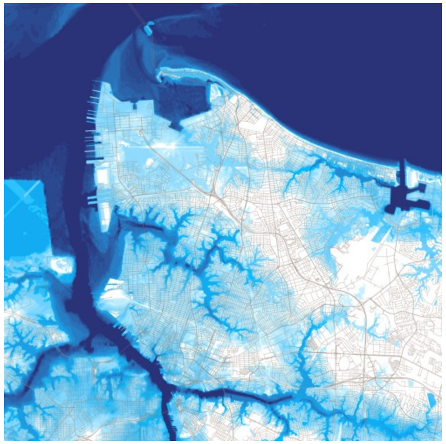


Narragansett Bay
RI



Jamaica Bay
NY

Atlantic City and
Chelsea Heights NJ



Norfolk
VA

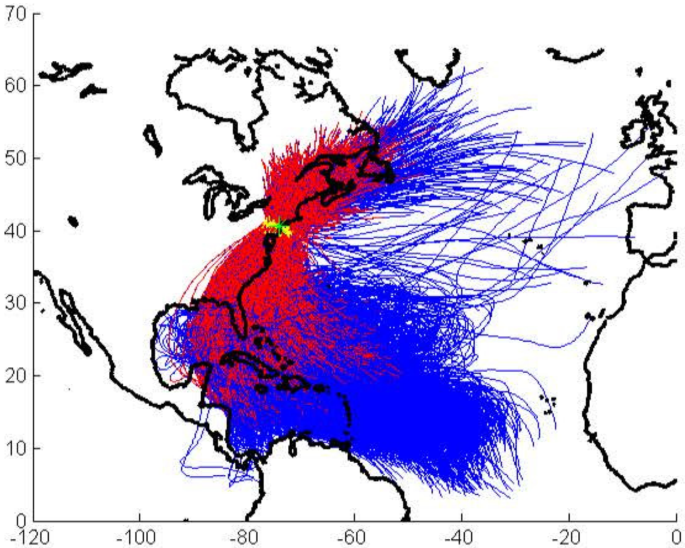
Regional Sea Level Rise Probability Distributions

Percentile	Median	5	95
NYC	96	44	154
Newport	93	43	151
AC	104	53	163
Norfolk	105	59	158
Global Mean	79	52	121

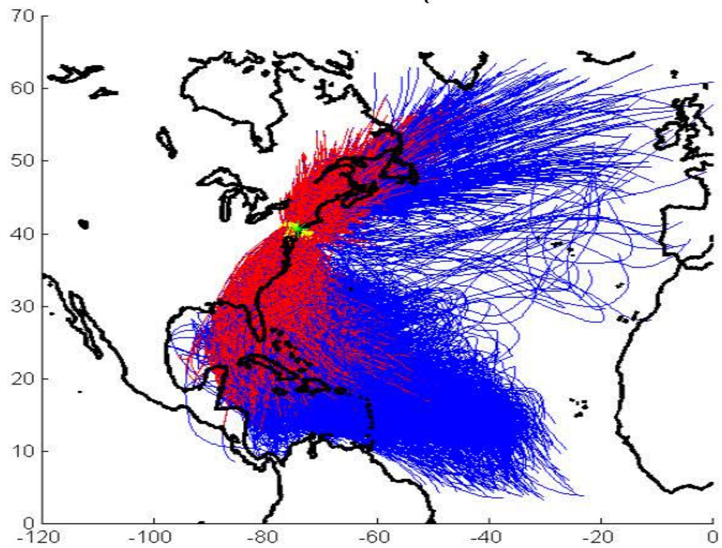
**(note today's numbers are 2100 relative to 2000 baseline; will be 2080-2099 relative to 1980)

Global Circulation Model Driven NYC Region Storm Simulation

GFDL 1981-2000



GFDL 2081-2100 (IPCC-AR4 A1B)



Model	Designation	Institute
CNRM-CM3	CNRM	Centre National de Recherches Météorologiques, Météo-France
ECHAM5	ECHAM	Max Planck Institute
GFDL-CM2.0	GFDL	NOAA Geophysical Fluid Dynamics Laboratory
MIROC3.2	MIROC	CCSR/NIES/FRCGC, Japan

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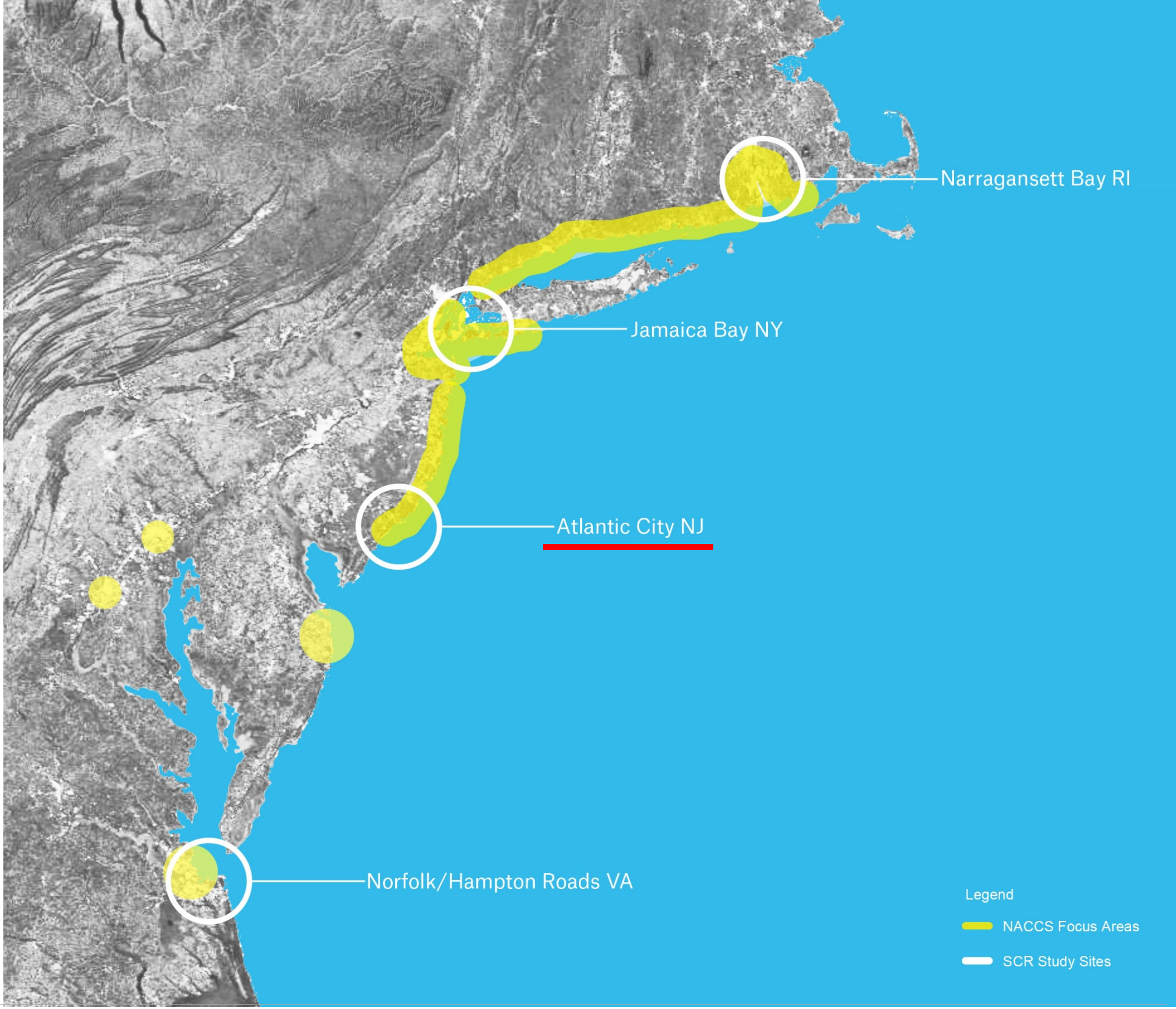
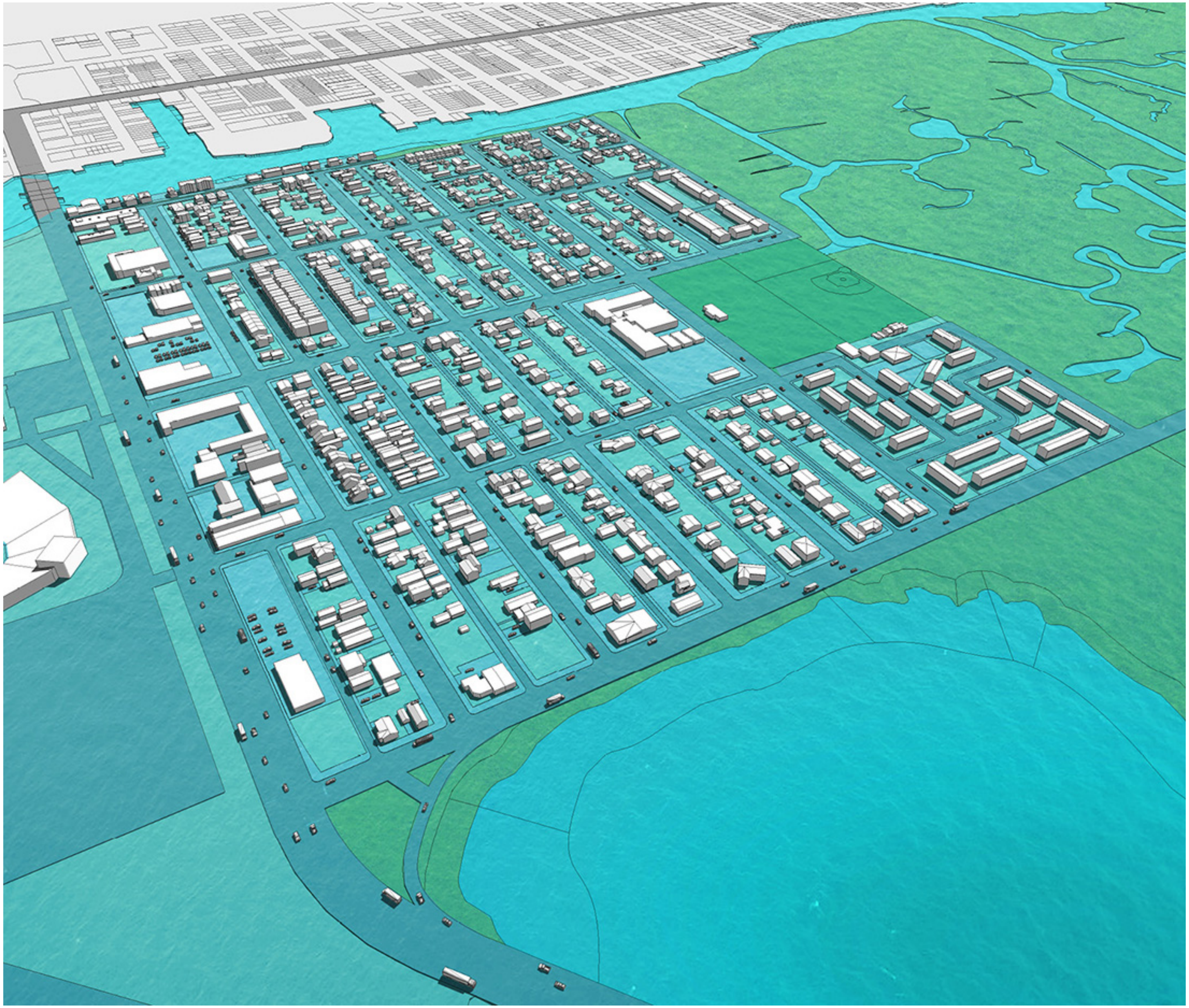
SCR
Chelsea Heights
New Jersey

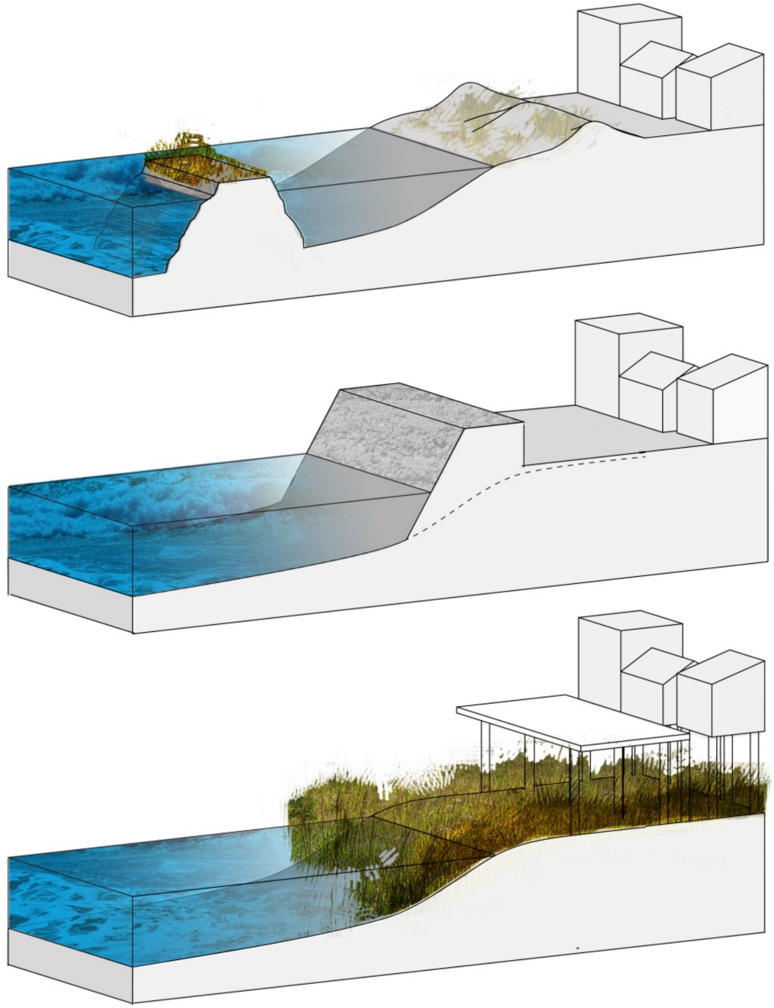


SCR
Chelsea Heights
New Jersey

2014
Surge



Performance Based Design for Flood Risk Mitigation



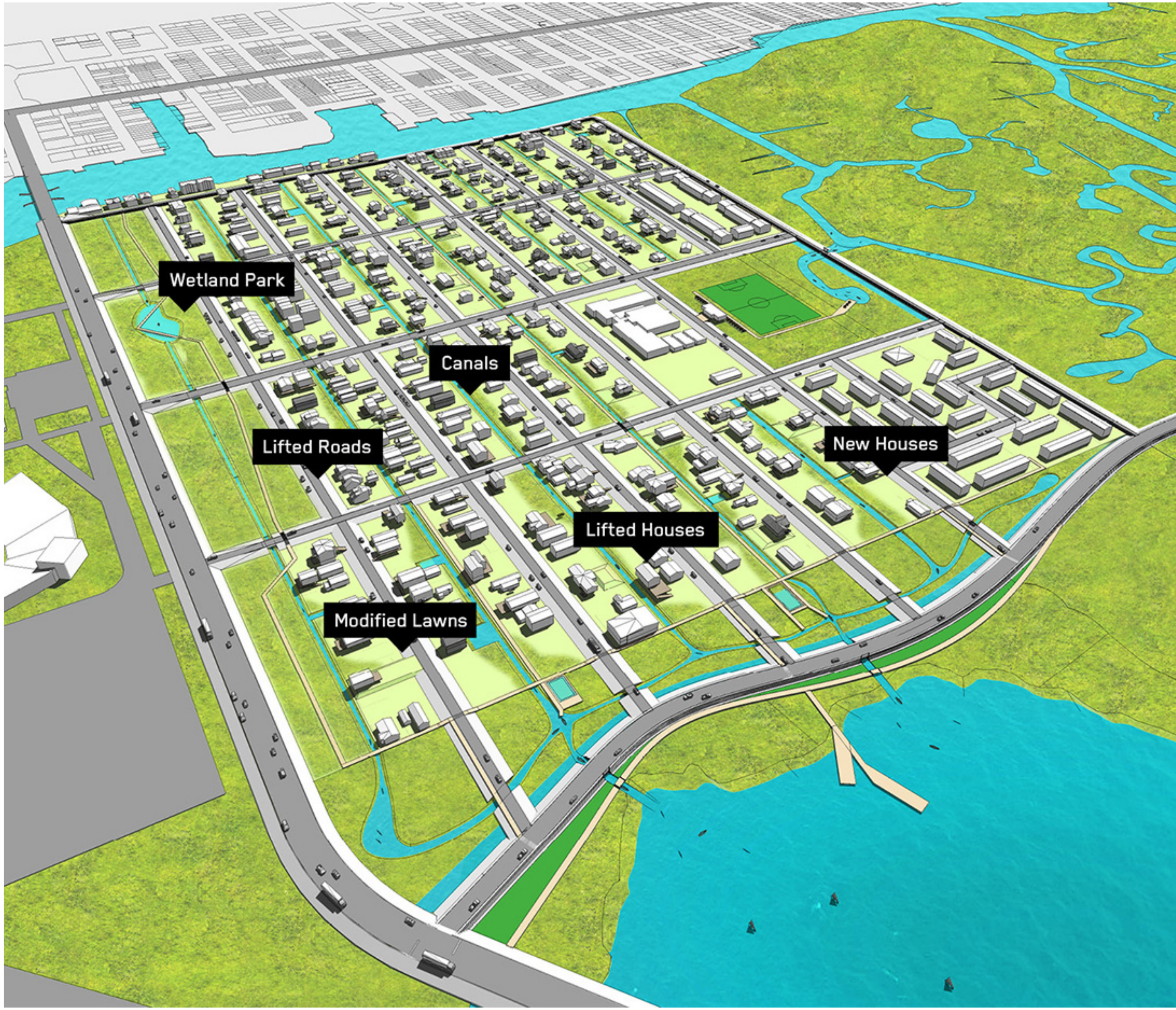
ATTENUATION & DISSIPATION

PROTECTION

PLANNING

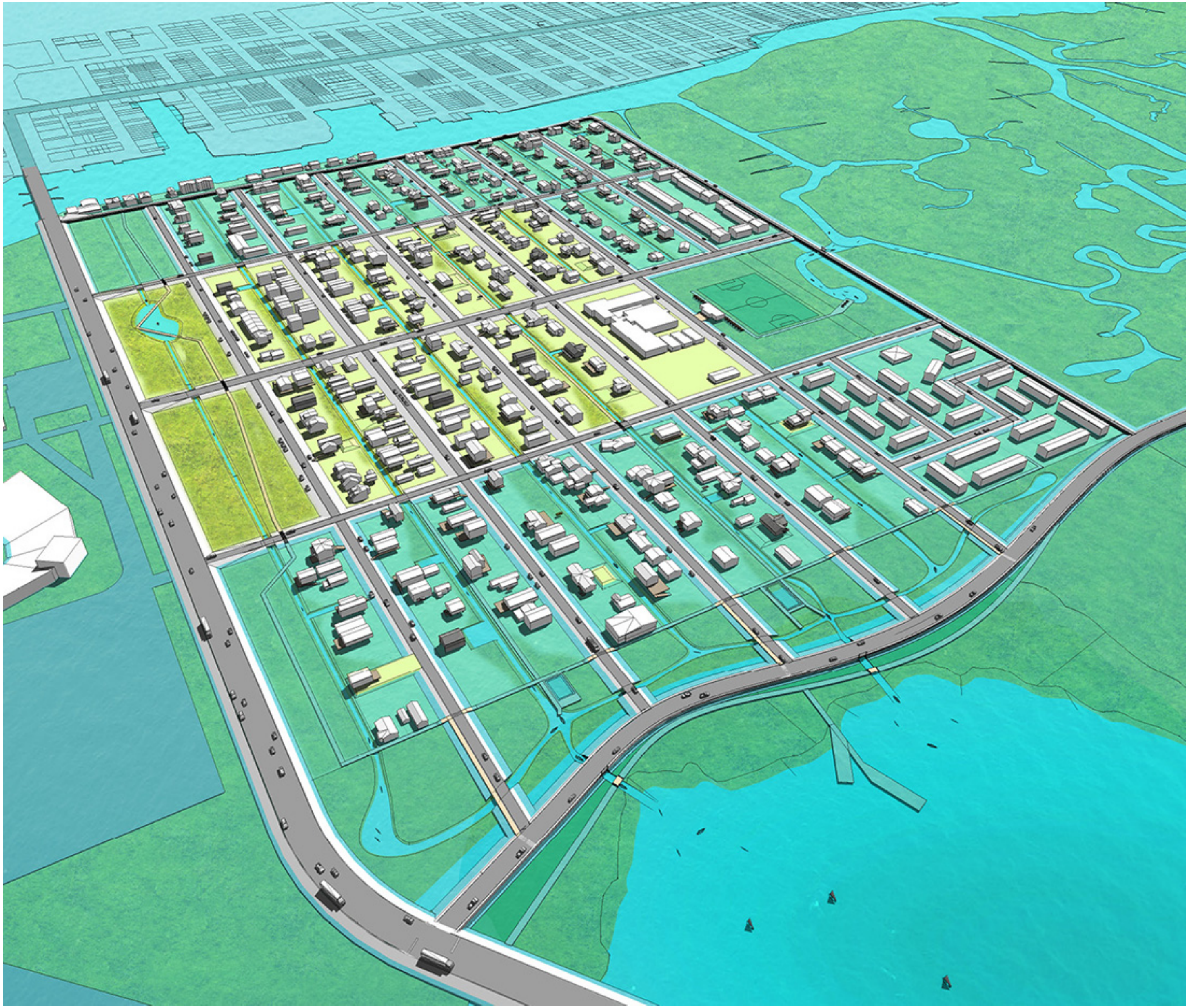
SCR
Chelsea Heights
New Jersey

2050

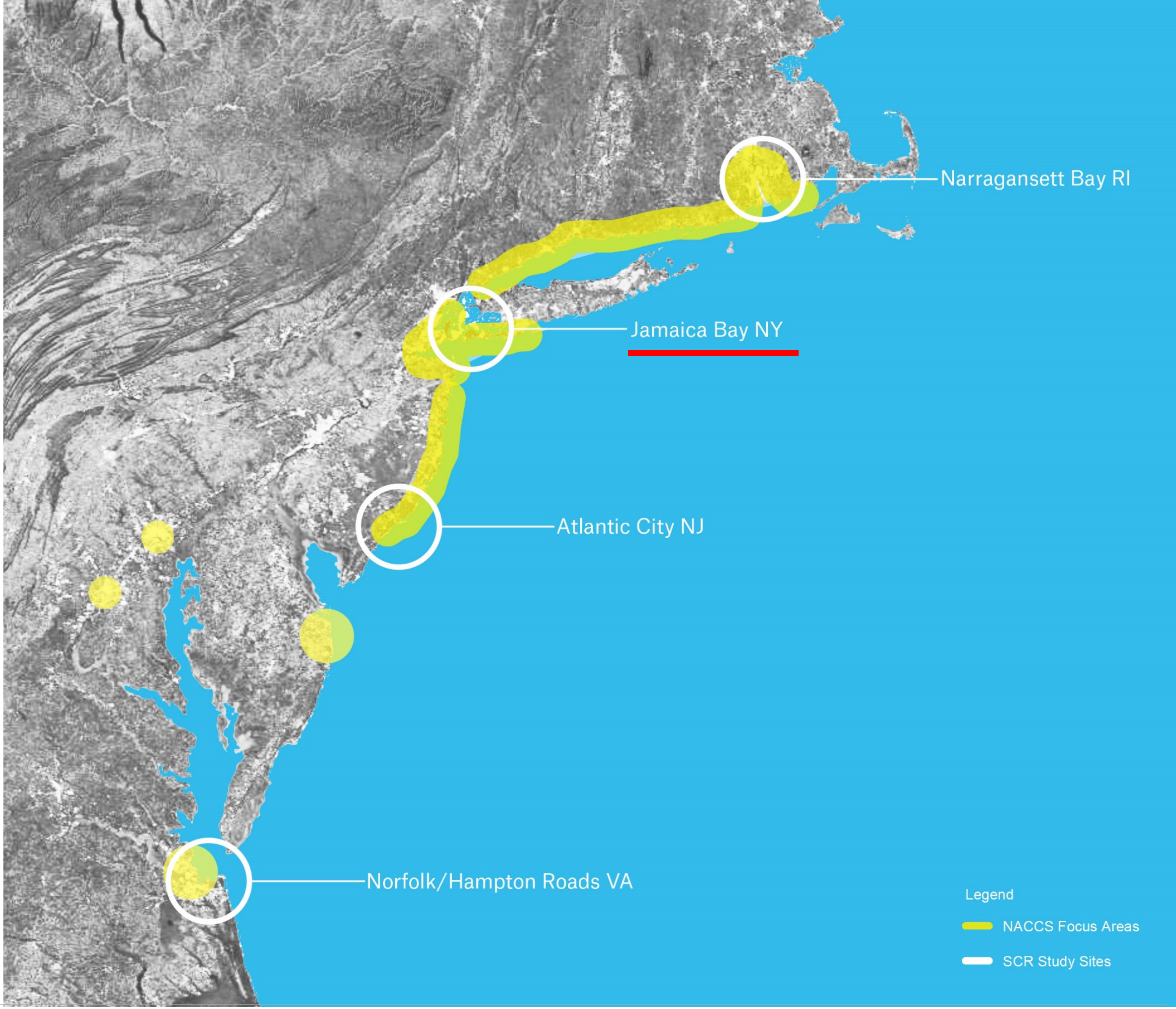


SCR
Chelsea Heights
New Jersey

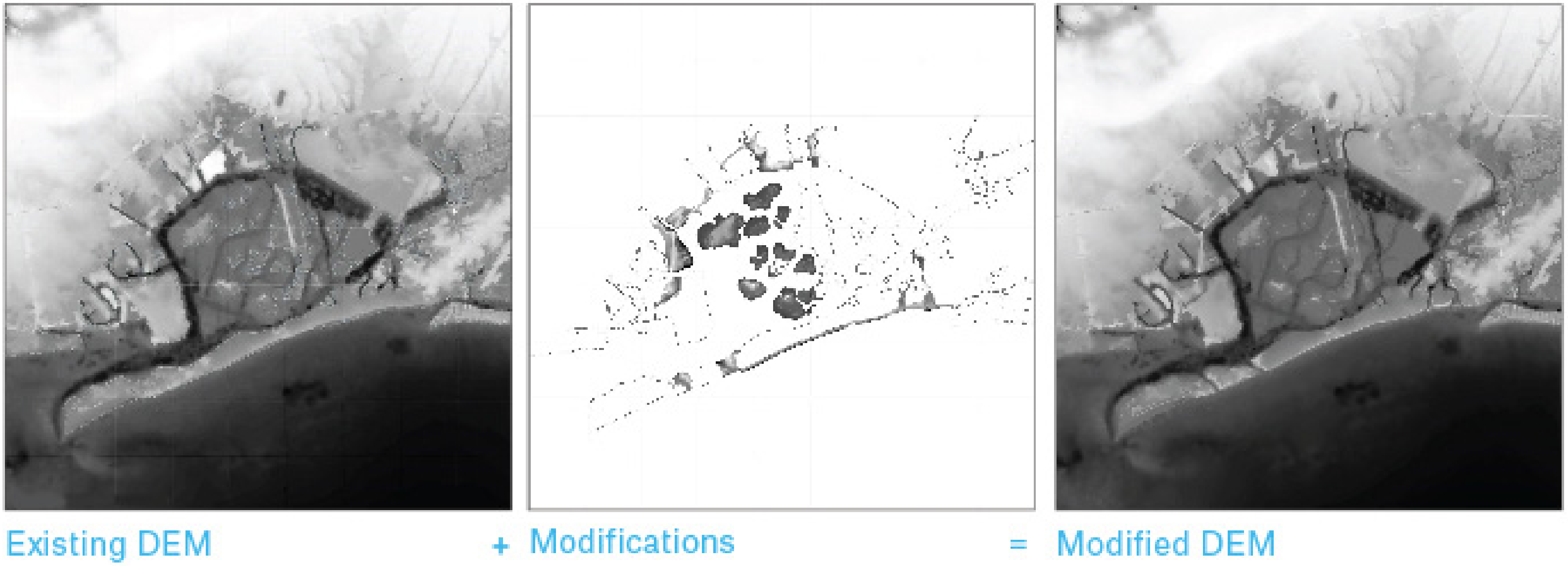
2050
Surge



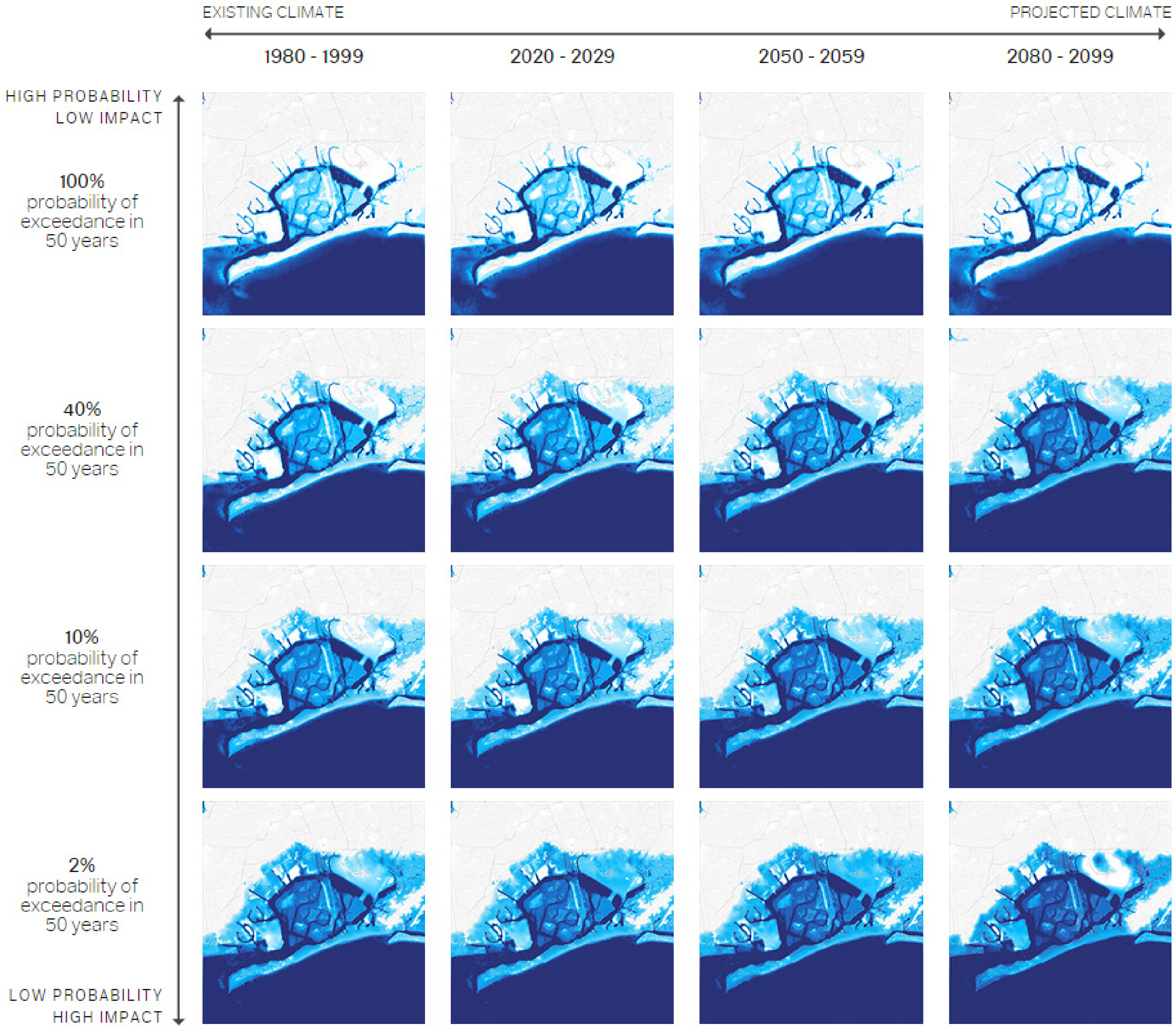
SCR
Jamaica Bay



Dynamic Performance Based Design

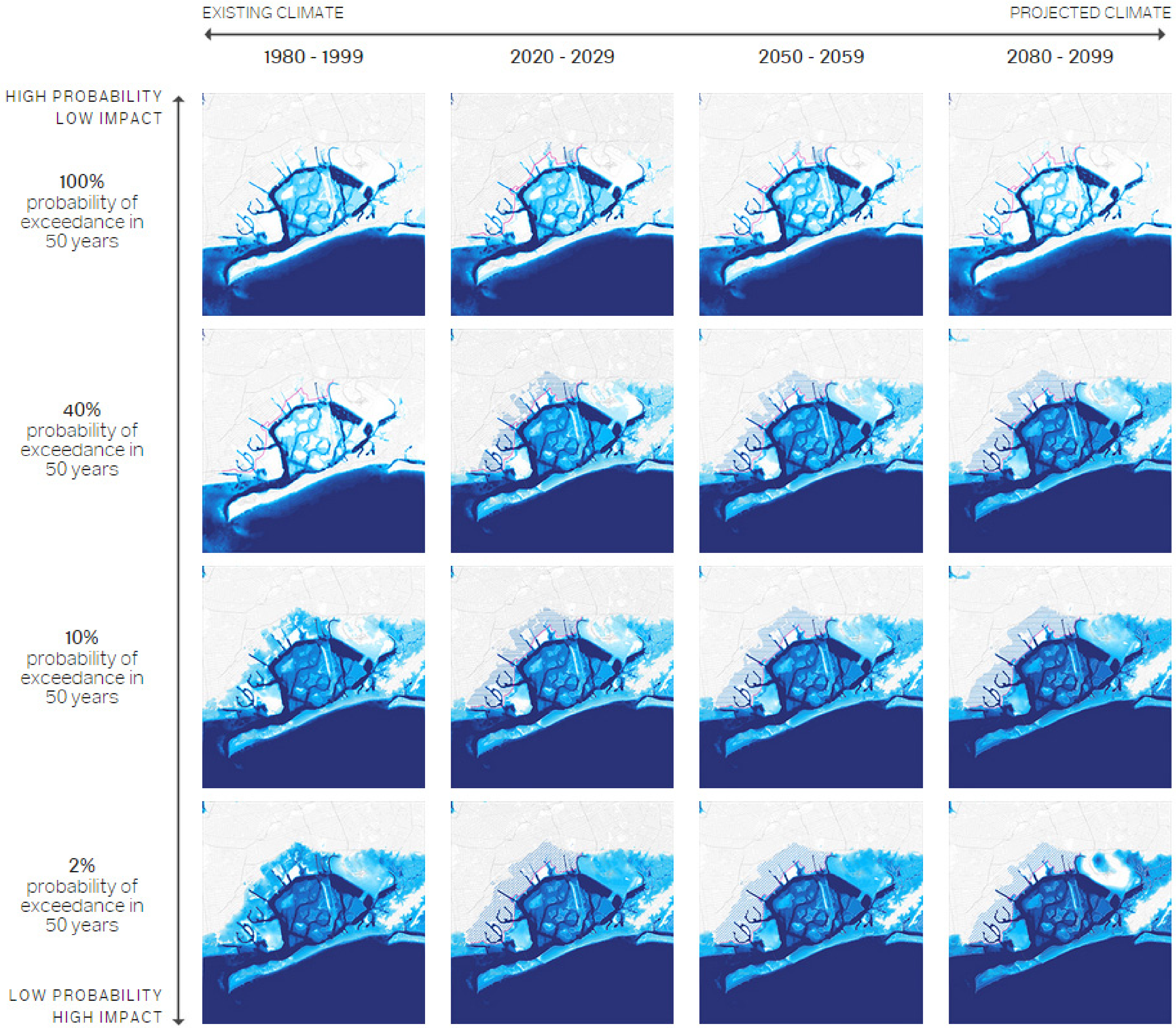


Existing Topography Proposed Topography

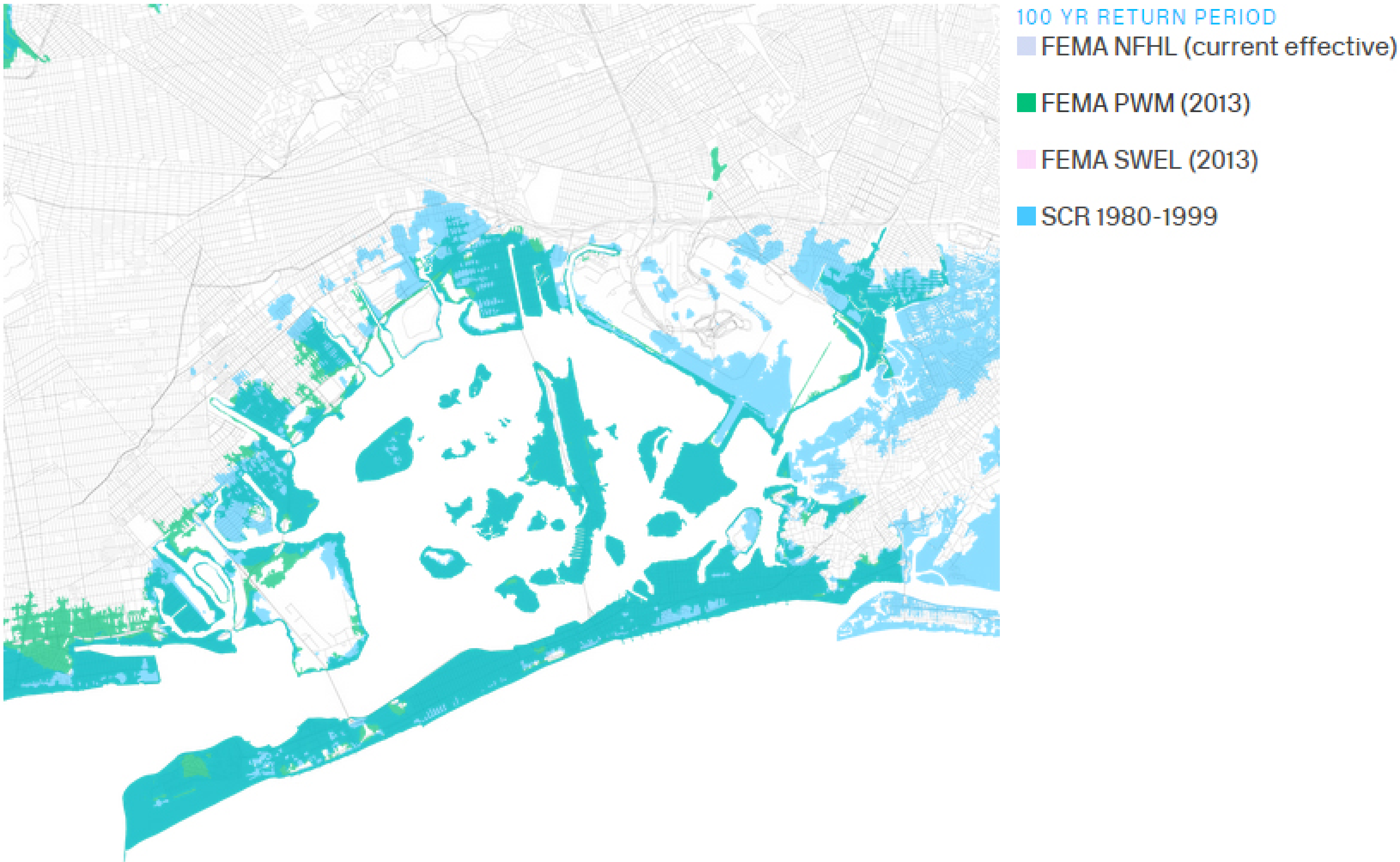


Existing Topography

Proposed Topography



FEMA Preliminary Work Map 100 (1%) year and SCR 100 year (1%) floodplains



www.structuresofcoastalresilience.org