ON THE WATER | PALISADE BAY is the collaborative initiative of a group of engineers, architects, landscape architects, planners, and students to imagine a "soft infrastructure" for the New York–New Jersey Upper Bay by developing interconnected infrastructures and landscapes which rethink the thresholds of water, land, and city. The proposal is sited on the water, along the coastal edge, and within the local communities. It presents a new coastal planning strategy which not only mitigates potential damage from storms but also provides new ground for recreation, ecologies, agriculture, and urban development. With climate change and sea level rise acting as catalysts for this work, a quantitative analysis of dynamic systems serves as the foundation for this new soft infrastructure, which both enriches the ecology of the urban estuary and creates a vibrant culture on the water.

Research from this project is the inspiration for the exhibition *Rising Courrents: Projects for New York's Waterfront*, opening at The Museum of Modern Art, New York, in March 2010.

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ON THE WATER | PALISADE BAY

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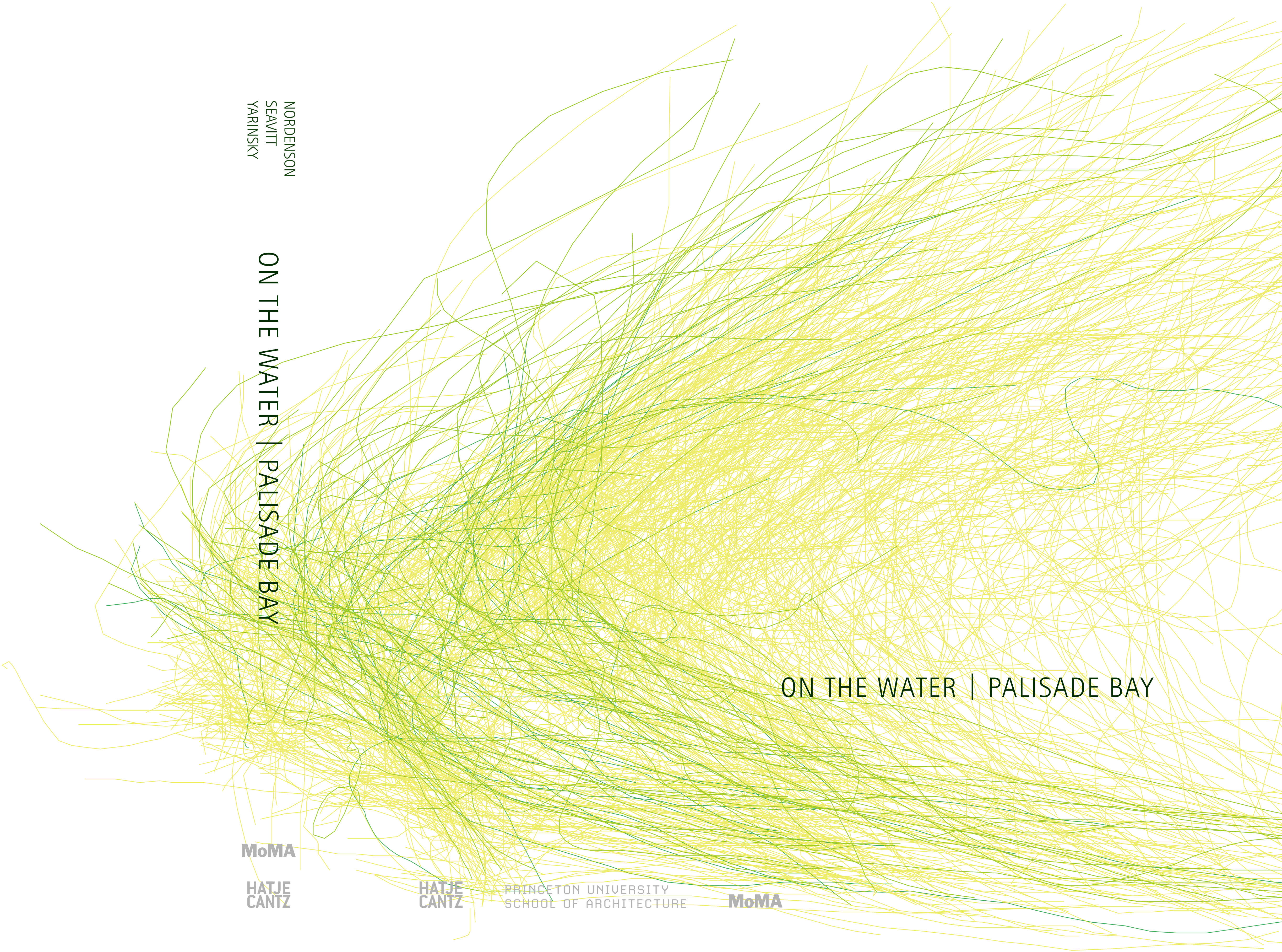
HATJE CANTZ



ON THE WATER | PALISADE BAY

HATJE CANTZ

PRINCETON UNIVERSITY
SCHOOL OF ARCHITECTURE

MoMA

Soft infrastructure aims to synthesize solutions for storm defense and environmental enrichment along the coast.

Opposite
New York–New Jersey Upper Bay, 2009

INTRODUCTION

On the Water: Palisade Bay *is the research and design initiative of a team of engineers, architects, planners, professors, and students to imagine the transformation of the New York–New Jersey Upper Bay in the face of certain climate change. The work began during the summer of 2007 upon award of the 2007 Latrobe Prize, a biannual research grant awarded by the American Institute of Architects College of Fellows. This book is a product of our two-year collaboration.*

The New York–New Jersey Upper Bay is a large estuarine harbor fed by the Hudson River and connected to the Atlantic Ocean through the Verrazano Narrows and the Long Island Sound. Its surface area is approximately twenty square miles and it measures nearly four miles across at its widest point. This vast body of water is surrounded by the dense urban development of New York City—adjacent to the New York–New Jersey Upper Bay are the three boroughs of Manhattan, Brooklyn, and Staten Island, as well as Jersey City and Bayonne in Hudson County, New Jersey. With an estimated population of 20 million people, the greater metropolitan region is the largest in the United States. The island of Manhattan alone has almost 2 million residents, making it one of the most densely populated places in the country.

Within the next fifty years the New York–New Jersey Upper Bay is likely to see its waters rise by as much as one foot as a consequence of global climate change. In the next one hundred years, that rise could be as much as two feet. Furthermore, given the possibility of rapid and widespread melting of polar ice caps due to dynamic feedback mechanisms in the global climate system, it is quite possible that waters in the New York–New Jersey area could rise by more than four feet by the end of the century.[1]

Sea level rise in itself will lead to an increase in the occurrence of what is presently recognized as extreme flooding. Because of a higher baseline of water, the frequency and extent of flooding due to severe storms—hurricanes, tropical storms, and nor'easters—will increase dramatically. Within this century, what is currently considered the one-hundred-year flood could recur as often as every fifteen years, and the 500-year flood may recur closer to every 120 years.[2] Moreover, a rise in ocean surface temperatures could bring about an increase in the frequency and intensity of severe storms, escalating the threat of damaging storm surge far beyond that which we know today.

These climatic changes threaten our local infrastructures, ecosystems, and communities. A substantial portion of the area bounding the Upper Bay—and some of the most valuable real estate in New York City—lies just above sea level, and there is a prevalent risk that the city will be severely paralyzed due to predicted inundation and wave action associated with storm surge. Buildings and infrastructure at low elevations may face irreparable damages and public


MANHATTAN
NEW JERSEY
NEW YORK–NEW JERSEY
UPPER BAY
BROOKLYN
STATEN ISLAND

Flooding in New Orleans after Hurricane Katrina, 2005

Opposite
Combined observed and projected temperature, precipitation, and sea level rise, in *Climate Risk Information*, New York City Panel on Climate Change, Release Version, February 17, 2009

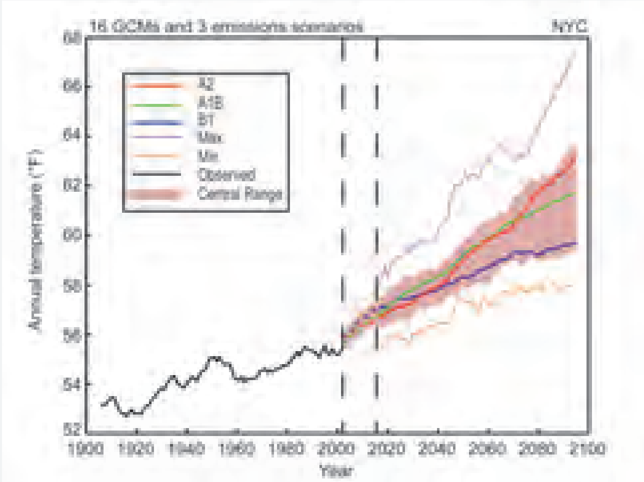
transportation, highways, and local streets will experience extreme delays or even shutdowns in the event of a major storm. Increased inflow to water control systems will result in overloaded wastewater treatment plants, increased discharge from combined sewer overflows, and flooding of brownfields will lead to heightened pollution. Saltwater intrusion into freshwater sources and wetlands will reduce the quality and availability of drinking water, increase erosion, and weaken precious ecosystems.

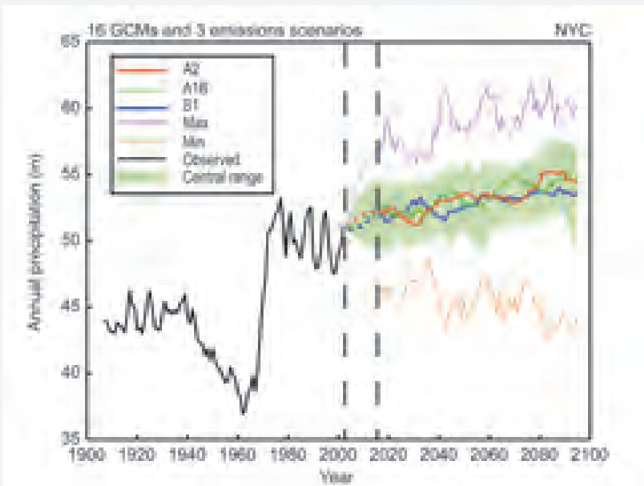
The need to address these risks provides an opportunity to rethink the relationship between infrastructure, ecology, and society in the urban environment. The conventional response to flooding has been hard engineering: cities fortify their coasts to protect real estate at the expense of nature. If this approach persists as the default solution, seawalls and bulkheads will be raised to define a clear boundary between dry land and deep water, while native tidal wetlands along the coast will erode and eventually wash away. The loss of these wetlands not only diminishes the variety of plants, invertebrates, fishes, and birds that inhabit them but also erases the naturally occurring buffer zone between land and water which mitigates the impact of fluctuating sea levels and lowers the risk of flood damage. Moreover, the hard engineering habit has proven costly, unreliable, and often ineffective. The disastrous failure of the levees in the aftermath of Hurricane Katrina speaks to our excessive reliance on this risky solution to flood control. Adequately protecting cities from the hazards posed by climate change and sea level rise requires a more holistic approach to coastal planning.

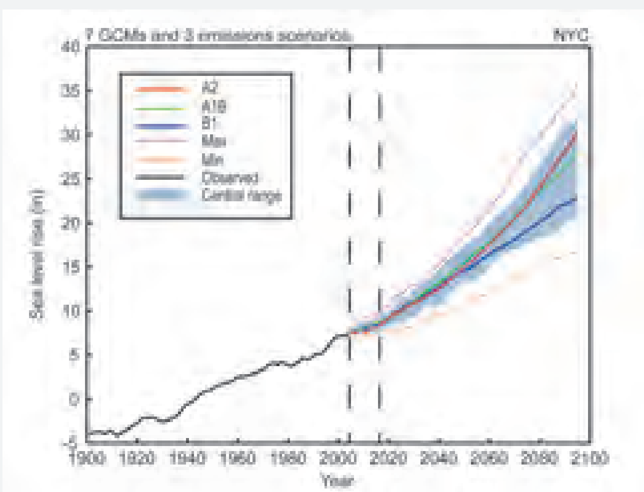
This study invents a “soft infrastructure” which aims to synthesize solutions for storm defense and environmental enrichment along the coast. It is an adaptable solution that adjusts to varying climatic conditions and urban demands by balancing environmental, technical, and economic priorities. Our goal is to layer these priorities throughout the harbor zones to not only create a comprehensive storm defense system but to also provide new places for recreation, agriculture, ecologies, and urban development. By arraying these activities on the water, the bay becomes a regional center, and the city refocuses on the body of water it embraces.

CHARACTERIZING DYNAMIC SYSTEMS

While the behavior of the earth’s atmosphere is complex it can, like other complex systems, be modeled in ways that represent and bracket the possible consequences of various factors. Combinations of statistical and historical data analysis, derived mathematical models of atmospheric physics, and sensitivity analyses can provide a full and accurate understanding of the range and trend of future outcomes. In this fashion it is possible for models of complex natural systems to predict the probability that a parameter characterizing a natu-







ral hazard—earthquake peak ground acceleration, peak hurricane wind velocity, or average flood height above mean sea level—will be exceeded in any period of time by some probability, say five percent in fifty years (475-year average return period). It is further possible to characterize the uncertainty of such predictions quantitatively by distributing the predicted outcomes around an average value, and then assigning a marginal rate by which the increase of a particular parameter, with an increased time exposure period, decelerates or remains steady. In short, it is possible to fully and realistically characterize the "complexion" of a complex environmental system.

The ability to thoroughly characterize complexity is important for two reasons. First, complex natural systems are dynamic, both as phenomena and in their patterns of recurrence. Second, the probability that any human settlement will survive a severe natural hazard is dependent on a broadly configured resilience to endure a disaster and fully recover its livelihood. A large aspect of developing this resilience is in calculating accurate predictions and designing appropriate tools and methods to withstand disaster. Doing this effectively may well be the clearest way that the enormous complexity of cities is both developed and put to the test. For example, depending solely on the construction of levees as a solution to flood control is not adequate. Appropriate maintenance and monitoring procedures must be enacted, and regularly reviewed contingency plans must be designed, for the built infrastructure to perform in response to a dynamic environmental system. In other words, a broad capacity in the built and natural environment, as well as in social policy, must be developed in order for survival and recovery to be successful.

SOFT INFRASTRUCTURE

If a device such as a bridge, buoy, or radio is excited by an alternating force, or other effect that is in synch with one of its own natural periods of vibration, it will resonate. This effect can be either beneficial or destructive. In the case of natural hazards, the "coupling" between systems—for example the buffeting of wind or the vibrations of the ground—needs to be identified and mitigated. Otherwise, such resonance may lead to a build-up of energy that will lead to systemic or local catastrophes.

System modeling often approaches static and dynamic effects separately. Flows of fluid or wind may be characterized as having both a steady velocity and resulting pressure and a separate turbulent or dynamic component. Often the steady state or "static" component can be understood with great simplicity and certainty, while the "dynamic" component is characterized in terms of probability distribution, spectra, or other nuanced descriptions. Thus, the resistance required to withstand either static or dynamic components is effectively different. Static demands require strength and stiffness

Natural ecologies are resilient; forests grow back after fires, animals recover from illness, and wetlands return to equilibrium after severe storms.

Wildflowers grow after a forest fire in the Kenai National Wildlife Refuge, 2001

Opposite
Observed annual temperature and precipitation in Central Park, 1901-2006, and sea level rise at the Battery tide gauge station, 1901-2006, in *Climate Risk Information*, New York City Panel on Climate Change, Release Version, February 17, 2009

to assure that the response to loads is elastic (without lasting effect) and stable (without buckling or other instabilities). The resistance to dynamic demands also requires strength, stability, and stiffness, but it also needs devices to dissipate energy such as shock absorbers, fuses, or dampers to withstand unexpected peak demands or effects from resonance.

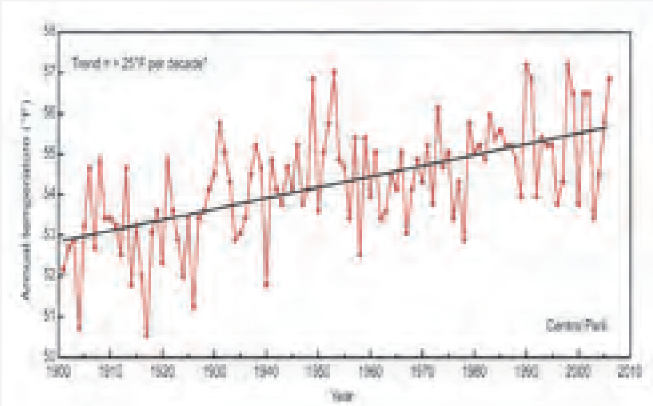
Natural ecologies are resilient, within the range of phenomena for which they have evolved; forests grow back after fires, animals recover from illness, and wetlands return to equilibrium after severe storms. This ability to recover from accidents and catastrophes over time is a direct consequence and distinct characteristic of complex ecologies. As a result, successful design for mitigating natural hazards is based on the sophisticated understanding and mimicry of such natural systems.

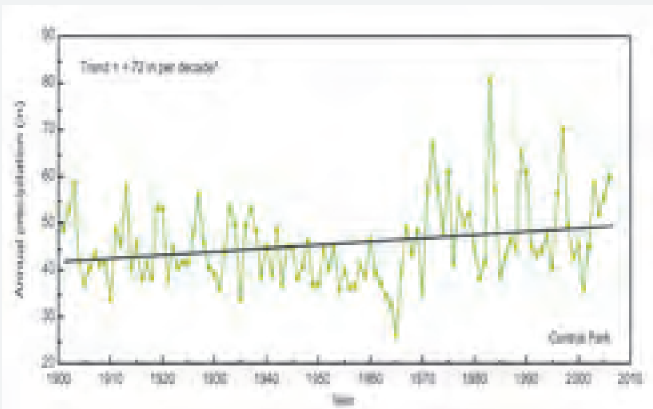
For example, the key insight in earthquake engineering during the mid-twentieth century was the realization that building structures could be designed and detailed to withstand the shock of earthquakes with considerable structural damage, but without collapse. Just as a car can be designed to protect the passengers inside when it is nearly destroyed in a severe crash, a building can be designed to "crumple" without collapse in the event of an earthquake to allow occupants to safely exit. This is accomplished by introducing ductility, or energy absorbing capability, into structural elements and connections. In the most sophisticated designs this capability is located in discrete elements that isolate the damage and allow the majority of the structure to survive with little or no damage. Through similar means, resilience can be implemented in urban settings which are vulnerable to floods and storm surges. A balanced combination of infrastructure, landscapes, and social policy can comprise a coastal defense system that is resilient to the volatility of sea level rise and severe storms.

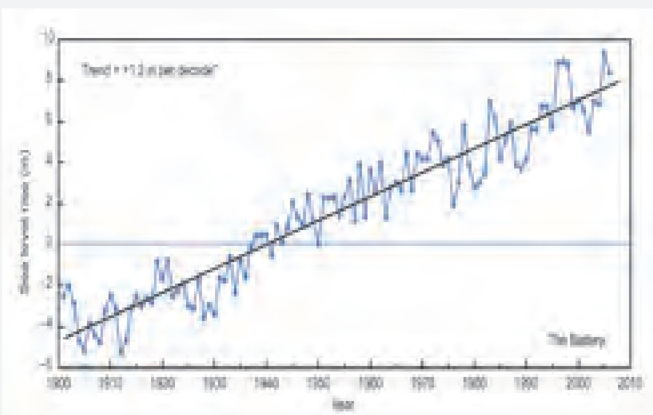
CLIMATE CHANGE

There is ample evidence and general international agreement that the global climate is changing at an accelerating rate and that human-driven emissions of greenhouse gases into the atmosphere and shifts in land use are the main processes driving this trend. In the past century, the temperature in the New York–New Jersey metropolitan region has increased by 2.5°F.[3] Global climate models (GCMS) project that temperatures in and around New York City are likely to increase by 1.5 to 3°F by the 2020s, 3 to 5°F by the 2050s, and by 4 to 7.5°F by the 2080s.[4]

A recent Intergovernmental Panel on Climate Change (IPCC) assessment report gives estimates of between 1.8°C and 4°C for the change in global average temperature projected between 2000 and 2100.[5]







Global climate models project that the rate and amount of warming, as well as the frequency and severity of extreme events, such as heat waves and droughts, will increase over the twenty-first century as a result of this warming.

SEA LEVEL RISE

Although sea level has been rising along the Eastern Seaboard since the end of the last glaciation, the rise in the twentieth century can be attributed to both natural and anthropogenic factors. In New York City, the rate of relative sea level rise is currently 0.11 inches per year (2.73 millimeters/year).[6] This rate of sea level rise for the metropolitan area is greater than the rate for global sea level, most likely due to continuing regional subsidence of the land.

Future sea level rise will lead to greater damage from coastal floods, increased salinity of aquifers, and loss of coastal land. Taking projected climate change into account, it is extremely likely that sea level in the region will rise between 2 and 5 inches by the 2020s, between 7 and 12 inches by the 2050s, and between 12 and 23 inches by the 2080s. These higher predicted sea levels would lead to more damaging storm floods in coastal areas and a marked reduction in the return period for a given flood level.[7] In New York City, the one-hundred-year flood would have an average probability of occurring once in sixty-five to eighty years by the 2020s, once in thirty-five to fifty-five years by the 2050s, and once in thirty-five years to as often as once every fifteen years by the 2080s.[8]

FLOODING

Flooding is generally a result of tropical storms (hurricanes) and extra-tropical storms (nor'easters). Hurricanes are major tropical cyclones or low-pressure systems that intensify over the open ocean. The destructive power of hurricanes derives from their very high wind speeds of at least 74 miles/hour (119 kilometers/hour), flooding due to the high storm surge and wave action, as well as heavy rainfall.[9] The most prevalent climate extremes in the New York–New Jersey region are flooding events either occurring from heavy precipitation or, in coastal areas, from storm surges.

Nor'easters are the dominant type of storm producing major coastal flooding and beach erosion north of Chesapeake Bay, generally occurring between January and March. This type of storm gains wind speeds from the convergence of cold arctic air and the warmer gulf streams. While wind speeds are lower than in hurricanes, nor'easters cause considerable damage due to their greater areal extent and longer duration, often over several tidal cycles at a given location.[10]

The apparent increase in flooding is a consequence of the regional sea level rise, beach erosion, and coastal development over the last fifty years.

A stretch of 9th Street in Brooklyn after heavy rains, 2004

Opposite
New York City Hurricane Evacuation Zone Map, Office of Emergency Management, 2008

Precipitation has also increased over the past hundred years with a tendency towards greater extremes and may increase more rapidly in the future. Heavy rains falling during a very short period of time can overwhelm drains, causing flooding in streets, basements, and on subway tracks. The situation is worsened by the fact that antiquated New York City drainage infrastructure combines sewage and stormwater outlets, so uncontrolled combined sewage overflow (CSO) runoff flows into the Upper Bay in excess of federal and state CSO discharge allowances.

STORM SURGE

A storm surge is a dome of water produced by the pairing of low barometric pressure and strong wind shear on the right side of an advancing low-pressure system. High wind speeds push on the ocean surface and cause the water to rise up higher than the ordinary sea level. As a storm surge advances past the shore, the extent and impact of its damage is amplified if it coincides with the lunar high tide. Geographically, the New York City region is highly susceptible to storm surge. The right-angle bend between the New Jersey and Long Island coasts funnels surge waters towards its apex, the New York–New Jersey Upper Bay. Additionally, surge waters pile up at the western end of the Long Island Sound.

The National Hurricane Center forecasts storm surge using the SLOSH (Sea, Lake, and Overland Surges from Hurricanes) model. SLOSH-estimated surge levels have been computed using the effects of a hurricane surge for a worst-case scenario Category 3 hurricane (with wind speeds of 111–130 miles/hour on the Saffir-Simpson scale). Based on these calculations, maximum surge levels could reach 25 feet (7.6 meters) above the National Geodetic Vertical Datum at JFK Airport, 21 feet (6.4 meters) at the Lincoln Tunnel entrance, and 24 feet (7.3 meters) at the Battery.[11]

FREQUENCY

Within the last fifty years, storm frequencies along the Eastern Seaboard peaked in the late 1960s, decreased in the 1970s, and then rose again in the early 1990s. Twentieth-century tide-gauge records from Atlantic City, New Jersey and Charleston, South Carolina show no statistically significant trends in either the number or duration of storm surge events after accounting for tidal factors and long-term sea level rise.[12] The apparent increase in flooding is a consequence of the regional sea level rise, beach erosion, and coastal development during this period.

While hurricanes may occur less often than nor'easters in the Northeast, they are generally more destructive. Influenced by the

Hurricane Evacuation Zones

ZONE A
Residents in Zone A face the highest risk of flooding from a hurricane's storm surge. Zone A includes all low-lying coastal areas and other areas that could experience storm surge from ANY hurricane making landfall close to New York City.

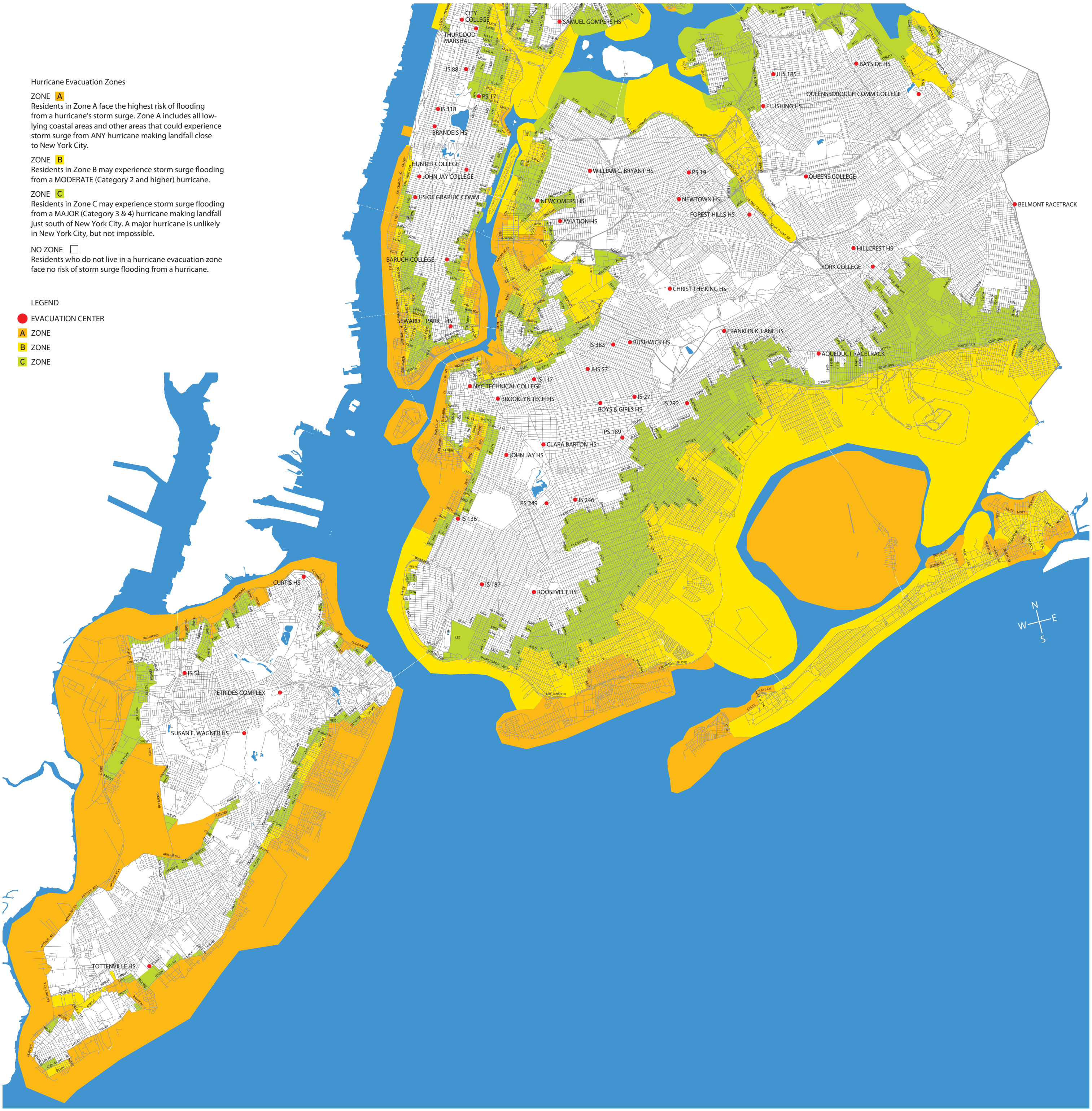
ZONE B
Residents in Zone B may experience storm surge flooding from a MODERATE (Category 2 and higher) hurricane.

ZONE C
Residents in Zone C may experience storm surge flooding from a MAJOR (Category 3 & 4) hurricane making landfall just south of New York City. A major hurricane is unlikely in New York City, but not impossible.

NO ZONE
Residents who do not live in a hurricane evacuation zone face no risk of storm surge flooding from a hurricane.

LEGEND

- EVACUATION CENTER
- A ZONE
- B ZONE
- C ZONE



Debris along the Hackensack River, 2006

Robert Smithson, *Untitled (Map on Mirror—Passaic, New Jersey)*, 1967

Bruno Munari, from the book *The Sea as a Craftsman*, Corraini Edizioni, 1994

Opposite
Aerial view of Shooters Island, 2008

atmospheric shifts of the El Niño Southern Oscillation (ENSO), Atlantic hurricanes are thirty-six percent more likely to occur and six percent more intense during a La Niña phase than during an El Niño phase. In the last two centuries, nine or more hurricanes have struck the metropolitan New York City region, including major ones in 1893 and 1821 and the infamous Long Island Express of 1938.[13]

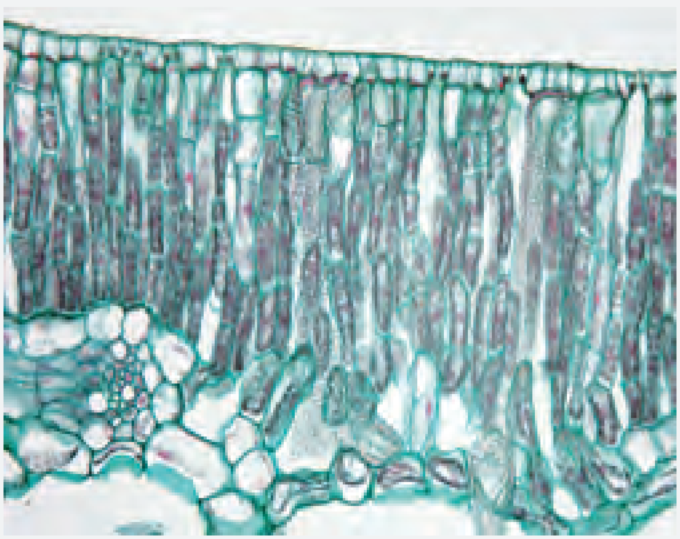
FLUX

An aerial view of Shooters Island, a 43-acre island at the end of the Kill Van Kull, displays the enigmatic ecological *informe* that speaks to the rich cycles of growth and decay within the harbor. In the image, remnants of wooden ships and piers, relics of the several shipbuilding companies that operated here from approximately 1860 through 1918, are gradually disintegrating into the water. The island has since been acquired by the NYC Department of Parks and Recreation and has been preserved as a bird sanctuary. From its state of industrial decay, the island now supports habitat for nesting pairs of wading birds such as herons, ibis, egrets, and double-crested cormorants.

The collection of found objects photographed in Bruno Munari's book, *The Sea as a Craftsman,* beautifully illustrates the observation that some of the most evocative objects are those which have been created by the ocean and its tides. The notion that the sea can be a craftsman suggests that un-authored processes can act on objects and develop unique phenomenona which cannot be predicted or copied.

Robert Smithson's work that evolved from his expeditions to the fringes of New Jersey is also a generative example. In his essay "A Provisional Theory of Non-Sites," written in 1968, Smithson notes that his three-dimensional works negotiate the space between actual sites and the systems of abstractions and logic which attempt to represent them. Within this "space of metaphoric significance," Smithson defines sites "in terms of esthetic boundaries rather than political or economic boundaries."[14] In his 1966 essay, "Entropy and the New Monuments," Smithson discusses contemporary art through the lens of entropy, the thermodynamic law that states energy is more easily lost than obtained. He notes that the monumental has caused us to forget the future rather than remember the past—it has eliminated the notion of time as decay. He argues for a new kind of sight which looks beyond conventional progressive scales of time and space, and into the possibility of alternative relationships between development and decay.

This work is inspirational to us as we begin to reinvent the Upper Bay for the future. Though the intervention is extensive, we do not aim for monumental development, nor do we look backward to emulate



The Giant's Causeway, Northern Ireland, 2006

Palisade cells seen under a microscope

Opposite
Thomas Davies, *The Landing of the British Forces in the Jerseys 1776*, watercolor

a former condition. Rather, we insert our project within the current space of the harbor as a series of conditions which will be enveloped into the larger and uncertain processes of ecological transformation. The figure of the Upper Bay we envision is not fixed but is instead a fluid body with a porous boundary developed with soft infrastructure. The figure-ground relationship of the water and the land constantly changes as it is subject to forces ranging from diurnal tides, flood and dry seasons, and modes and intensity of use.

PALISADE

The word "palisade" derives from the Latin word *palus,* meaning stake. Within the framework of our proposal for the Upper Bay, the various definitions of the word speak to the ranging goals and interests our proposal assumes. The possibility of marking a porous boundary across both politically staked borders and along the edge where water meets land deeply influences this research and our design proposal.

Most commonly, palisade refers to a type of fortification dating back to ancient civilization. In this case, a palisade is a wooden fence made of tightly arrayed tree trunks sharpened to points and driven into the ground. Protecting the encampments of Greek and Roman militaries and many native settlements in the Southeastern United States, these defensive structures vary in robustness depending on the size and density of the stakes. Fences found today are not much different from the original forts, and range from structures defining suburban lawns to porous boundary markers defining zones on beaches and other park lands.

Palisade is also the geological description of the vertical cliffs rising steeply near our site above the western bank of the Hudson River. The New Jersey Palisade is a Triassic period rift which was uplifted during the breakup of Pangaea when molten magma intruded upward into sandstone. The sandstone was later eroded and the igneous columnar formation remains. The Lenape people, the original denizens of the region, called the cliff "we-awk-en," meaning "rocks that look like rows of trees." Similar volcanic formations exist throughout the world including at the Giants Causeway in Northern Ireland where columnar, volcanic formations are eroded by the ocean to form a stepped terrace which is exposed and revealed as the tide cycles from low to high.

In plant biology, a vertical array of cylindrical palisade cells makes up a layer of mesophyll below the upper epidermis of the leaves in dicot plants. The cells contain the chloroplasts necessary for photosynthesis and produce carbohydrates for the plant by absorbing light and harnessing solar energy. In this sense, palisade refers to a geometrical resemblance of the photosynthetic cells to the geological formations and aligns this formation with cellular level energy production.

Interconnected infrastructures and landscapes rethink the current thresholds of water, land, and city.

ON THE WATER | PALISADE BAY

This project is the initiative of a group of engineers, architects, planners, professors, and students to imagine a "soft infrastructure" for the New York–New Jersey Upper Bay by developing interconnected infrastructures and landscapes which rethink the thresholds of water, land, and city. Three objectives summarize the strategies we have developed:

Construct an archipelago of islands and reefs along the shallow shoals of the New York–New Jersey Upper Bay to dampen powerful storm currents as well as encourage the development of new estuarine habitats.

Revitalize the waterfront by designing a broad, porous, "fingered" coastline which combines tidal marshes, parks, and piers for recreation and community development.

Enact zoning formulae that adapt efficiently in response to the impact of storms in order to increase community resilience to future natural disasters.

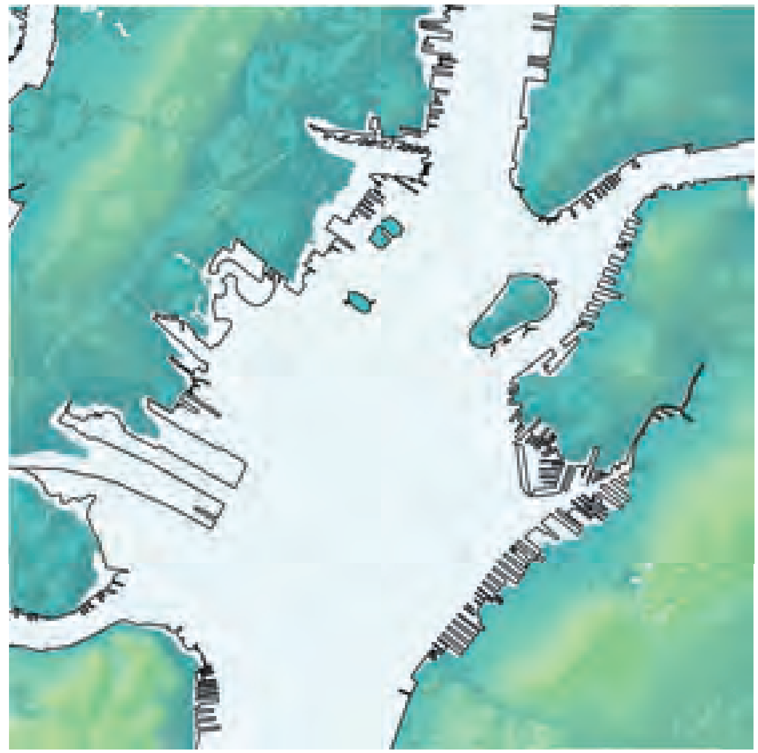
These three principles—on the water, along the coast, and in the communities—comprise a proposal for a coastal planning strategy which seeks not only to protect the New York–New Jersey region from sea level rise and storm surge flooding, but also to re-conceptualize the relationship between infrastructure and ecology in the twenty-first century waterfront city. With looming climate change as the catalyst for this work, we seek to incorporate conclusions drawn from complex numerical analysis of dynamic systems, as well as formal sensibilities, into a comprehensive plan which enriches ecology and the health of the urban estuary to create a vibrant culture on the water.

Kenzo Tange, *A Plan for Tokyo*, 1960

Opposite
The proposed "soft infrastructure" transforms the Upper Bay into Palisade Bay.

1 FT INUNDATION

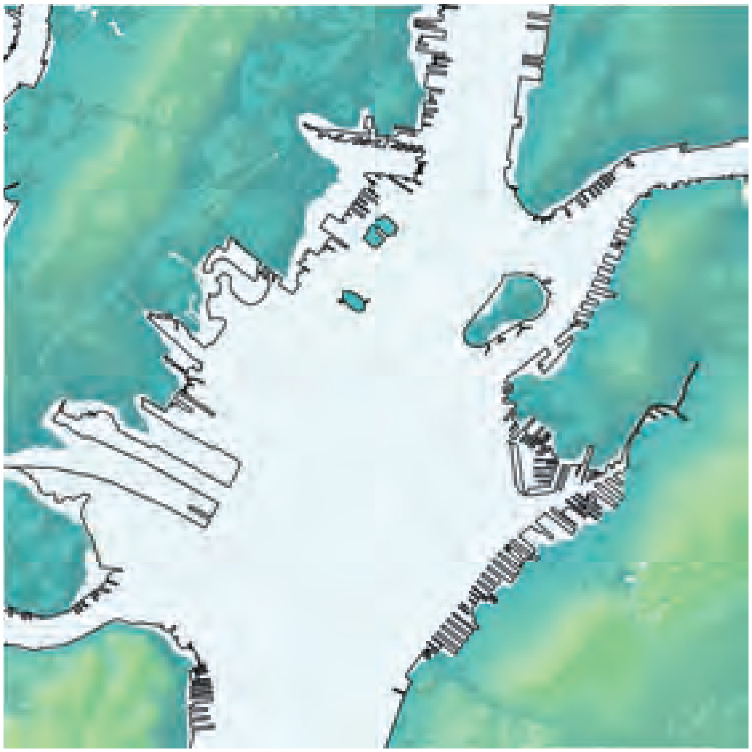
2 FT INUNDATION



Incremental inundation

Maps illustrating the incremental inundation of the New York-New Jersey Upper Bay and surrounding area. This GIS-generated map sequence was created by applying one-foot increases in water level to a merged elevational and bathymetric model. The eight-foot and ten-foot increases in water level roughly correspond to the inundation expected in the one-hundred-year and 500-year floods as described in the New York City Panel on Climate Change's Climate Risk Information report. The twelve-foot, twenty-foot, twenty-six-foot, and twenty-eight-foot increases correspond to inundation levels at the Battery caused by four SLOSH scenarios[15].

3 FT INUNDATION



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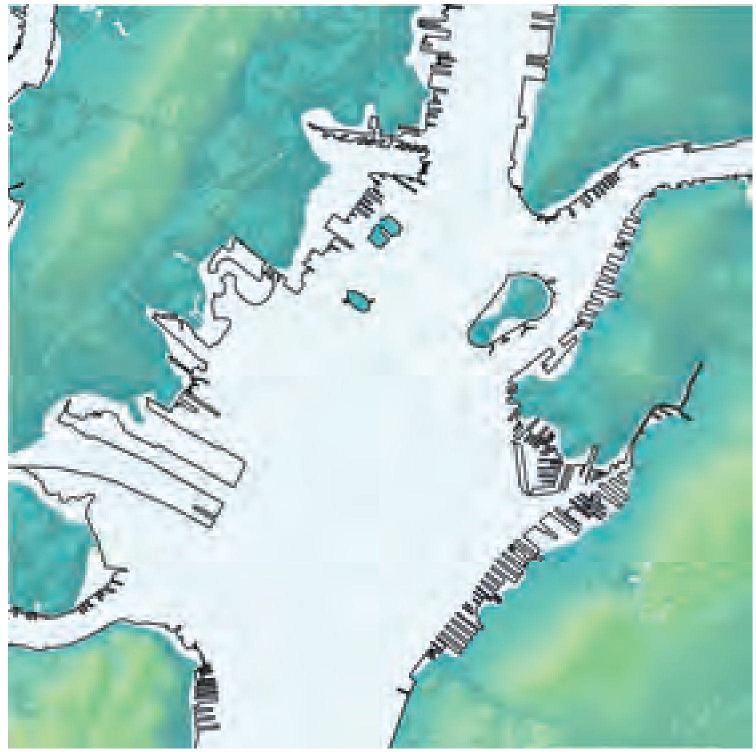

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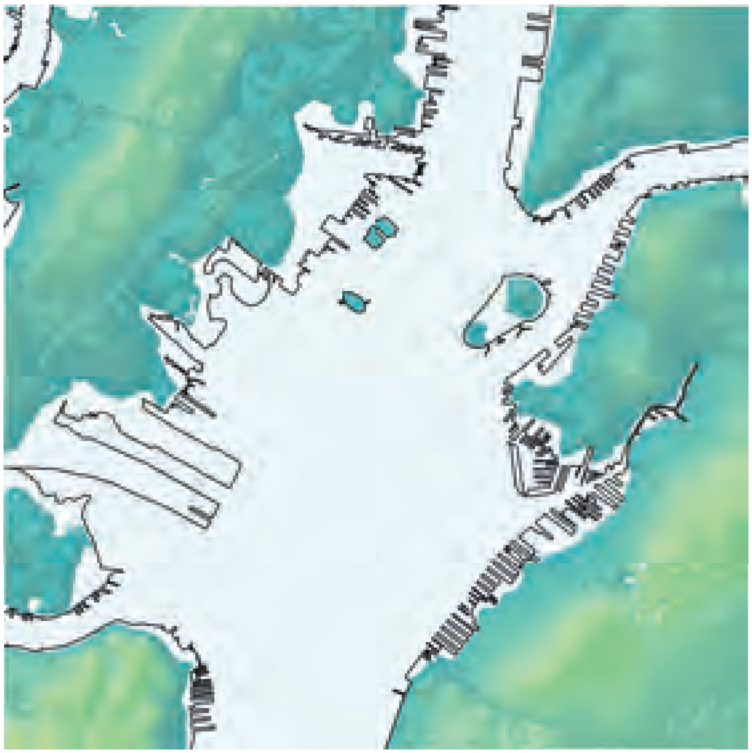
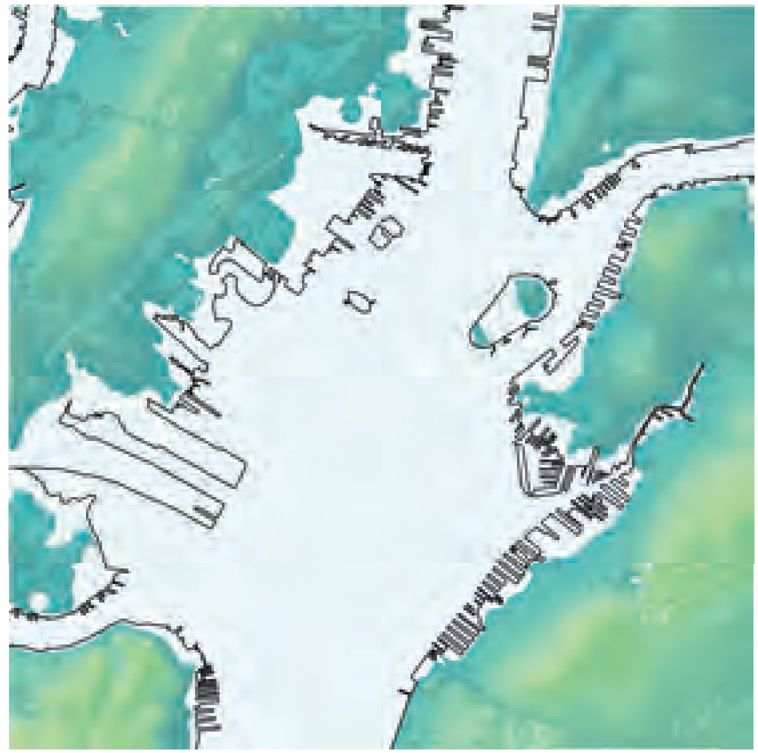
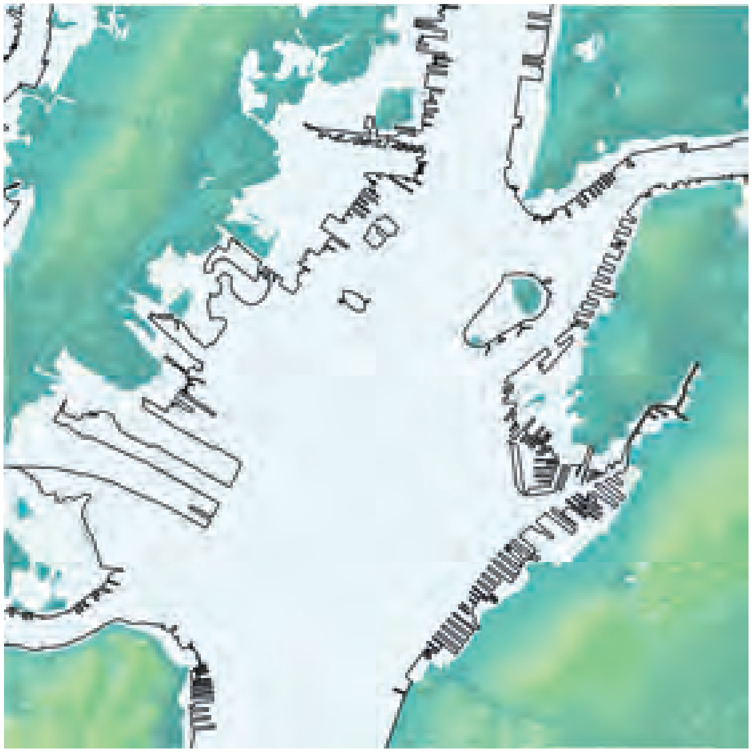


8 FT INUNDATION—ONE-HUNDRED-YEAR FLOOD



10 FT INUNDATION—500-YEAR FLOOD / CATEGORY 1 HURRICANE



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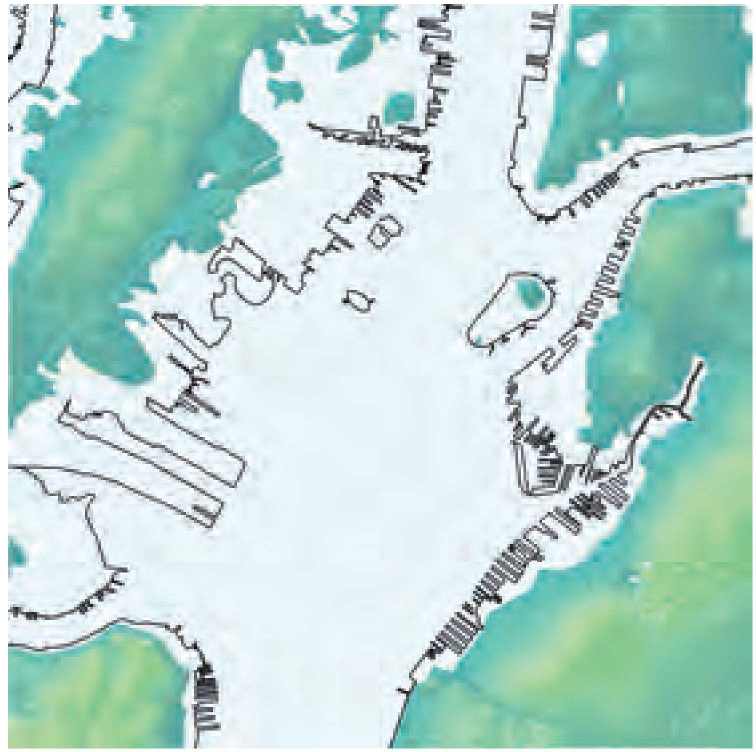

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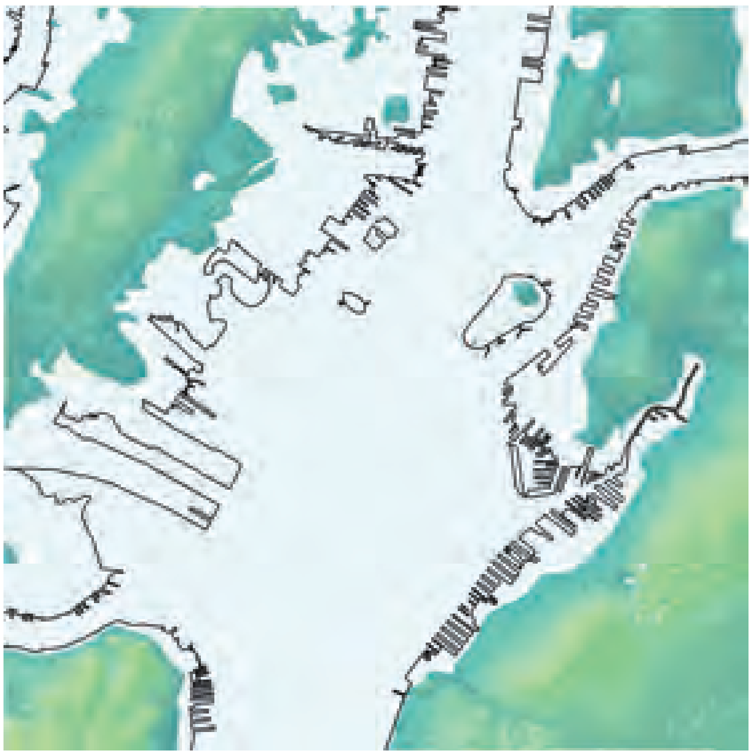
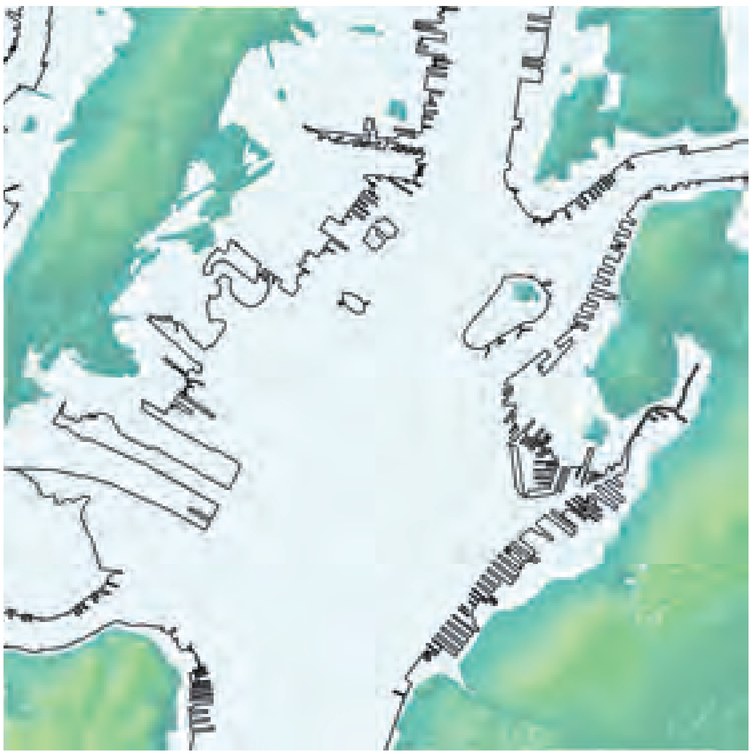


16 FT INUNDATION—CATEGORY 2 HURRICANE

18 FT INUNDATION



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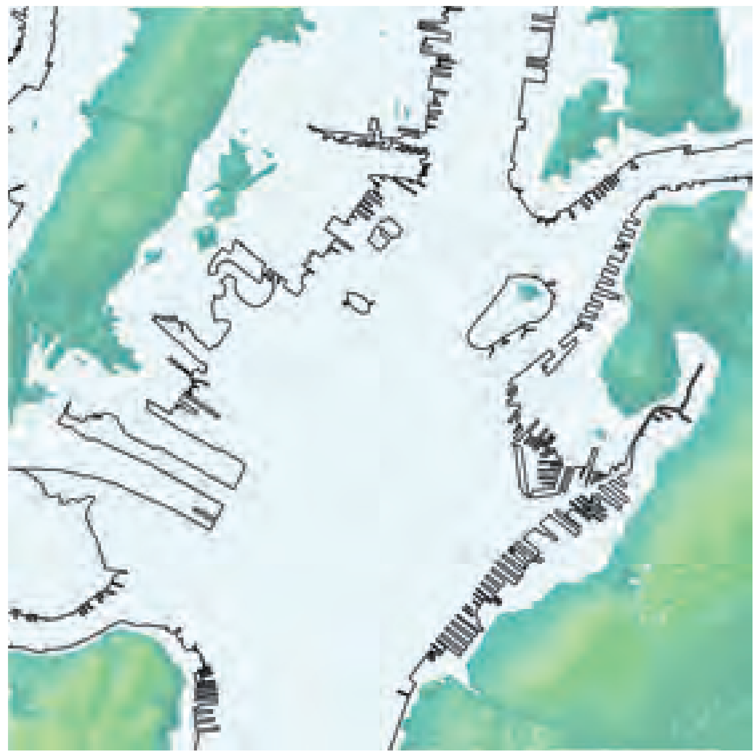
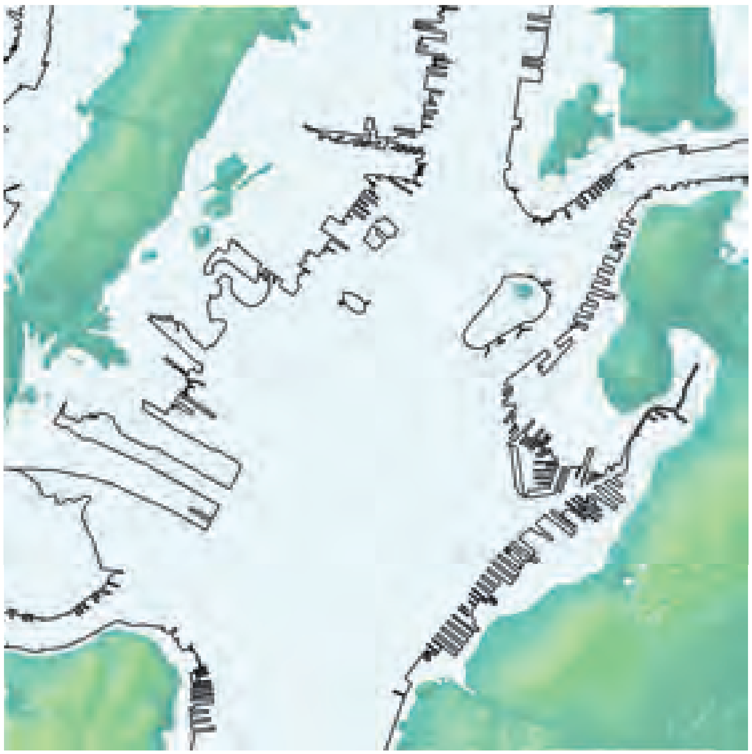
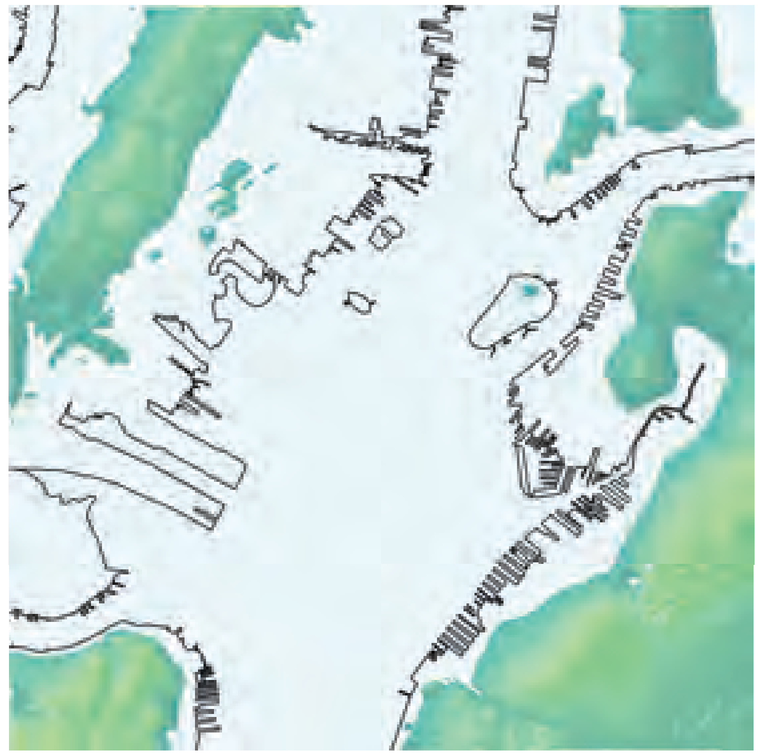


22 FT INUNDATION



24 FT INUNDATION—CATEGORY 3 HURRICANE



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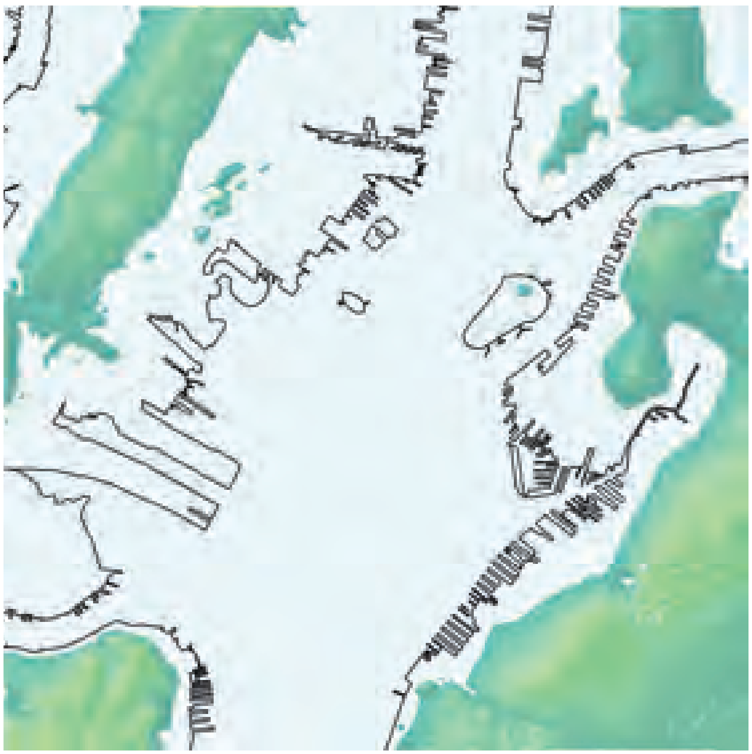
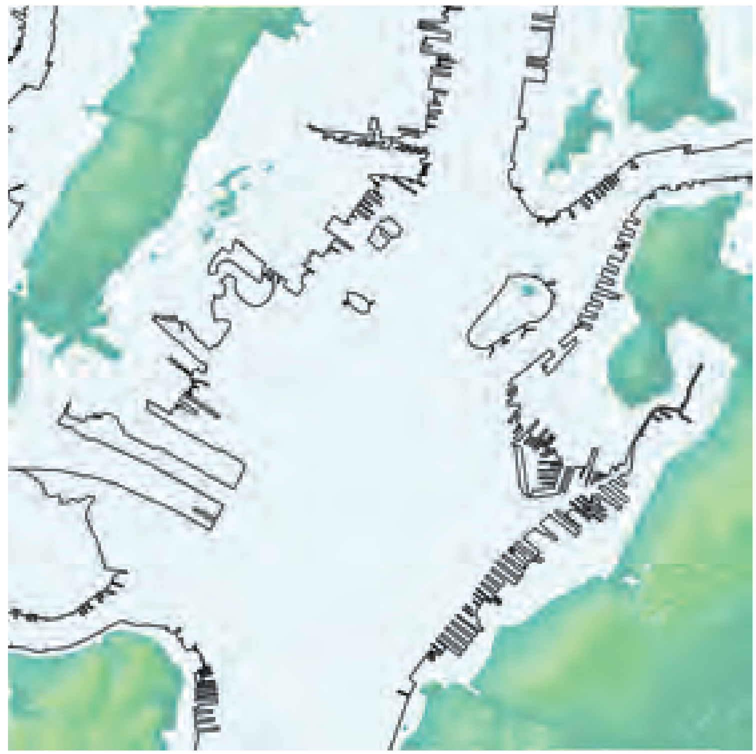
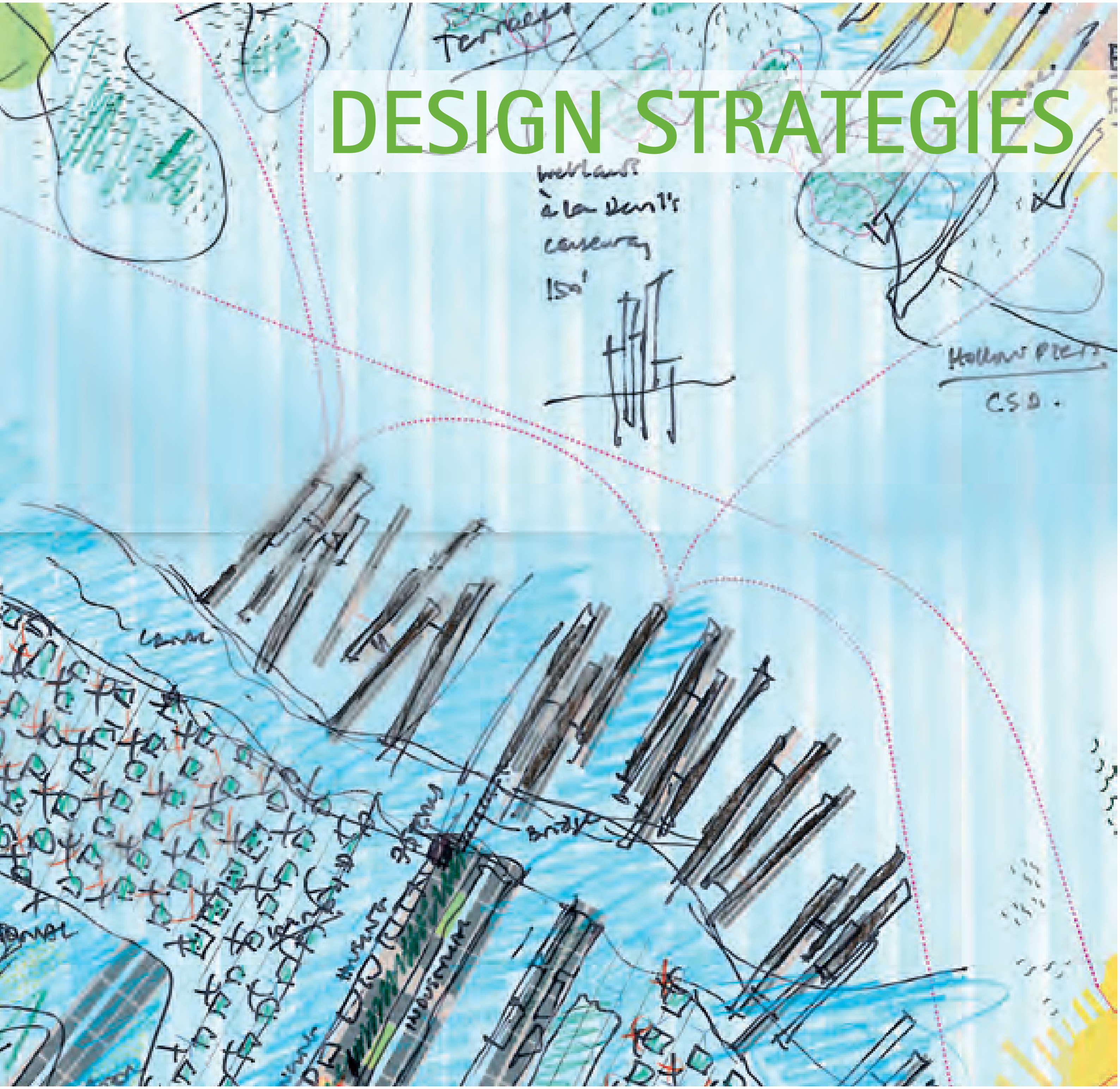
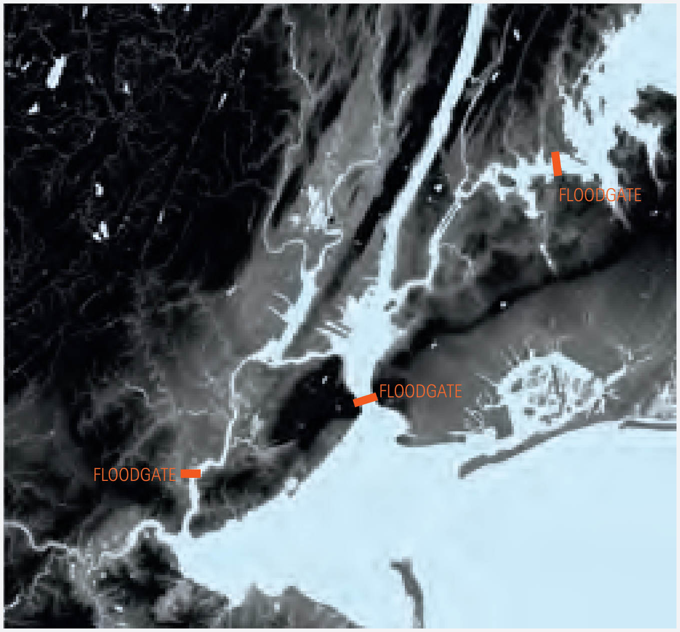


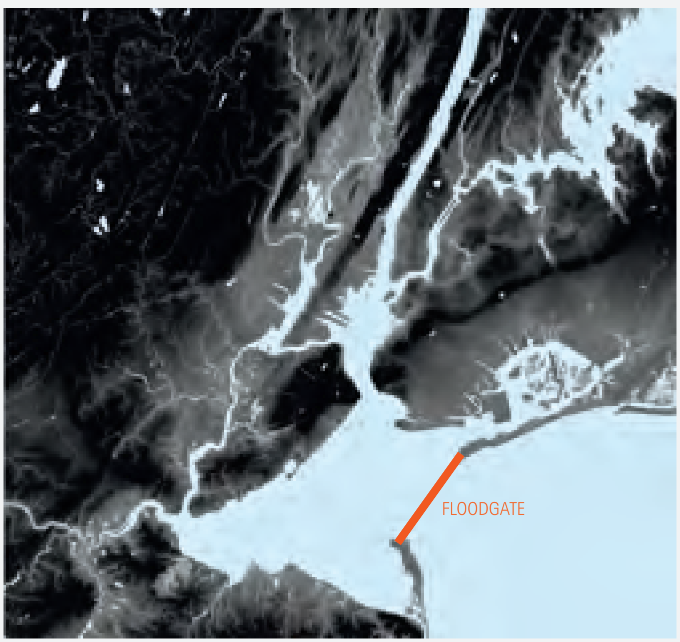
28 FT INUNDATION—CATEGORY 4 HURRICANE



DESIGN STRATEGIES







Two possible locations for storm surge barriers

Opposite
Historical North Atlantic Hurricane Tracks

PALISADE BAY

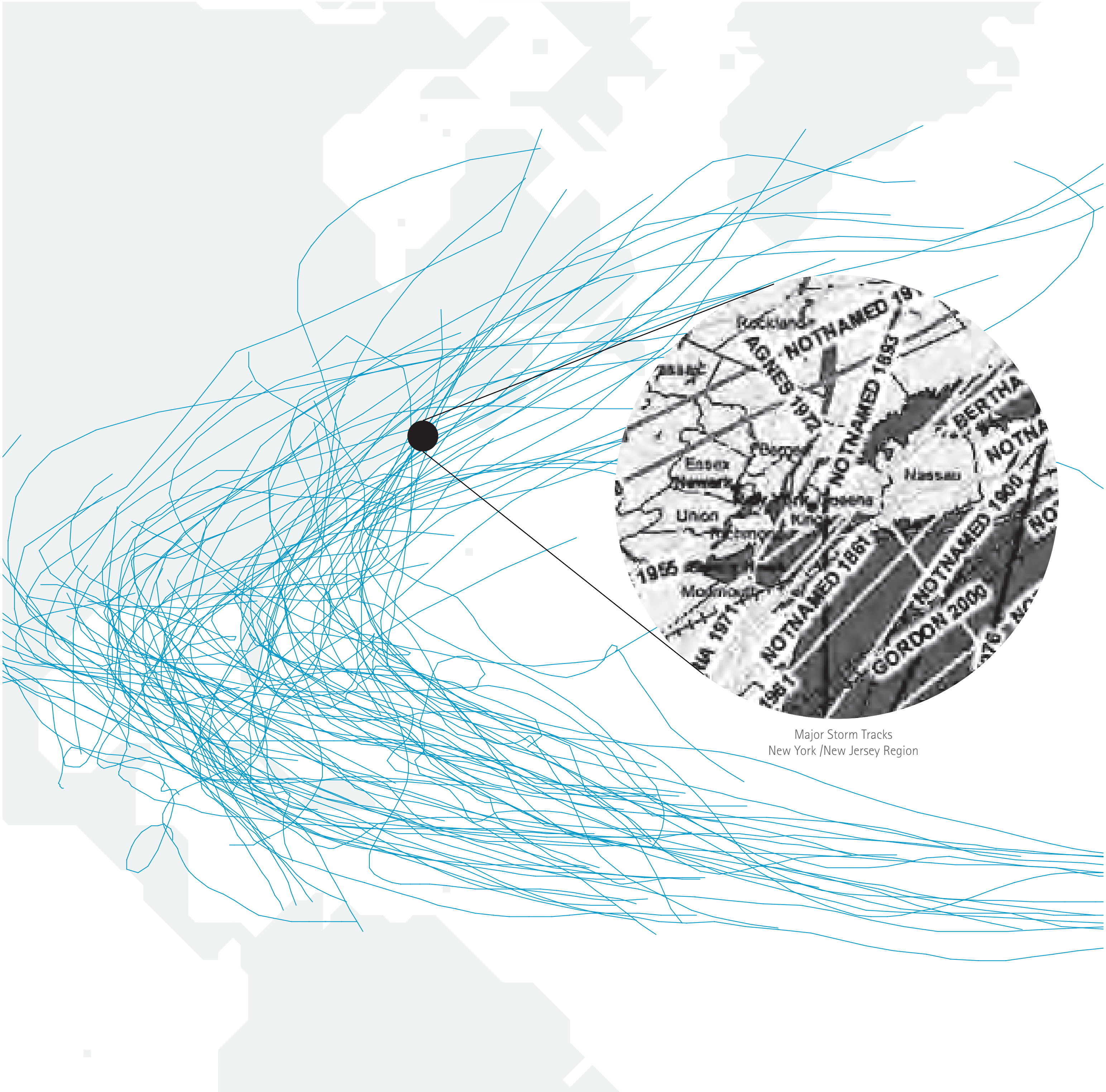
The Palisade Bay proposal reinvents the Upper Bay as the central gathering place for the region. The proposal implements a series of "soft infrastructure" strategies to alternatively buffer or absorb flooding, while also creating a new destination on the water.

RESILIENCE

Approaching the design for the Upper Bay requires an overall strategy which satisfies both the need to protect the region from storm surge and also introduces a new program within the harbor and along its edge. Considering this two-fold criteria led to a new kind of infrastructure—soft infrastructure—that is dispersed throughout the region and implemented by combining natural and artificial landscape elements to provide new ground to eroded areas, remediation to polluted areas, and protection to areas at high risk of storm surge damage. By using the techniques of landscape design, instead of building fortified edges, we can layer programs such as housing and parks, or fresh water storage and urban farms to create activities and destinations within the revitalized harbor zone. A comprehensive harbor transportation system is necessary to facilitate mobility between these new destinations and define this harbor as the center of the New York/New Jersey urban region.

The notion of building a single, massive structure to prevent storm surge—such as in London, Venice (forthcoming), and Rotterdam—is an obvious solution for mitigating storm damage. Malcolm C. Bowman and his colleagues have proposed such a system of storm surge gates to handle the expected consequences of climate change in the Upper Bay. These barriers would be located in three strategic places: at the Narrows, the mouth of the Arthur Kill, and at the upper end of the East River where it meets the Long Island Sound. However, there are unanswered questions regarding the effectiveness of such structures, the degree of flooding on the weather-side of the structures, and the protection provided by partial blockage barriers at certain locations. In theory, the barriers would be closed for just a few hours during hurricane surges, and for several days during high tides in the case of a nor'easter event.[18] A similar solution would be to build a storm gate outside of the harbor along the New York Bight, which is the gulf formed by the geographical indentation of New Jersey and Long Island along the Eastern Seaboard. Placing a flood gate here would prevent surge from severe storms just off the coast from entering the harbor region.

Simply cutting off the flow of water into the bay when such a gate is closed is appealing in some respects because the water basin is controlled to a specific design capacity. While massive storm blockades are invariably expensive to build, they are also manageable construction projects with clear boundaries and extents. The risk of such an



Major Storm Tracks
New York /New Jersey Region

Waterborne shipping traffic routes through the Upper Bay

Shoals and flats in the Upper Bay

Opposite
Exploded axonomentric showing elevation relationships between new design components and existing topography and bathymentry

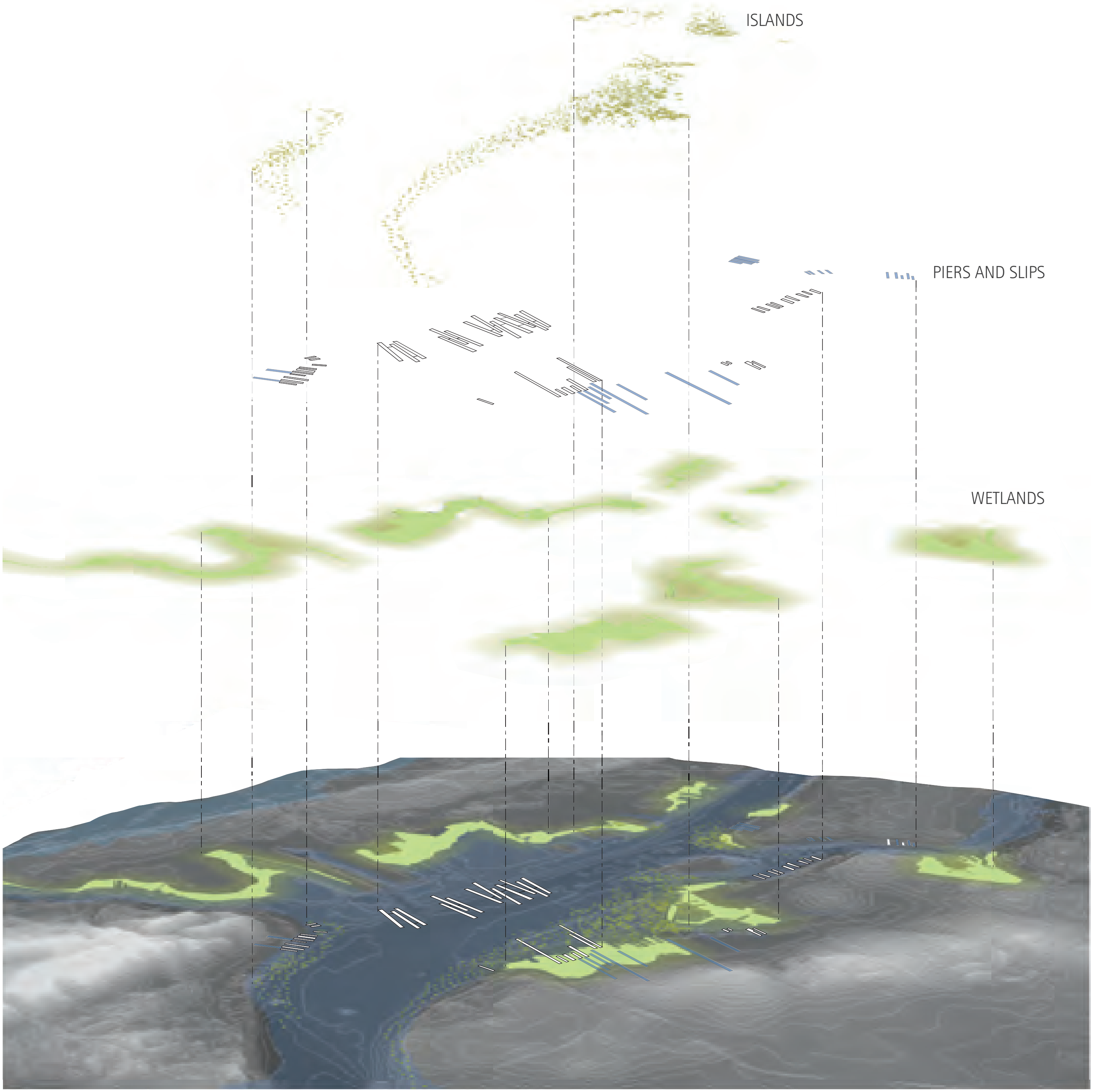
approach is the unpredictable disturbance a massive infrastructure might have upon the existing estuarine ecosystems both locally and regionally. It is also a great risk to rely on a single defense system to prevent damage from a natural disaster; the failure of the levees in New Orleans after Hurricane Katrina is clear evidence of the devastation which can result from positioning a city against nature in this way.

By implementing a defense strategy that consists of soft infrastructure, the city becomes a place that is resilient to, rather than fortified against, the impact of natural disasters. The components of this soft infrastructure are clusters of constructed islands within the harbor, restored piers in addition to new elongated piers along the southeast and southwest coasts, and constructed wetlands along the harbor perimeter. By combining these elements throughout the harbor in various ways to suit the distinct urban and geographical conditions of a particular site, new places for wildlife, recreation, and industry emerge from the existing harbor area.

MOVEMENT CORRIDORS AND CONSTRAINTS

Maritime traffic in the Upper Bay includes recreational sailboats, the Staten Island Ferry, and industrial container ships. While container shipping has predominantly been relocated from the piers of the Upper Bay to the Port Elizabeth Marine Terminal, massive container ships still need to travel through The Narrows and along the Kill Van Kull to reach these ports. Other ports in Red Hook, Brooklyn are the destination of large cruise ships, as well as container ships operated by American Stevedoring Incorporated. Thus, it is necessary to maintain deep channels in the harbor to accommodate the passage of large ships along specific pathways. These paths are maintained by a dredging process executed by the Army Corps of Engineers.

Adjacent to these corridors are zones of shallow shoals and flats. These areas have not been dredged and thus could be built up with artificial islands, reefs, and wetlands. Roughening these shoals with additive landforms would contribute to curbing the force of storm surge in the harbor.


ISLANDS
PIERS AND SLIPS
WETLANDS

HERITAGE OF THE HARBOR

Transformation of the waterfront edge of the New York–New Jersey Harbor has occurred continually over hundreds of years. After the founding of the city in 1626, the edge was first altered by human intervention to accommodate landing ships. As the shipping industry developed, long piers extended along more and more edges to create a characteristic fingered waterfront edge. Over hundreds of years, the ecosystem of the harbor has come to coexist with the pier/slip typology—the shade provided below the piers, in fact, has become a valuable habitat for certain species of spawning fish and other benthic plants and animals. After the peak of the shipping industry in the New York Harbor this infrastructure has gone into disuse, but still contributes to local habitats by providing protected areas of still water and ecological refuge away from the dynamic current conditions in the harbor's tributaries. As the city has grown to incorporate all of the landmasses surrounding the harbor, nearly the entire coastline has been fortified by a sea wall backfilled with earth. The edge is no longer a natural shoreline but rather a border zone of artificial lands which have been filled into the bay.

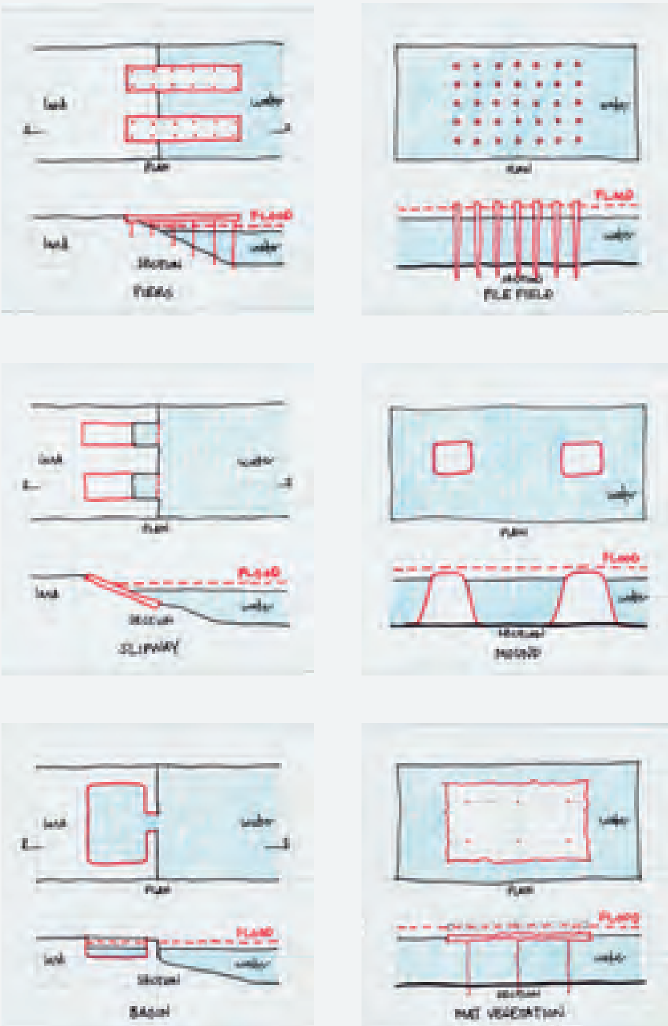
STRATEGIES FOR THE UPPER BAY

This project proposes a new infrastructural system for the Upper Bay with three main design elements: wetlands; piers and slips; and islands. These elements act alone and in conjunction with one another, and with a series of more isolated and smaller-scale interventions such as oyster beds and offshore windmills, to generate habitat, energy, and a sense of place that is the Upper Bay.

Sunset Park, Brooklyn, existing condition 2006

Sunset Park, Brooklyn, a proposed future transformation

Opposite
Palisade Bay Master Plan



Catalogue of design strategies for the edges (left column) and the flats (right column)

Opposite
Palisade Bay, key to elements used in the masterplan

STRATEGY FOR THE EDGES AND THE FLATS

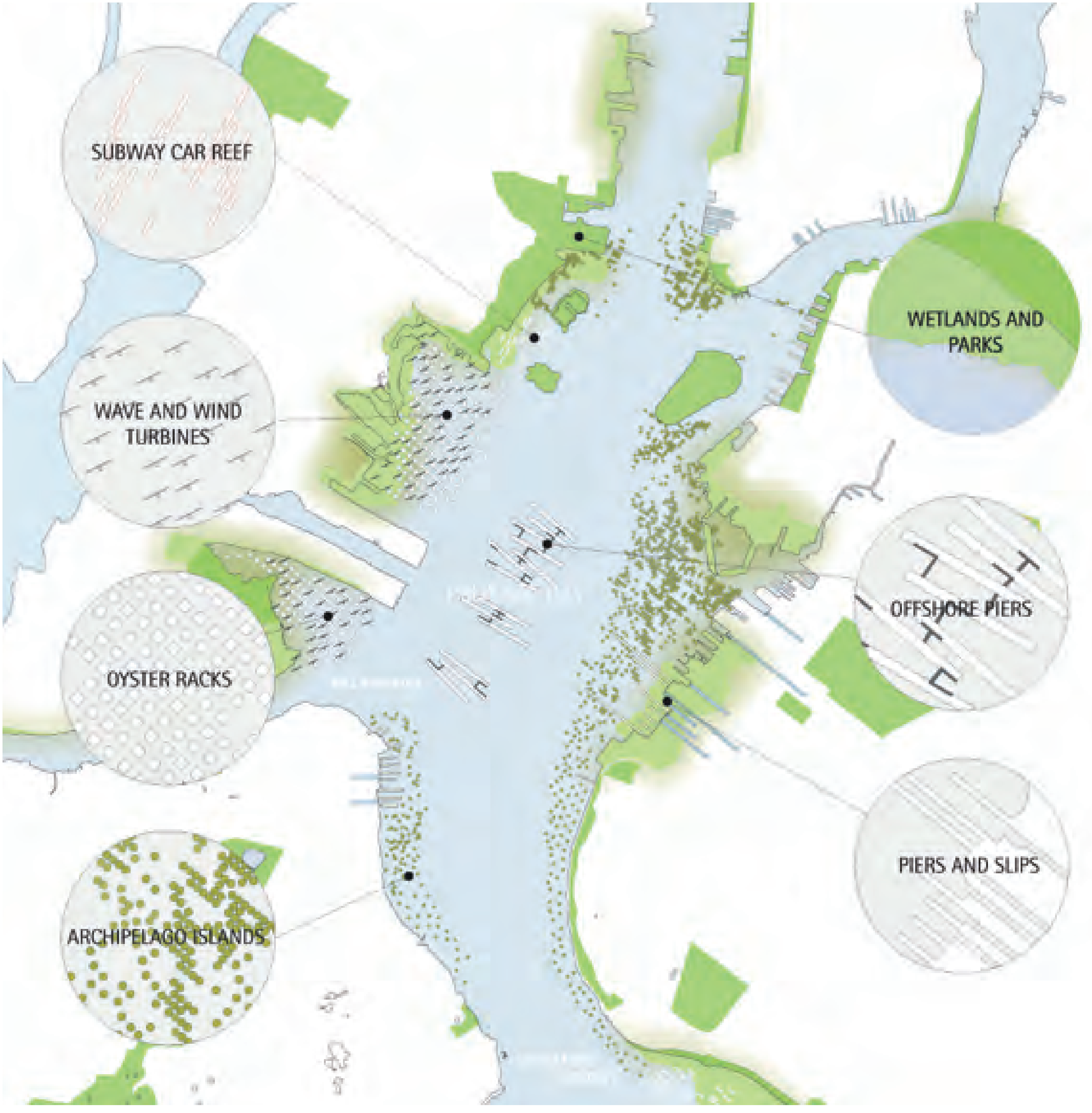
We see a potential design and planning strategy for the Upper Bay that would serve to remediate the harbor region ecologically; provide the potential for transit links and recreation; and mitigate both the effects of global warming induced flooding, as well as the forces of storm surges due to hurricanes and nor'easters. These design strategies would be implemented within two broad strategic categories, defined here as the edge and the flats. Various design strategies have been catalogued for possible interventions within each zone.

The Edges

The image of the Upper Bay found at the beginning of the Edge Atlas is a temporal overlay of a century of fluctuation along the water's edge, reflecting both the movement of the shoreline in and out, as well as the filling and dredging of the shallow-water flats. The edge is considered to be not just a line dividing water from land, but a zone of varying width. This edge surface expands and contracts between four abstract lines that historically circumscribe the entire Upper Bay: the pier-head line, the bulk-head line, the former coastline, and the extent of former wetland marsh. Our catalog of intervention strategies at the water's edge works with both additive and subtractive methodologies within that zone. The shoreline strategies presented here are deployed either perpendicular or parallel to the edge. Most of the perpendicular strategies have evolved from the shipping language of access—wharves, piers, and slips—whereas the parallel strategies tend to reflect protective natural or man-made conditions such as wetlands, mangroves, and reefs.

The Flats

The flats, sometimes called beds, middle ground shoals, or anchorages, are areas where the bathymetry of the underwater surface approaches the surface of the water. These shallow zones have historically been the site of shellfish beds and ship anchorages, and are often the foundations for landfill. This may be seen with Governors Island, Liberty State Park, and Ellis and Liberty Islands. In some areas, particularly the flats to the southwest of Red Hook and the mouth of the Gowanus Canal, the shoal has been accentuated due to the dredging of shipping channels around its perimeter. The catalog of intervention strategies at the flats examines various possibilities of the creation of "islands" at the surface or transformations of the underwater bathymetry. In both cases these strategies aim to serve as anchorages for the establishment of a new natural growth and habitat, as well as acting to absorb and mitigate wave energy within the bay.


SUBWAY CAR REEF
WAVE AND WIND TURBINES
OYSTER RACKS
ARCHIPELAGO ISLANDS
WETLANDS AND PARKS
OFFSHORE PIERS
PIERS AND SLIPS