Climate Adaptation by Design

// Coastal Adaptation and Resilience Design

//// Probabilistic Coastal Flood Hazards Mapping

Easy as N E H R P

/// Challenges of Interdisciplinary Research

Princeton WWS STEP Seminar
26 February 2018

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Climate Adaptation by Design

Coastal Adaptation and Resilience Design

1. On the Water | Palisade Bay _2010
2. MoMA Rising Currents _2010
3. Mississippi Delta | Venice Biennale _2010
4. Yangtze River Delta Project _2013
5. Post Hurricane Sandy Policies, Rebuild by Design and Structures of Coastal Resilience _2015
6. RPA Design Initiatives _2017
7. NSF Jamaica Bay Project _2018
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1 On the Water | Palisade Bay _2010
Public Space

Palisade Bay and Central Park
Land and Water Continuum: Topography + Bathymetry = “Topobathy”
ADCIRC Analysis
ADCIRC Analysis

Hurricane Isabel

Sea Level Pressure (hPa)
Surface Wind Speed (m/s)

Sea Level Pressure Contours: 900 to 1100 by 4

Surface Wind Speed (m/s)

10 15 20 25 30 35 40 45 50 55 60 65 70 75 80

OUTPUT FROM WRF V2.2.1 MODEL
Phys Opt = 2; PBL Opt = 1; Cu Opt = 0; WE = 347; SN = 403; Levels = 28; Dto = 4km

ADCIRC Analysis

Adaptation by Design

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2 MoMA Rising Currents _2010
RISING CURRENTS

New York City and its environs face climate-related challenges, including rising seas and more extreme weather events. The climate change adaptation projects on display at the exhibition scope a wide range of issues, from the development of new coastal防护 structures to the transformation of existing waterfront spaces into vibrant public spaces. The projects on display are the result of a design competition organized by the Weather Underground, a collaborative project between the New York City Department of Environmental Protection, the Metropolitan Transportation Authority, and the New York City Department of Parks and Recreation. The exhibition features a range of projects, from temporary pop-up installations to permanent public artworks, that address the challenges of climate change and offer creative solutions for the future of our cities. The projects on display are by a diverse group of designers, architects, and artists, who have come together to create a vision for a more resilient future.
3 Mississippi Delta Project and Venice Biennale _2010
Mississippi Delta Topobathy
Mississippi Delta Project
Climate Adaptation by Design
Davis Pond LA
Mississippi Delta Project

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Mississippi Delta Project
4 Yangtze River Delta Project _2013
Yangtze River Delta Project Map and Topobathy
Yangtze River Delta Flooding
Yangtze River Delta Typhoons

Combined severe past century storms
Yu the Great (2200-2100 BCE, Xia Dynasty)
Yangtze River Delta Atlas
Yangtze River Delta Atlas
Yangtze River Delta Atlas
Chénier and Open Polders
Yangtze River Delta *Chénier*
Chénier

Yangtze River Delta Chénier

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5/a Post Hurricane Sandy Policies _2013
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Recommendations to Improve the Strength and Resilience of the Empire State’s Infrastructure

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. 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 part 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,
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: Ballast Point project by City Montessori, Catherine Seaborn, and Adam Yarmo, which considered potential interventions to alleviate 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 safer 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 waterfront 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.

VISION 2020
NEW YORK CITY COMPREHENSIVE WATERFRONT PLAN

Post Hurricane Sandy Policies
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VISION 2020: NEW YORK CITY COMPREHENSIVE WATERFRONT PLAN 57
5/b  Rebuild by Design _2013
Storm Surge Flood Mapping for Four Sites

Narragansett Bay
RI

Jamaica Bay
NY

Atlantic City and Chelsea Heights NJ

Norfolk VA
Inundation Maps = (Storm Tide + Sea Level Rise) – (Topography and Bathymetry)
## Regional Sea Level Rise Probability Probability Distributions

<table>
<thead>
<tr>
<th>Percentile</th>
<th>Median</th>
<th>5</th>
<th>95</th>
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<tbody>
<tr>
<td>NYC</td>
<td>96</td>
<td>44</td>
<td>154</td>
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<tr>
<td>Newport</td>
<td>93</td>
<td>43</td>
<td>151</td>
</tr>
<tr>
<td>AC</td>
<td>104</td>
<td>53</td>
<td>163</td>
</tr>
<tr>
<td>Norfolk</td>
<td>105</td>
<td>59</td>
<td>158</td>
</tr>
<tr>
<td><strong>Global Mean</strong></td>
<td><strong>79</strong></td>
<td><strong>52</strong></td>
<td><strong>121</strong></td>
</tr>
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</table>

**(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

<table>
<thead>
<tr>
<th>Model</th>
<th>Designation</th>
<th>Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNRM-CM3</td>
<td>CNRM</td>
<td>Centre National de Recherches Météorologiques, Météo-France</td>
</tr>
<tr>
<td>ECHAM5</td>
<td>ECHAM</td>
<td>Max Planck Institute</td>
</tr>
<tr>
<td>GFDL-CM2.0</td>
<td>GFDL</td>
<td>NOAA Geophysical Fluid Dynamics Laboratory</td>
</tr>
<tr>
<td>MIROC3.2</td>
<td>MIROC</td>
<td>CCSR/NIES/FRCGC, Japan</td>
</tr>
</tbody>
</table>
SCR
Chelsea Heights
New Jersey

Structures of Coastal Resilience

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69
SCR
Chelsea Heights
New Jersey
2014
SCR
Chelsea Heights
New Jersey

2014
Surge

Chelsea Heights, Atlantic City NJ

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Performance Based Design for Flood Risk Mitigation

ATTENUATION & DISSIPATION

PROTECTION

PLANNING
SCR
Chelsea Heights
New Jersey

2050

Chelsea Heights, Atlantic City NJ
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SCR
Chelsea Heights
New Jersey

2050 Surge

Chelsea Heights, Atlantic City NJ
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SCR
Jamaica Bay
Dynamic Performance Based Design

Existing DEM + Modifications = Modified DEM
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Dynamic Performance Based Design

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Climate Adaptation by Design

Dynamic Performance Based Design

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Dynamic Performance Based Design

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FEMA Preliminary Work Map 100 (1%) year and SCR 100 year (1%) floodplains
In order to provide a fine-grained study of vulnerability at Jamaica Bay, layered indices of social, environmental, and infrastructural risk are geospatially mapped. Sea level rise affects each of these categories, through possible loss of life and property from flooding, loss of valuable wetland ecologies, and loss of critical infrastructures such as transportation, power, and communication. These vulnerability maps provide a focused lens for assessing at-risk communities and ecologies, and often reveal unexpected patterns of exposure to hazard.
https://design-competition.rpa.org/
MoMA PS1 Exhibition
Triboro Corridor in NYC

The Low Carbon Corridor

Catalysts
NSF Jamaica Bay Project: East Jamaica Bay NY
NSF Jamaica Bay Project: Extreme Flooding Protection
NSF Jamaica Bay Project: Local Seasonal Flood and SLR Protection
NSF Jamaica Bay Project: 3 Layered System
NSF Jamaica Bay Project: Seasonal Flooding to NAVD88 +10ft
NSF Jamaica Bay Project: Seasonal Flooding to NAVD88 +10ft
NSF Jamaica Bay Project: Design Flooding to NAVD88 +20ft
NSF Jamaica Bay Project: Extreme Flooding above NAVD88 +20ft (Weir)
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// Probabilistic Coastal Flood Hazards Mapping
Easy as N E H R P
Comparison of 100 year (1%) Floodplain in 1983 and Sandy Inundation Area
Fig. 8 Loss ratio of Ortley Beach houses (*blocks*) overlaid on FEMA flood zones (*shades*).

- The loss ratio ranges from 0% (*green block*) to 100% (*red block*; measured by the *color bar*).

- Flood zones of FEMA include (in order of high to low risk): VE zone (*red shade*), AE zone (*yellow shade*), AO zone (*light green shade*), and X zone (*blue shade*).

Ref. Xian, Siyuan, Ning Lin, and Adam Hatzikyriakou. "Storm surge damage to residential areas: a quantitative analysis for Hurricane Sandy in comparison with FEMA flood map." *Natural Hazards* 79.3 (2015): 1867-1888

(a) current effective FIRM and (b) preliminary new FIRM
Compare SCR Floodplains with other Flood Maps

100 YR RETURN PERIOD
- FEMA NFHL (current effective)
- FEMA PWM (2013)
- FEMA SWEL (2013)
- SCR 1980-1999
FEMA Preliminary Work Map 100 year floodplain and SCR 100 year floodplain
NEHRP Recommended Provisions

for Seismic Regulations for New Buildings and Other Structures

FEMA 450-1 / 2003 Edition


FEMA

National Earthquake Hazards Reduction Program (NEHRP)
Earthquake Hazards Reduction Act of 1977, As Amended
Earthquake Hazards Reduction Act of 1977 (Public Law 95-124, 42 U.S.C. 7701 et. seq.)

SECTION 3. PURPOSE.
It is the purpose of the Congress in this Act to reduce the risks of life and property from future earthquakes in the United States through the establishment and maintenance of an effective earthquake hazards reduction program. The objectives of such program shall include:
(1) the education of the public, including State and local officials, as to earthquake phenomena, the identification of locations and structures which are especially susceptible to earthquake damage, ways to reduce the adverse consequences of an earthquake, and related matters;
(2) the development of technologically and economically feasible design and construction methods and procedures to make new and existing structures, in areas of seismic risk, earthquake resistant, giving priority to the development of such methods and procedures for power generating plants, dams, hospitals, schools, public utilities and other lifelines, public safety structures, high occupancy buildings, and other structures which are especially needed in time of disaster;
(3) the implementation, to the greatest extent practicable, in all areas of high or moderate seismic risk, of a system (including personnel, technology, and procedures) for **predicting damaging earthquakes and for identifying, evaluating, and accurately characterizing seismic hazards**;

(4) the development, publication, and promotion, in conjunction with State and local officials and professional organizations, of **model building codes** and other means to encourage consideration of information about seismic risk in making decisions about land-use policy and construction activity;

(5) the development, in areas of seismic risk, of improved understanding of, and capability with respect to, earthquake-related issues, including methods of **mitigating** the risks from earthquakes, **planning** to prevent such risks, disseminating warnings of earthquakes, organizing emergency services, and planning for reconstruction and redevelopment after an earthquake;

(6) the development of ways to **increase the use of existing scientific and engineering knowledge to mitigate earthquake hazards**; and

(7) the development of ways to assure the availability of **affordable earthquake insurance**.
Documentation for the 2008 Update of the United States National Seismic Hazard Maps

Open-File Report 2008–1128

U.S. Department of the Interior
U.S. Geological Survey

National Earthquake Hazards Reduction Program (NEHRP)

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Seaside, Oregon Tsunami Pilot Study—Modernization of FEMA Flood Hazard Maps

By Tsunami Pilot Study Working Group

500-year tsunami—
maximum wave height (m) with
a 0.002 annual probability
of exceedance

Joint NOAA/USGS/FEMA Special Report
U.S. National Oceanic and Atmospheric Administration
U.S. Geological Survey
U.S. Federal Emergency Management Agency

Figure 29: Tsunami wave heights (m) with a 1% annual probability of exceedance. Wave heights include the effects of tides.

Figure 30: Tsunami wave heights (m) with a 0.2% annual probability of exceedance. Wave heights include the effects of tides.
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