DESIGN AND PLANNING FOR FLOOD RESILIENCY:

Guidelines for NYC Parks

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WELCOME

A NOTE FROM NYC PARKS COMMISSIONER SILVER

Dear Friends,

New York City's parks and public spaces are the cornerstone of strong communities, providing essential space for our residents to live, play, and interact with their neighbors. Accessible and beautiful open spaces enhance our quality of life, promote better public health outcomes, and deepen our connections to our city's diverse recreational, cultural, and natural resources. They are also one of our many tools to adapt the city to the impacts of climate change.

As was made clear during Hurricane Sandy, New York City's 160 miles of shorefront parkland are often the city's first defense against climate change. And those who design for and build on our city's shorelines not only have a special responsibility to develop vibrant parks and public spaces, but also should ensure they are safe and will last into the future. This guide has been written to inform planners, designers, builders, and advocates of waterfront parks. Here you will find lessons from recent storms and floods, guidelines for resiliency-focused planning and design processes, best practices for analyzing sites, and recommendations for selecting and assembling durable materials.

New York City has always been defined by ingenuity and innovation—and for that reason, it will remain home to the world's greatest and strongest parks, natural areas, beaches, and boardwalks, even as we face a changing climate. We look forward to working together to build a bright, resilient future.

Mitchell J. Silver, FAICP, PP, and Hon. ASLA
COMMISSIONER
NYC PARKS

WELCOME

A NOTE FROM THE NYC MAYOR'S OFFICE OF RECOVERY & RESILIENCY

The lessons from Hurricane Sandy have taught us that our parks and open spaces will increasingly play a crucial role in adapting New York City to our changing environment. In the future, not only will we continue to rely on these vital natural systems to serve as necessary public amenities for the city's growing population, we will also look to them to mitigate the risks of climate change by moderating higher temperatures, improving air, water and soil quality, and strengthening New York City's resiliency to coastal storms and sea level rise.

Design and Planning for Flood Resiliency: Guidelines for NYC Parks will serve as an essential tool for planners, designers, engineers, and consultants as they tackle the planning challenges associated with designing our parks and open spaces brought on by a changing climate. These Guidelines are grounded in sound climate-smart data and are aligned with the principles of OneNYC, the City's blueprint for building a more sustainable, more resilient, and more equitable city.

The City's approach to building resilient parks includes designs that provide access to the public, account for climate risks, and allow for quick recovery from storm events. Resilient waterfronts, when appropriate and feasible, should bolster ecosystems and aid in community scale coastal resiliency. The Guidelines are user-friendly, including step-by-step checklists for the planning and design processes and suggested materials and components for particular site types. Finally, the Guidelines provide practical lessons learned from case studies of noteworthy projects such as Bushwick Inlet Park and Rockaway Boardwalk.

These Guidelines reflect the latest resiliency design measures for our parks, while also ensuring that the quality and accessibility of our open spaces will deliver the greatest benefits to the most New Yorkers. As the science and data continue to evolve, so will these Guidelines, as the City continues to make strides in the advancement of resilient design.

Jainey Bavishi
DIRECTOR
NYC MAYOR'S OFFICE OF RECOVERY & RESILIENCY

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Executive Summary

New York City is a thriving coastal metropolis. The waterfront, an ever-present asset, provides recreational, ecological, aesthetic, cultural, and economic value throughout the five boroughs. The city's coastal location, however, does carry significant risk.

Climate change is a growing threat, contributing to estimated sea level rise, heightened probability of increased frequency and intensity of coastal storms, and other related hazards that especially affect land and resources near the waterfront. This will directly impact the population that lives, works, and recreates along the city's shoreline. Significantly, NYC Parks maintains approximately 160 miles, or almost half of publicly owned waterfront property.

In the wake of Hurricane Sandy's landfall five years ago, and in the face of climate change's current and forthcoming effects, NYC Parks presents these Guidelines. In this document NYC Parks suggests methods to plan and design for resilient waterfront parks, which include both parks and open spaces directly abutting the shoreline and those within the geographic floodplain. We intend for these Guidelines to bring awareness about resilient waterfront parks to a broad audience, identify and define major risks associated with waterfront parks, outline a process for planning and designing these parks, and recommend resilient materials and best practices to be used in these locations. The Guidelines can be considered an addendum to NYC Parks' 2010 "High Performance Landscape Guidelines: 21st Century Parks for NYC," a first-of-its-kind manual for the design of New York City parks.

The first chapter of these Guidelines explains the purpose and intended audience of the document, as well as some of the important lessons New York City learned from Hurricane Sandy. A glossary is also included in Chapter 1. The second chapter outlines NYC Parks' goals for resilient waterfront parks, lays a foundation to understand concepts that influence flood zone policy, describes some of the major risks waterfront parks face, and presents some broad strategies that seek to address those risks. Chapter 3 provides process checklists that outline considerations for both the planning and design of waterfront parks that can be used across different project types. Park typologies are categorically discussed in further detail with accompanying case studies highlighting best practice examples in Chapter 4. The fifth chapter presents a wide array of materials and components used in park sites with accompanying flood-related threats and recommended best practices to alleviate them. Finally, additional resources for a more comprehensive understanding of the concepts presented in the Guidelines are listed in Chapter 6.

In order to adapt our waterfront parks to be more resilient, they should be built more durably and with risks in mind, through proper material and plant selection as well as appropriate design detailing. Resilient waterfront park design should also account for "the norm, not the storm." In other words, waterfront parks should facilitate everyday public use during typical weather conditions while still including elements meant to face the risk. This approach maximizes parkland utility and public investment.

NYC Parks encourages a contextual, site-by-site approach to each new or renovated waterfront project. Every site is unique in its site-specific conditions, surrounding upland context, recreational, ecological, and community needs, and likely risk factors.

Pier 84 at Hudson River Park, Manhattan

As such, resilient waterfront parks, open spaces, and natural areas should, at a minimum, aim to meet the following goals:

Provide access and a high-quality park experience

Access to and within waterfront parks enables these spaces to thrive. Recreational opportunities and programming should be considered and provided when possible to enhance user experience, as detailed further in Chapter 3. In natural areas, access can still be provided, but in a more limited manner to protect ecological functionality, as detailed further in Section 4.3.

Recover quickly from both small and large storms

Waterfront parks should recover quickly with minimal pre- and post-storm intervention and maintenance. Chapters 4 and 5 provide guidance on how to achieve this by waterfront park site type and through use of resilient materials.

Be designed with risks in mind

By using durable materials, hardy plants, and appropriate design details, waterfront parks will be able to withstand harsh waterfront conditions as well as evolving climate patterns, as detailed further in Chapter 5.

Where appropriate and feasible, waterfront parks can also seek to:

Bolster urban ecosystems

Waterfront parks can strive to incorporate elements that promote functional ecosystems and employ natural systems-based coastal resiliency strategies, as detailed further in Section 3.3, throughout Chapters 4 under different site types, and through use of plantings and certain coastal edges as found in Chapter 5.

Adapt edges for sea level rise

Waterfront parks can adapt edges to account for future projected sea level rise by, for example, moving pathways further inland or subtly regrading wetland sites where appropriate, as detailed further in Section 3.3.

Aid in community-scale coastal resiliency

If sites are well suited, waterfront parks can play a role in addressing community-scale coastal resiliency by employing interventions that aid in upland protection, such as raising bulkheads or adding interior drainage, as further detailed in Section 3.2.

Hunter's Point South Park, Queens, Phase II under construction

1

Introduction

Introduction

New York City and other coastal urban centers are especially vulnerable to environmental stressors including the effects of climate change. The projected rise in sea levels, the heightened probability of increased frequency and intensity of coastal storms, and other related hazards pose significant risks to the city's waterfront environment.

Parks are an essential part of New York City's urban fabric. They play a vital role in the day-to-day functioning of the city, providing access to recreational opportunities, nature, and welcomed respite for residents and visitors alike. Waterfront parks, including those directly abutting the shoreline as well as those in the floodplain, are an integral component of this park system, and should be built to withstand a heightened risk of environmental stressors. With NYC Parks occupying approximately 160 linear miles of the city's coast, these Guidelines aim to set forth planning and design recommendations for the future of the city's substantial waterfront park assets.

Because our waterfront parks face heightened environmental threats, they should be adapted to be more sustainable and more resilient. "Design and Planning for Flood Resiliency: Guidelines for NYC Parks" identifies and recommends strategies, best practices, and appropriate materials for creating resilient waterfront parks and open spaces. These Guidelines arise out of a crucial need to think systematically about the ways in which parks and open spaces in New York City's coastal areas are planned, designed, constructed, and protected.

WATERFRONT PARKS

Throughout these Guidelines, the term "waterfront parks" is meant to act as a reference for parks and open spaces that are directly adjacent to the shoreline as well as those that lie within the geographic floodplain (a concept that is further described in Section 2.2).

Boardwalk under construction at Rockaway Beach, Queens

1.1 // **Purpose and Intended Audience**

Building a more resilient park system will be a gradual transformation over time. It requires close collaboration between city agencies, local communities, and industry experts.

This document can be considered an addendum to NYC Parks' 2010 "High Performance Landscape Guidelines: 21st Century Parks for NYC," (see Resource 14) a first-of-its-kind manual for the design of New York City parks. The High Performance Landscape Guidelines laid out best practices for assessing, designing, and constructing parks and open spaces, including maintenance and operations. These Guidelines focus on the unique risks, planning and design processes, site types, and materials that are specific to waterfront parks and open spaces, including those directly abutting the shoreline and those within the floodplain.

These Guidelines are intended for a broad audience of individuals and organizations interested in engaging with public park planning, design, development, and maintenance of the New York City waterfront. Designers, developers, property owners, and agency partners interested in or responsible for rebuilding and improving the resiliency of New York City's parkland will find this guide particularly useful. We also hope that those with a general interest in planning and designing for coastal resiliency will use these Guidelines to advocate for better project outcomes, including increased resiliency of waterfront parks and open space projects in the New York metropolitan area and beyond.

The purpose of these Guidelines is the following:

Bring awareness to a broad audience the unique issues, opportunities, and risks faced by waterfront parks.

Identify and define major risks that may impact our waterfront parks.

Outline a process for planning and designing waterfront parks.

Recommend best practices and resilient materials to be used in waterfront parks.

Community meeting for Stapleton Playground in Staten Island

1.2 // How to Use This Guide

These Guidelines are intended to be used as a practical reference during the planning and design process for waterfront parks and open spaces. Planning and design practitioners, project stakeholders, government agencies, and other users can deploy these materials to:

Understand key terms and concepts.

Chapter 1: Introduction includes a glossary that identifies and defines terms, concepts, and ideas presented in the Guidelines, many of which are elaborated upon in later chapters.

Gain a broader understanding of resiliency goals and related policy.

Chapter 2: Waterfront Parks: Goals and Policy outlines NYC Parks' goals for resilient waterfront parks, lays a foundation to understand concepts that influence flood zone policy, describes some of the major risks for waterfront parks, and presents some broad strategies that seek to address those risks.

Guide the planning and design process for the floodplain.

Chapter 3: Planning and Design Process provides checklists and guidance on project steps and essential inputs specific to waterfront parks.

Define project scopes and typologies.

Planners and designers (i.e., landscape architects, ecologists, engineers, and architects) of parks can use these Guidelines as a reference to identify different types of waterfront parks and understand what features accompany them. Chapter 4: Guidelines by Site Type identifies specific floodplain considerations and best practices based on a range of site typologies.

Make decisions about best materials.

The Guidelines identify best practices, including a preferred palette of plants, materials, and components for use within the floodplain. Chapter 5: Guidelines for Materials and Components gives designers and planners a common starting point from which to work as they create plans for new parks and adapt existing parks for resiliency.

Learn more.

Chapter 6: Additional Resources at the end of the Guidelines shares links and sources to the many additional publications, websites, studies, and guides that are referenced within the document.

Pier 15 at East River Park, Manhattan

1.3 // **Lessons from Hurricane Sandy**

New York City has set a goal of creating a more resilient city in the context of climate change, which is projected to impact our coastal, urban environment by way of increased temperatures and precipitation, rising sea levels, and increased frequency and intensity of coastal storms.

Recent severe storms, including Hurricane Sandy in 2012, have caused significant damage to property and infrastructure, ranging from subway tunnels to electrical service to waterfront parkland.

During Hurricane Sandy, 5,700 acres of New York City parkland were inundated with water from the city's surrounding waterways, causing nearly $800 million in damage. Since then, New York City has invested significantly in reconstructing and rehabilitating its coastal areas, including parkland. Many of these projects and plans follow through on recommendations that the City established through its 2012–2013 Special Initiative for Rebuilding and Resiliency (SIRR), which convened to address long-term planning and preparation to protect New York City against the impacts of climate change, as well as other initiatives and programs, like Rebuild By Design.

The city also released policy documents and technical reports that set the citywide framework for sustainable development and resiliency planning. Mayor Bill de Blasio's 2015 report, "One New York: The Plan for a Strong and Just City" (OneNYC) (see Resource 23), as well as the 2013 post-Sandy report produced by SIRR, "A Stronger, More Resilient New York" (see Resource 29), recommend strategic approaches to mitigate the impacts of climate change along the City's coastline as well as within the city's park system.

The following lessons learned draw on these initiatives as well as on the post-storm assessments by NYC Parks, as well as agency knowledge and experience, and industry best practices.

Geography and topography establish a baseline for risk.

The level of damage to parks varied greatly depending on each site's geographic location and topographic features relative to the storm's path. Topography—the hills and valleys on land and under water—can influence a storm's inundation depth and length. Some of the worst damage to parkland and upland communities was seen in low-lying areas, such as at the beaches and boardwalks in the Rockaways and on the shoreline of Staten Island. Additionally, low-lying but non-beachfront areas such as the neighborhoods of Red Hook and Gowanus, Brooklyn, experienced significant flooding during Sandy.

However, it should be kept in mind that storm trajectory, duration, and strength will differ with each event. For example, during Sandy, areas with similar geographic profiles to Red Hook, such as East Harlem in Manhattan, experienced relatively less inundation and property damage. This particular storm did not impact those areas to the same extent due to timing of high tides, wind, storm trajectory, and other factors that may differ during a future storm.

This variation points to a major caveat when trying to reduce damage from coastal storms and associated flooding: every storm will create unique conditions that in turn exacerbate different risks and effects. It is also essential to consider risks associated with the geography and topography of any waterfront project site, and make planning and design decisions based on relative costs and benefits of parkland and other development in the floodplain.

Constructed park features should be elevated.

Topographic elevation of a park has a major effect on how individual park features will fare during a flood event. Similarly, the location of an individual park feature at a higher elevation may be the sole factor in whether the feature—or its materials or components—will withstand a storm or flood event. During Hurricane Sandy, a few feet in elevation was the difference between park features surviving versus being destroyed, damaged, or washed away.

Subsurface construction matters.

While the above-ground design and finish of park materials and components are important, the subsurface footings and base materials are equally important. Subsurface footings and base materials should be designed and constructed with the proper materials, depth, and reinforcement in order to provide proper support to withstand the effects of erosion and scour during storm events.

Lifespan of materials in the floodplain may be shorter.

Catastrophic damage aside, much of the damage to park materials in the floodplain during severe storms and flood conditions resembles an accelerated effect of regular wear and tear. Generally, most materials and surfaces will show signs of deterioration with age, typically seen over a longer period of time outside of the floodplain. Therefore, if a typical palette of materials standard for upland areas is also used within the floodplain, it may need to be replaced more frequently than the specified standard lifespan.

Following Sandy, some of the damage to park materials was consistent across material types (e.g., rubber safety surfacing fared poorly at multiple playground sites). Other damage was less consistent and seemed to depend entirely on the geographic and topographic conditions discussed above, such as the park's elevation above sea level.

Coastal ecosystems are resilient and can be protective.

Established coastal ecosystems can either survive or, if damaged, quickly recover after a storm. In some instances, they can even offer protection to nearby communities. Conserving and building new ecosystems that are designed to suit coastal environments will help ensure long-term, cost-effective, resilient, and sustainable coastal protection.

Some natural areas, such as the native flora at the Rockaways, rebounded well after Hurricane Sandy. There, the disturbance and movement of sand actually increased the population sizes of many native species. The regenerative drive of many coastal plant species became an asset to NYC Parks in areas that reestablished quickly. There were even record numbers of a federally listed endangered plant species found within protected beach areas.

Design and planning within the floodplain should adapt with every new piece of information gathered. While absolute protection against flood damage is an unattainable goal, these lessons from past storms can help predict the range of future risks. These lessons also form the basis of these Guidelines.

1.4 // **Glossary**

Accession
A collection of plant material from a particular location.

Accretion
Process of coastal sediment depositing on the visible portion of a beach, wetlands, and sub-tidal areas.

Aggradation
The deposition of sediment by water.

Alienation
A legal procedure that consists of the taking of parkland for a non-park use.

American Disabilities Act (ADA)
Legislation passed in 1990 that prohibits discrimination against people with disabilities. Under the Act, discrimination against a disabled person is illegal in employment, transportation, public accommodations, communications, and government activities.

Backflow prevention device
A mechanism used to protect potable water supplies from contamination by preventing the backflow of water.

Base flood elevation (BFE)
The computed elevation to which floodwater is anticipated to rise during a 100-year storm. BFEs are shown on FEMA Flood Insurance Rate Maps (FIRMs) and on the flood profiles. The BFE is the regulatory requirement for the elevation or flood-proofing of structures.

Beach nourishment
The process of adding sand to the shore to secure and replenish the beach against shoreline erosion. Beach nourishment does not stop erosion but rather allays the erosional forces.

Bioretention areas
Landscaping features adapted to store storm water runoff. Surface runoff is directed into shallow, landscaped depressions that are designed to incorporate many of the pollutant removal mechanisms that operate in forested ecosystems. During storms, runoff infiltrates the soil and is stored in the system. The remaining runoff ponds above soil in the system. Runoff from larger storms is generally diverted past the facility to the storm drain system.

Biotechnical erosion control
The use of plants, plant materials, and engineered structures that use plant materials for protecting against water pollution, soil loss, wildlife habitat loss, and human property loss.

Bituminous setting bed
A layer of a tar-like substance used as a base layer adhesive for pavers.

Blue sky flooding
See Nuisance Flooding.

Breakwater
A barrier built out into a body of water to protect a shoreline, coast, or harbor from the force of waves.

Climate change
Climate change refers to a significant change in the state of the climate that can be identified from changes in either the average state or variability of weather and that persists for an extended time period, usually decades, centuries, or longer.

Climate hazard
A weather or climate state such as a flood, heat wave, high wind, heavy rain, drought, etc., that can cause harm to people and damage property, infrastructure, land, and ecosystems.

Cloudburst
An extraordinarily heavy rainfall event occurring over a relatively short period of time.

Coastal erosion hazard area (CEHA)
Coastal areas, such as beaches, bluffs, and dunes, delineated by the New York State Department of Environmental Conservation, which are subject to coastal erosion hazards. Regulated activities of land disturbance to properties within the CEHA zone require DEC's written approval.

Color seal coat
A colored chemical mixture applied to seal pavement; is used for recreation marking in basketball courts and tennis courts. It is also used as a road and parking lot marker to identify traffic lanes, fire lanes, handicapped parking spaces, etc.

Combined sewer overflow (CSO)
The discharge of a mix of excess storm water and untreated wastewater into a waterbody (rivers, streams, estuaries, and coastal waters).

Critical root zone
An area on the ground beneath a tree that corresponds with the dripline of that tree, sometimes called the tree protection zone. This zone is used in determining allowable disturbance to the area around an existing tree during construction. Since the dripline is very irregular, the trunk diameter is often referred to for calculating CRZ.

Debris displacement
The shifting of sand, soil, and sediments by high winds and hurricane conditions. Debris can include trees, construction and demolition material, and personal property.

Dune / Back-dune
Hills of sand or sediment often found on beaches. A back-dune is a specific type of dune that is more densely vegetated and therefore more stabilized.

Erosion
The wearing away of land caused by wind, waves, currents, and rainwater that happens over a period of time.

Estuary
Geographic areas where salt water and freshwater meet.

Fetch
The distance that wind travels across open water in one direction, which can affect wave formation and storm surge.

Flood Insurance Rate Maps (FIRMs)
Maps produced by the Federal Emergency Management Agency (FEMA) that identify Base Flood Elevations (BFEs). At the time of this publication, FEMA's Preliminary Flood Insurance Rate Maps, or P-FIRMs, released in January 2015 are currently being updated. P-FIRMs are currently being used for planning purposes in the interim.

Flood zone
Defined geographic areas with varying levels of flood risk that encompass different parts of the floodplain, determined with an analysis resulting in projections of varying levels of flood risk.

Floodplain
Any land area susceptible to being inundated by floodwaters from any source.

Forever Wild
The Forever Wild Program, currently including over 8,700 acres of towering forests, vibrant wetlands, and expansive meadows, is an initiative of NYC Parks to protect and preserve the most ecologically valuable lands within the five boroughs.

Functional ecosystem
Robust, self-sustaining biological communities composed of interacting organisms and their physical environments.

Gabions
Rectangular, galvanized wire baskets filled with stones used as pervious, semi-flexible building blocks for slope and channel stabilization.

Green Infrastructure
Approach to water management that protects, restores, or mimics the natural water cycle. NYC has a citywide system of engineered landscapes that transform unused impervious areas into vibrant and pervious green space.

Groins
Hard structures installed on beaches that extend from the shoreline into the sea meant to retain sediment on the shore and prevent longshore drift. Also known as groynes.

Ground hydrant
An outlet connected to the water main, typically constructed of cast iron or bronze, used to water plantings.

Hurricane
A specific type of storm consisting of a rotating low pressure system with winds exceeding 74 mph that occurs in the Atlantic and Northeast Pacific Oceans. Hurricanes (Atlantic and Northeast Pacific

Oceans), cyclones (South Pacific and Indian Oceans), and typhoons (Northwest Pacific Ocean) are different names for the same type of weather phenomenon occurring in different global regions.

Hydrostatic load
The pressure that a fluid substance exerts.

Integrated Flood Protection System (IFPS)
A set of distinct coastal protection measures composed of a variety of flood intervention strategies that are combined and customized to create a line of protection against flooding.

Intertidal zone
The waterfront land area between low and high tide marks that is exposed to air during low tide and is submerged during high tide. Also known as the littoral zone.

Inundation
The total water level that occurs on normally dry ground as a result of storm surge or land-side floods. Inundation is expressed in terms of height of water, in feet, above ground level.

Littoral zone
See intertidal zone.

Live stake
A stake or pole fashioned from a dormant cutting of a live woody plant used for soil, sediment, or revetment stabilization.

Living shoreline
A type of soft coastal edge that incorporates combinations of terrestrial and submerged aquatic vegetation, sand fill, stones, intertidal shellfish reefs, and other structural and organic materials.

Longshore drift
A geological process during which sediment is transported by water along a shoreline in a parallel direction to the coast.

Nor'easter
A type of storm that occurs along the northeastern part of the United States that typically causes heavy precipitation, be it rain or snow, usually between the months of September and April. Nor'easters derive their name from the direction of the northeastern winds that drive them.

Nourishment
A process in which sand and sediment is added to the current shoreline of a beach.

Nuisance flooding
Flooding that occurs without the presence of a storm, often from high tide events that exceed the norm, such as during the full or new moon. Also known as tidal flooding, blue sky flooding, or sunny day flooding.

Parapet
A low wall or railing to protect the edge of a platform, roof, or bridge.

Powder-coat
A type of coating, typically applied to metal, that is applied electrostatically as a dry powder, and then cured under heat to allow it to flow and form a "skin." It is more durable than paint, and can protect metal from corrosion.

Quick coupler
A constantly pressurized valve set vertically in the ground to provide supplemental water.

Recycled Plastic Lumber (RPL)
Building material that is manufactured with recycled plastics. In contrast to wood, it does not splinter, rot, or warp.

Reduced Pressure Zone Device (RPZ)
A type of backflow prevention equipment used to protect water supplies from contamination.

Revetment
A term used to describe sloping structures placed on banks or cliffs in such a way as to absorb the energy of incoming water. Riprap and gabions are examples of revetments.

Riprap
Rock or other material used to armor shorelines, streambeds, bridge abutments, pilings, and other shoreline structures against scour and water or ice erosion.

Salt marsh
A type of vegetated coastal wetland that is regularly flooded and drained by salt water brought in by the tides.

Saltwater inundation
Flooding by salt water which, over time, can lead to corrosion and other damage due to the deposition of salt on vulnerable surfaces.

Scour
Localized loss of soil often around a foundation element, causing a structure to become unstable.

Seawall
Vertical structures constructed to protect shoreline areas from heavy wave action. They can be constructed using a range of materials, the most common being poured concrete, steel sheet pile, concrete blocks, gabions, and timber cribs.

Sewer, combined
A sewer system that collects sewage and surface runoff into a single pipe system.

Sewer, separated
A sewer system that conveys sewage and surface runoff in separate pipes.

Sheet drain
Flow or runoff that occurs without being directed into a defined channel. Also known as sheet flow or overland flow.

Spray showers
Recreational water fixtures often found in play areas. In NYC spray showers operate on days when the temperature reaches 80 degrees or higher.

Storm surge
An abnormal rise of water generated by a storm, over and above the predicted astronomical tides. A storm surge can overtop seawalls and flood low-lying areas, toppling large objects, damaging site furnishings, and carrying debris.

Structural pilings
A long, slender foundation member, made either of timber, structural steel or concrete, which may be cast in-situ or driven, that acts as a structural member to transfer the load of the structure to a required depth.

Subbase, subgrade
Subgrade is the native (or improved) soil, which is usually compacted. Subbase is a layer of stone aggregates or stone combined with soil on top of the subgrade as additional structural support for pavement.

Synthetic turf
A surface of artificial fibers made to look like natural grass and used for recreational fields. There are two types of synthetic turf systems used in NYC Parks:

> **Infill-style** uses a carpet that is manufactured using polyethylene fiber, into which infill material is incorporated to support the polyethylene fibers, provide additional shock absorbency, and keep the carpet in place. The polyethylene fiber is softer than nylon and preferred by users.
>
> **Carpet-style** uses a carpet that is manufactured using nylon fiber, (a more durable fiber). This fiber is more abrasive and may not be preferred by users.

Topography
The hills and valleys on land and under water.

Tremie concrete
A concrete placement method that uses a pipe through which concrete is placed below water level.

Unit pavers
Any type of manufactured paving block, typically made of asphalt, concrete, or brick.

Vulcanized rubber
Rubber that has been chemically treated with sulfur and heat for enhanced durability.

Wave attenuation
Any mechanism to reduce the strength and impact of a wave.

Wetland
Interstitial land between open water and the shore that is saturated with water. Wetlands can exist in both fresh and salt water and are often vegetated with marsh grasses.

2

Waterfront Parks: Goals and Policy

Flood Zone Planning and Policy

New York City's waterfront parks are home to beaches, boardwalks, esplanades, marinas, and natural areas. Each of these spaces offers recreational opportunities, exposure to the city's urban ecology, and access to the water itself for residents and visitors alike. As the city adapts to address the risks associated with a changing climate, which include a projected increase in both frequency and intensity of coastal storms and rain events, waterfront parkland can be built to be resilient. This chapter outlines NYC Parks' approach toward creating more resilient waterfront parks, explains the concepts of floodplains and flood zones, identifies risks associated with climate change and major storms, and provides an overview of different coastal resiliency strategies.

Discovery Day at Freshkills Park, Staten Island

2.1 // **Resilient Waterfront Parks**

Our waterfronts are not simply the edges of the city; they are functional spaces in and of themselves. NYC Parks is committed to ensuring resilient waterfront parks are accessible, provide much-needed recreational amenities, and serve an ecological function.

In order to adapt our waterfront parks to be more resilient, they should be built more durably and with risks in mind, through proper material and plant selection as well as appropriate design detailing. Resilient waterfront park design should also account for "the norm, not the storm." In other words, waterfront parks should facilitate everyday public use during typical weather conditions while still including elements meant to face the risk. This approach maximizes parkland utility and public investment.

NYC Parks encourages a contextual, site-by-site approach to each new or renovated waterfront project. Every site is unique in its site-specific conditions, surrounding upland context, recreational, ecological, and community needs, and likely risk factors. As such, resilient waterfront parks, open spaces, and natural areas should, at a minimum, aim to meet the following goals:

Provide access and a high-quality park experience

Access to and within waterfront parks enables these spaces to thrive. Recreational opportunities and programming should be considered and provided when possible to enhance user experience, as detailed further in Chapter 3. In natural areas, access can still be provided, but in a more limited manner to protect ecological functionality, as detailed further in Section 4.3.

Recover quickly from both small and large storms

Waterfront parks should recover quickly with minimal pre- and post-storm intervention and maintenance. Chapters 4 and 5 provide guidance on how to achieve this by waterfront park site type and through use of resilient materials.

Be designed with risks in mind

By using durable materials, hardy plants, and appropriate design details, waterfront parks will be able to withstand harsh waterfront conditions as well as evolving climate patterns, as detailed further in Chapter 5.

Where appropriate and feasible, waterfront parks can also seek to:

Bolster urban ecosystems

Waterfront parks can strive to incorporate elements that promote functional ecosystems and employ natural systems-based coastal resiliency strategies, as detailed further in Section 3.3, throughout Chapters 4 under different site types, and through use of plantings and certain coastal edges as found in Chapter 5.

Adapt edges for sea level rise

Waterfront parks can adapt edges to account for future projected sea level rise. This could range from moving pathways to higher ground, to subtly regrading wetland sites where appropriate, as detailed further in Section 3.3.

Aid in community-scale coastal resiliency

Waterfront parks can play a role in addressing community-scale coastal resiliency by employing interventions that aid in upland protection. Examples of this could range from raising bulkheads to restoring a coastal forest, as further detailed in Section 3.2.

2.2 // **Understanding the Floodplain and Flood Zones**

While the terms floodplain and flood zone are related, they have different geographic extents. This section defines and explains each term and other related concepts.

Floodplain

The floodplain is a low-lying land area adjacent to a water body that is susceptible to inundation by floodwaters from a variety of causes. "Floodplain" is a geological term, referring to the formation and elevation of the land itself. The shape of a floodplain is determined over time, through the processes of erosion and aggradation, or the removal and deposition of sediment by water. In other words, the floodplain is defined by nature and not by science or policy. New York City's coastal floodplain is home to dense human populations, critical infrastructure, and many of our city's important cultural, natural, and historic resources. Waterfront parks, including both those abutting the shoreline and those within the floodplain, are, of course, a part of this network.

Flood Zones

Flood zones, on the other hand, are projected approximate geographic areas that encompass different parts of the floodplain and that have been defined according to an analysis resulting in projections of varying levels of flood risk. Flood zones in the United States are determined by the Federal Emergency Management Agency (FEMA). Risk associated with storm-related flood events is calculated based on a future storm's projected severity, and its probability of occurring during a certain time frame. For example, flood zones are categorized as the 10-year flood zone, 50-year flood zone, 100-year flood zone, and 500-year flood zone. The geographic extent of the 10-year flood zone is smaller than that of the 100-year flood zone, and it is anticipated that it will flood with greater frequency.

100-Year Flood Zone

Most important among these zones for planning and design purposes is the 100-year flood zone, which is the projected approximate geographic area at risk of flooding during a 100-year flood event. The 100-year flood event (also called 1 percent annual flood, or base flood) is the flood that has a one percent chance of occurring during any given year. The 100-year flood event is the standard used by the FEMA for mapping flood-prone areas. Flood insurance requirements, development regulations, and building codes for new construction are determined in part by the 100-year flood zone.

10-Year Flood Zone

The 10-year flood zone is the projected approximate geographic area which has a 10 percent chance of occurring during any given year. While the 10-year flood zone is not typically mapped by FEMA, the 10-year flood zone is important to consider when planning and designing parks. These parks and their materials and features will be more frequently flooded, and therefore at more risk to damage. Damage in these areas could be more routine.

Nuisance Flooding

Not all floods occur because of storms. Tidal flooding, also known as "blue sky flooding" or "nuisance flooding," is a temporary inundation of low-lying areas. This can happen during high tide events that exceed the norm, such as during the full or new moon. Nuisance floods are just that, and cause public inconvenience due to closed roads and overwhelmed sewers. Over time, however, flooded roads and parks could suffer damage from routine exposure to floodwaters, salt water inundation, and erosion, leading to expedited deterioration. According to the National Oceanic and Atmospheric Administration, nuisance flood events are significantly increasing around the United States, especially off the east coast. These increases are due to factors like sea level rise, land subsidence (or sinking), and the loss of natural barriers. In New York City, nuisance flooding is already a concern in some communities.

FEMA FIRMs

FEMA is responsible for producing Flood Insurance Rate Maps (FIRMs), which are generated by modeling the most up-to-date topographic, hydraulic, and climate data available. The FIRMs identify an elevation to which the floodwaters are projected to rise during a 100-year flood event, known as the base flood elevation (BFE). Using this information, FEMA defines Special Flood Hazard Areas (SFHAs) in flood-prone areas, further dividing the SFHAs into zones of vulnerability, ranking them according to specific risk. SFHAs are labeled with letter/numerical designations. In New York City, there are five zones, ranked from high- to moderate-risk areas: VE, AE, AO, A, and X.

FEMA updates its data on an annual basis, using a cost-benefit approach to selecting a limited number of communities each year for new or revised risk studies. As of 2017, note that FEMA is in the process of updating the FIRMs for New York City and has released Preliminary FIRMs (P-FIRMs) which should be used for planning purposes (see Resource 11).

SPECIAL FLOOD HAZARD AREA

Zone VE: Portion of the 100-year flood zone subject to high-velocity wave action (defined as 3 feet or greater breaking wave).

Zone AE: Portion of the 100-year flood zone that is not subject to wave action.

Zone AO: Portion of the 100-year flood zone susceptible to shallow flooding (usually sheet flow on sloping terrain) where average depths are between 1 and 3 feet.

Coastal Zone A: Portion of the 100-year flood zone subject to breaking waves of 1.5 to 3 feet.

Zone X: The 500-year floodplain—an area that has a 0.2 percent or greater chance of flooding in any given year.

LiMWA: The limit of moderate wave action, which identifies an area that will be affected by waves with a 1.5-foot height or greater within the coastal A zone.

HELPFUL CLARIFICATIONS

A 100-year flood can happen more frequently than every 100 years.

The definition of a 100-year flood is that it has a one percent chance of happening in any given year. As such, it is possible that 100-year floods can occur two years in a row. The term "100-year flood" simplifies the way we express this statistical probability. It is calculated using a frequency analysis, which is a series of statistical techniques that account for peak flood risk for a given geographic area over a period of time.

Flooding is still possible outside the mapped 100-year flood zone.

Sites adjacent to but not explicitly within the mapped 100-year flood zone should also receive consideration because flood zones are projected approximate limits. Therefore they may still be subject to flooding during a major storm event. It is also worth noting that every storm is different. Tides, wind, exposure to wave action, and other factors can vary the extent of flooding.

The 100-year flood zone will likely change.

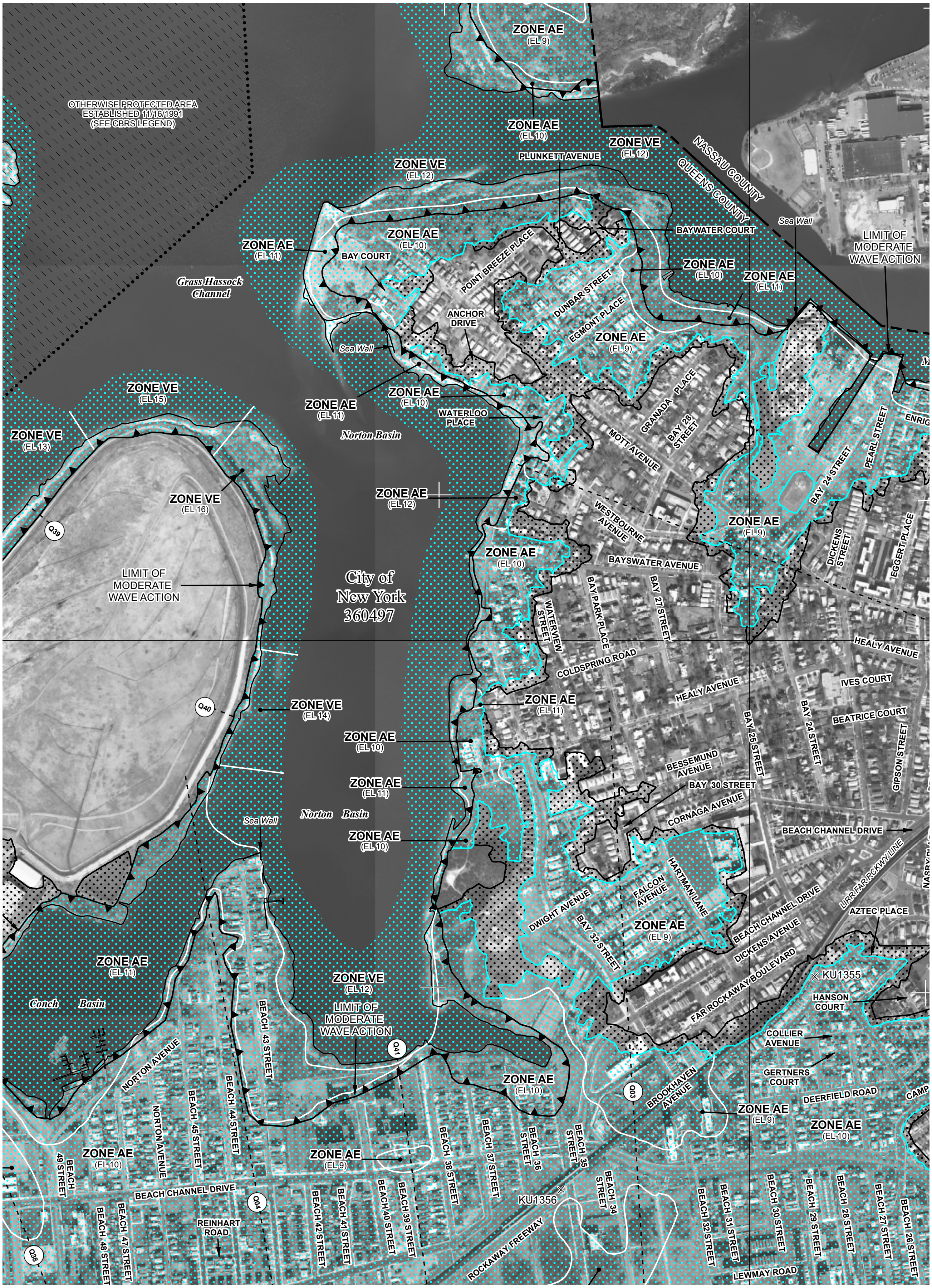
As more data is collected over time, and as the city's geography changes (due to erosion or alterations to land in the floodplain from development), there is a need to re-evaluate flood risk. As such, flood zones will likely be updated periodically to reflect these changes. It should also be noted that today's 100-year flood zone does not take into account future sea level rise, which will likely alter the 100-year flood zone in future.

Changes to the Floodplain: Projected Sea Level Rise

In February 2015, the New York City Panel on Climate Change (NPCC), a group of scientists, academics, and private sector practitioners convened to examine climate change in NYC, released their latest report, "Building the Knowledge Base for Climate Resiliency" (see Resource 4). NPCC's report details climate change risks to the city, including projections of future sea level rise in the New York metropolitan area. Using global climate models, the report published a range of sea level rise projections over the next century, which are summarized below. Many of New York City's coastal resiliency planning initiatives overseen by the Mayor's Office of Recovery and Resiliency (ORR) (see Resource 18) use the 2050s high estimate projections for planning purposes. These projections effectively establish a best guess at the future baseline water levels for the region. With projected sea level rise and other climate hazards and effects, the shape of the New York City coastline will change over time, as will the extent of the floodplain throughout the region.

	PROJECTED SEA LEVEL RISE		
Year	Low Estimate 10th Percentile	Middle Range 25th–75th Percentile	High Estimate 90th Percentile
2020s	2"	4–8"	10"
2050s	8"	11–21"	30"
2080s	13"	18–39"	58"
2100	15"	22–50"	75"

Chart Source: NPCC 2015 Report Chapter 2: Sea Level Rise and Coastal Storms // Photo: Bushwick Inlet Park, Brooklyn



Source: FEMA NYC Preliminary FIRM Data Viewer

2.3 // **Major Risks**

As New York City thinks about how to evolve our parks for a 21st century city, we should plan for projected climate change hazards and the possibility of major storms events. Planners and designers of waterfront parks should consider the potential of each site or system to reduce vulnerability to the risks associated with both climate change and severe storms. We can think about the risks associated with building and maintaining parks in the floodplain as falling into two main categories:

First, there are projected **climate change hazards,** including estimated sea level rise, heightened probability of more frequent and severe storms, potentially increased precipitation, and exacerbated urban heat island effects. These are gradual phenomena but are also compounding factors when combined with other risks. These hazards may establish new baseline conditions in the future.

Second, there are **impacts that arise from major storm events.** These impacts include increased erosion and scour, saltwater inundation, storm water flooding, storm surge, damaged or downed trees and electric lines, debris displacement, and wave action amongst others.

This section outlines climate change-related hazards and impacts of major storm in more detail.

Climate Change Hazards

Sea Level Rise

Strong evidence indicates that the global sea level is rising at an increased rate. Sea levels are projected to rise up to 30 inches (1.5 feet) by 2050. Parks occupy a large portion of the city's coastline, and as such, parks will become increasingly inundated over time by daily tidal cycles and storm events. Increased daily tidal inundation threatens a wide variety of the city's functioning systems—from salt marsh habitats to roadways.

Increasing Frequency and Intensity of Precipitation

Storms and cloudbursts—heavy downpours occurring within a relatively short period of time—are big weather challenges for New York City, even today. Average annual precipitation has been increasing at a rate of about 0.8 inches per decade from 1900–2013, as measured in Central Park, according to the New York City Panel on Climate Change. During the same time period, year-to-year variability of precipitation has also become more pronounced. These increases in rain volume and variability may be coupled with increases in the number and severity of severe storms like hurricanes and nor'easters. In recognition of these trends, NYC, in conjunction with a Danish firm, released the "Cloudburst Resiliency Planning Study" (see Resource 7) in January 2017. The study presents a framework for developing planning strategies that consider cloudburst events.

Increasing Frequency and Intensity of Coastal Storms

The NYC Panel on Climate Change finds that the number of intense hurricanes and extreme winds from storms are likely to increase. As the ocean and atmosphere continue to warm, intense precipitation from hurricanes in the North Atlantic Basin is also likely to increase. As such, heavy downpours will increasingly exacerbate the natural absorptive capacity and erosion of softscapes within waterfront parks. More frequent coastal storms could inundate these parks causing need for more intensive maintenance unless designed with more resilient materials and features in mind.

Increasing Temperatures

As temperatures increase, the effects of the urban heat island effect are increased as well. New York City is to expect increases in the number of extreme heat days, which can contribute to human health problems, higher energy consumption due to hotter weather, as well as changes in local weather patterns. More time spent at temperature extremes, whether hot or cold, can also impact the fate of local plant species.

Major Storm Impacts

Increased Erosion

Erosion occurs over time when constant wave action causes water to remove soil and rock, transporting these materials to another location where they are deposited. Eroded sediment may be transported just a few millimeters or thousands of miles. It is important to note that erosion is an ongoing natural process but, significantly, major storm events facilitate more rapid erosion.

Increased Scour

Scour—a specific type of erosion during which hydrological forces shift sediment and other bed material around coastal structures, such as piles—is also exacerbated during major storm events. Negative effects are seen, for example, when soil or rock around the periphery of an abutment or pier erode, causing structures or pavement to become unstable. Scour may also contribute to the reduction or destruction of some coastal marine habitats by disrupting ecosystems around the marine structures that scour effects.

Saltwater Inundation

Saltwater inundation from the region's saltwater bay and brackish tributaries can corrode metals, electrical utilities, and suffocate or poison non-adapted vegetation over time.

Storm Water Flooding

Heavy rain, runoff, and overloaded sewers can produce flooding, especially in low-lying areas. Overflowing storm sewers within parks and throughout the floodplain can lead to pooling and standing water if areas are not properly graded.

Storm Surge

Storm surge is an abnormal rise of seawater generated by a storm, over and above the predicted astronomical tides. A storm surge can overtop seawalls and flood low-lying areas with force, toppling large objects, destroying site furnishings, and carry damage-causing debris.

Damaged or Downed Trees and Electrical Lines

High winds and hurricane conditions can cause extensive damage and lead to downed trees and electrical lines by the water's edge as well as inland, and can create hazardous situations for communities and infrastructure.

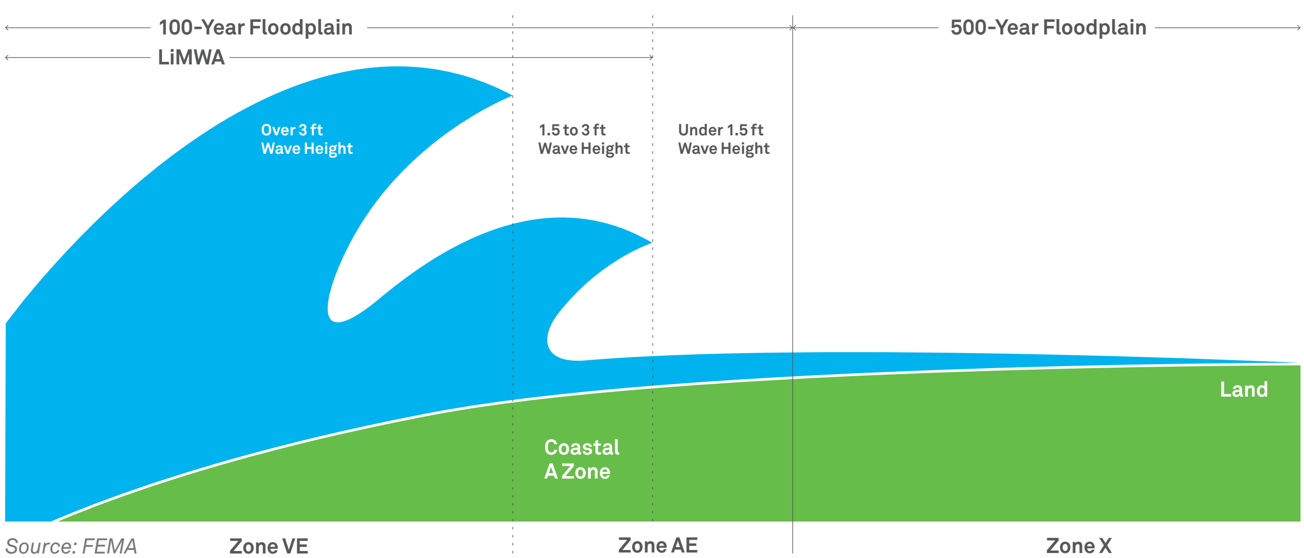
Debris Displacement

High winds and hurricane conditions can detach objects and materials from their fixed locations, causing damage when they collide with other objects, surfaces, or structures. Strong storms with wind and flooding can inundate areas and shift sand, soil, and sediments. Debris can include trees, construction and demolition material, and personal property. Debris can collect in drainage structures and exacerbate flooding.

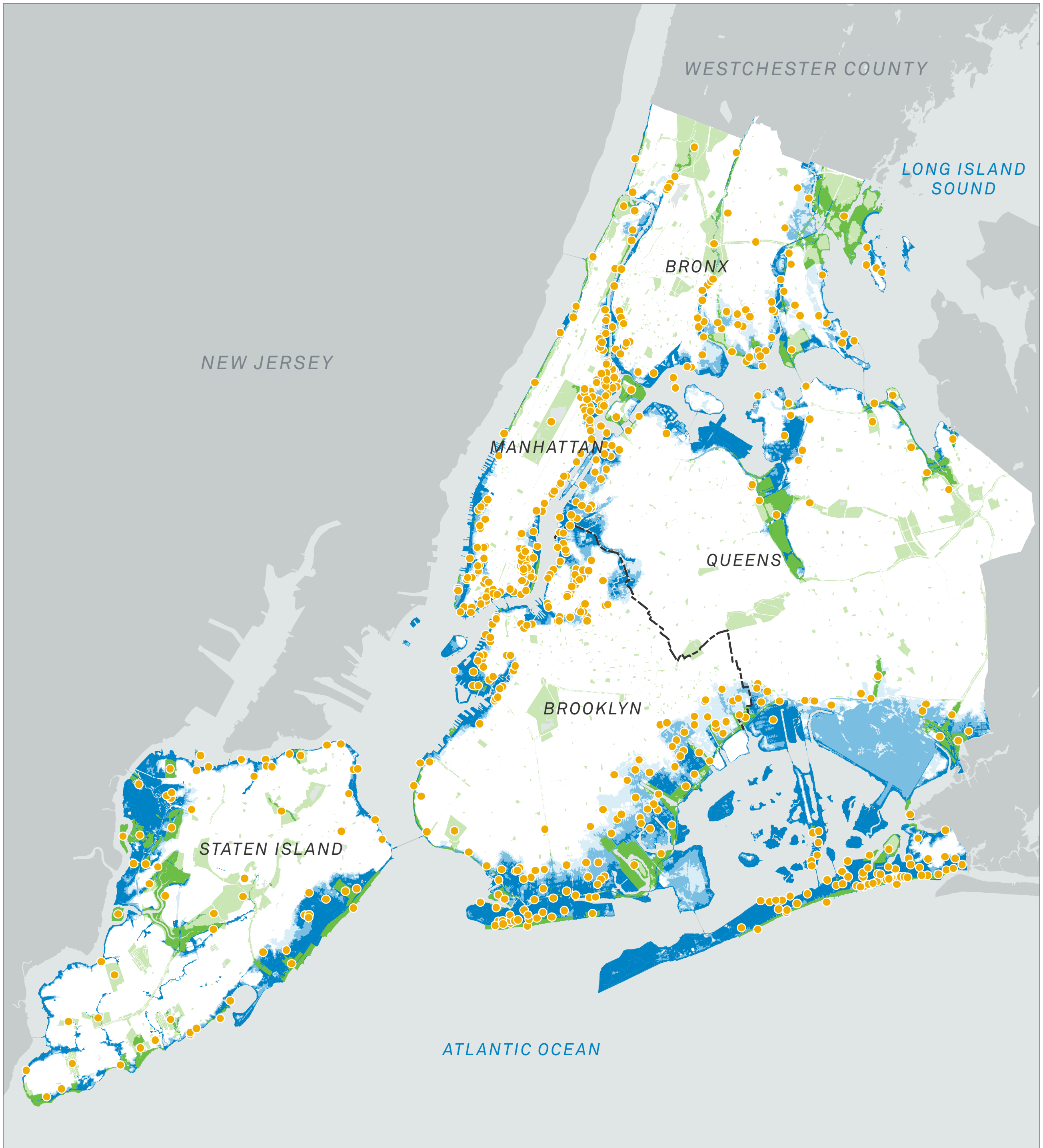
Wave Action

Generally, waves contribute to the natural building up and breaking down of the shoreline. In extreme weather events, waves can inundate and cause significant damage to the built environment, as they repeatedly impact the shoreline and recede. According to FEMA, waves of just 1.5 feet or higher have been shown to cause significant damage to structures. As such, FEMA indicates a Limit of Moderate Wave Action (LiMWA) line on some Flood Insurance Rate Maps (FIRMs). Wave action during storms can impact parks by lifting up unit pavers, scouring concrete and asphalt, causing structural damage to facilities not built on piles or stilts, and erode soils and pavements.

SPECIAL FLOOD HAZARD AREAS



Source: FEMA



NYC Parks in the Flood Zone

Citywide

- NYC Park in the Flood Zone by 2100s
- NYC Park
- Total Parks in 2100s 100-Year Flood Zone
- 2015 100-Year Flood Zone
- 2050s 100-Year Flood Zone
- 2100s 100-Year Flood Zone

Miles: 0 4 8

N

Data Source: NYC Parks, FEMA 2015 Preliminrary FIRM, NPCC 2014

2.4 // **Coastal Resiliency Strategies**

This section provides an introduction to coastal resiliency strategies. The differences between strategies that primarily employ natural systems versus strategies that are reliant on hard structures are presented herein. This section also outlines that these different strategies can be utilized cooperatively as integrated systems. The examples provided are only a sample of existing coastal resiliency strategies. A more comprehensive overview of NYC Parks' approach to some of these strategies is detailed in later chapters.

Natural Systems-Based Strategies

Various coastal resiliency strategies use vegetation and/or build upon natural topographic features to minimize damage in the floodplain. As such, these nature-based strategies have the potential added benefit of facilitating functional ecosystems and biodiversity, while capturing atmospheric carbon dioxide. There are a wide range of natural systems-based strategies, suitable to various site types. For example, wetland creation and restoration might be appropriate for development adjacent to certain waterfront parcels, while nourishment and dune creation would benefit beaches. Creation of living shorelines, which include a variety of natural elements to attenuate wave action and buffer against storm surge, can become a viable alternative or accompaniment to the installation of hard structures such as seawalls or bulkheads. Restoration of coastal ecosystems such as maritime forests can stabilize the shoreline while encouraging habitat succession. As discussed throughout these Guidelines, parks in the floodplain should consider use of natural systems-based strategies whenever possible and appropriate. The following examples of nature based strategies are not exhaustive nor are they listed in any order of preference.

Beach Nourishment and Dunes

Beach nourishment is a process in which sand and sediment lost over time due to erosion is added back to the current shoreline of a beach. Dunes, or hills of sand and sediment, can also be created during the process of nourishment. By nourishing beaches and creating dunes, widened and elevated shorelines can protect upland neighborhoods against storm surge and wave action. Established dunes can play host to plant life, whose root systems protect against erosion, while simultaneously encouraging ecosystem establishment.

Wetlands

Coastal wetlands and salt marshes serve as an interstitial environment between the water and the shore. They buffer upland areas from effects of coastal storms by attenuating wave action and filtering debris from the water. They also serve as a critical ecological resource, providing natural habitat for a large number and diversity of plants, fish, and wildlife. Tidal wetlands are highly productive ecosystems that filter water through plant growth and microbial processes. Wetlands can be bolstered where they currently exist or

Top to bottom: Living shoreline at Bronx Kill, the Bronx; constructed reef at Soundview, the Bronx can be newly constructed along shorelines to help absorb wave energy. Most importantly, wetlands are resilient, require very little management, and continue to provide important ecosystem services as sea levels rise and storms become more frequent.

Maritime Forests

Maritime forests are woodland areas that occur along coastlines and can tolerate high salinity and sandy soils at an elevation above high tide. The root systems of shrubs and trees found in maritime forests prevent erosion, and the above-ground branches, stems, and trunks can be effective in buffering upland areas from wave energy by providing resistance to flow.

Living Shorelines

Living shorelines are a type of waterfront edge that incorporate an array of structural and organic materials to stabilize shorelines, protect intertidal environments, and dissipate wave energy. They employ combinations of riparian, wetland, and submerged aquatic vegetation, sand fill, stones, intertidal shellfish reefs, and other elements to create a nature-based buffer against the coast as an alternative or addition to hard shoreline interventions.

Hard Structures-Based Strategies

Hard structures-based strategies play a significant role in coastal resiliency. While less environmentally accommodating than nature-based strategies, hard structures are commonly found in the urban floodplain. Different interventions serve different purposes, and as such project sites should appropriately tailor hard structures-based strategies accordingly. Some structures, such as floodwalls, floodgates, and levees, create physical barriers and blockades against incoming water. Alternatively, bulkheads and revetment keep waterfront edges in place and bolster shorelines. Other structures, such as jetties and groins, facilitate sediment buildup and retention. Installation of structural interventions should always consider effects on local habitats and ecosystems. Designers and planners should work to ensure damage and/or disturbance to natural systems is minimized as much as possible. Any structural applications on the waterfront should also consider how their placement may affect water flow, potentially contributing to erosion down current from the project site. The following list of structures is meant to provide a brief introduction to a few strategies and is not exhaustive, nor is it listed in any order of preference.

Seawalls

Constructed vertical walls built along shorelines are meant to provide enough height to protect the shorelines and upland assets against erosion, wave action, and sea level fluctuation. These seawalls, a type of floodwall, act as static physical barriers against flooding on the waterfront. While implementation should consider effects on sediment transport and endemic ecosystems, seawalls are often considered in places with limited space for other coastal resiliency strategies.

Revetments

Revetments—sloping structures such as slabs, boulders, or other hard materials placed adjacent to waterfront edges—help absorb the energy of incoming water and aid in reducing or halting erosion of a shoreline. Permeability of revetment as seen in use of riprap or gabions allows tidal and wave energy to be more easily attenuated. Riprap uses piles of rock to armor shorelines, whereas gabions employ metal wire baskets filled with stones or similar material. As with other hard engineering interventions, revetment should consider effects on erosion at sites adjacent to or down-current from installation.

Groins

Groins are in-water structures placed perpendicular to shorelines. They are used to protect beaches and waterfronts against erosion and facilitate accretion by trapping sediment as it moves with the current. As with other hard structures-based strategies, groin placement will affect sedimentation down current from the site of implementation and should consider effects on local habitats.

Integrated Flood Protection Systems

An Integrated Flood Protection System (IFPS) is composed of a variety of elements or distinct coastal protection measures, both natural systems- and hard structures-based, that can be combined and customized to create a "line of protection." This integrated approach is useful for connecting multiple individual sites or stretch across a longer reach of the coast. While New York City is in the process of planning and evaluating IFPS options at several sites, other coastal cities such as Rotterdam and New Orleans have implemented various coastal protection measures in recent years.

CASE STUDY: **ROTTERDAM**

Rotterdam, a port city situated predominantly below sea level in the Netherlands, continues to expertly adapt to ever-present flood challenges and serves as a trailblazer in implementing flood protection measures. After a number of historic flood events, the Netherlands initiated Delta Works, a series of public infrastructure projects, to safeguard its coast against major risk from the neighboring North Sea. Among these projects was the construction of the Maeslantkering, a massive sea gate built to protect the port of Rotterdam. While the Maeslantkering serves as the first line of defense against storm surge, Rotterdam prioritizes working with water as opposed to solely barricading against it. While dams and dikes do exist throughout the city, various parks, plazas, and parking garages serve as public amenities day-to-day but double as water retention areas during flood events. Land area near rivers and canals throughout the city and beyond is being adapted for Room for the River (see Resource 26), a program that aims to give water bodies more space to flow in the face of climate change.

CASE STUDY: **NEW ORLEANS**

Following Hurricane Katrina in 2005, the city of New Orleans began the process of reevaluating and bolstering their flood protection systems. As such, since 2005 New Orleans has implemented various measures to protect against future floods and storm surge. Levees along the Mississippi River were raised and reinforced, floodwalls were reevaluated, added, and restored along various channels and canals running throughout the city, a 2.9-kilometer floodgate was installed across a vulnerable navigation channel, and ailing wetlands surrounding the city were evaluated and replenished with sediment. In 2017, the State of Louisiana released "Louisiana's Comprehensive Master Plan for a Sustainable Coast" (see Resource 15). The plan outlines completed flood protection projects, including those mentioned above, and recommends 120 additional projects that build or maintain more than 800 square miles of land buffering the coast of Louisiana from flooding.

3

Planning and Design Process

Planning and Design Process

As the risk of major damage from coastal flooding increases, it is important that those planning and designing waterfront parks and open spaces understand the unique processes involved. While there are many standard processes for implementing projects in NYC, ranging from public review to regulatory permitting, this chapter outlines some of the unique steps and processes to consider when planning and designing waterfront parks.

Bush Terminal Park, Brooklyn

3.1 // **Applying Lessons Learned**

As outlined throughout these Guidelines, waterfront parks, including both parks located directly on the shoreline and those within the geographic floodplain, present challenges to uniform guidance because of the diversity of shoreline and coastal site typologies.

There are a variety of existing site conditions, unique project objectives, and risks associated with each waterfront park project. For example, a designer would approach the rehabilitation of an existing upland playground differently than they would the construction of a new esplanade. This notion, along with the various lessons learned following Hurricane Sandy, influenced the guidance set forth in this chapter. Planners and designers should consider unique site context, contemplate lessons learned, and look ahead using the best available guidance at the time of a project to predict future risks and design for resiliency.

In this context, **NYC Parks recommends a site-by-site approach to the planning and design process for waterfront parks.**

The following sections of this chapter focus on process over prescription, providing checklists for gathering information to shape project planning and for making decisions when designing waterfront parks.

3.2 // **Planning Process**

The objectives of the planning phase for any park or open space project include: establishing the scope of work, identifying funding sources and developing budgets, reviewing prior plans and regulations, conducting public outreach and engaging the community, prioritizing the inclusion of design features and amenities, and facilitating the necessary local public approvals process. Floodplain projects require the following additional steps.

Assess site-specific flood zones and risk.

Flood risk assessment has several components. Check to see where the site is located relative to current flood risk as defined by FEMA flood zones and erosion risk as defined by New York State Coastal Erosion Hazard (CEHA) zones. The location of a site relative to these zones is directly related to the site's probability of flooding and risk for coastal erosion.

The FEMA Region II (New York and Coastal New Jersey) FIRM can be used to see where a site is located relative to current risk to event-based flooding by 100-year and 500-year floods (see Resource 11).

New York State's Department of Environmental Conservation's (DEC) CEHA zone maps can be used to locate a site relative to current coastal erosion hazard areas (see Resource 22).

Assess flood risk: Check site against regulatory flood zones

Determine desired public uses.

Information about the desired uses of a site will help planners and designers identify and adapt best practices for resilient design. For waterfront park projects, this process should be particularly well-considered and well-communicated with the public, as there may be limitations based on site condition and flood risk. In the floodplain, certain amenities may become unfeasible due to environmental conditions, safety concerns, or high cost. However, it is still important for planners and designers to keep the recreational, ecological, and open space needs of the local community and other stakeholders in mind, and try to plan for these needs when possible.

Review topographic site data against future sea level rise projections.

As discussed in Chapter 2, sea level rise is projected to result in increased depth of coastal flooding, and is projected be a permanent condition. A detailed understanding of a site's topography and flood risk with specific focus on sea level rise is recommended when planning waterfront park projects. Gather and review additional site topographic data to understand where the site is situated relative to future sea level rise projections.

- Review tidal inundation predicted to occur due to sea level rise using NYC's Flood Hazard Mapper (see Resource 12), which is a tool helpful in determining the level of "blue sky flooding," or high-tide flooding and sea level rise flooding, separate from flood events or storms.
- Determine whether a site is covered by or assessed in other City, State, or federal initiatives or plans.

  The Department of City Planning (DCP) Waterfront Revitalization Program developed a sea level rise tool to help understand these levels and guide decision making (see Resource 34).

  Understanding sea level rise-specific future flood levels will influence where to best site various park features. If sites are determined to be subject to high-tide flooding at the time of a project's inception or in the future during the project's useful lifecycle, it may be necessary to consider alternative site options for critical and/or high-cost features.

  Refer to NYC Mayor's Office of Recovery and Resiliency's (ORR) "Climate Resiliency Design Guidelines" (see Resource 6) for additional mapping tools and step-by-step guidance on sea level rise-adjusted design flood elevation for use on all critical and non-critical City capital projects.

Understand shoreline conditions: Eroded riprap

PLANNING PROCESS CHECKLIST

- ☐ Assess site-specific flood zones and risk
- ☐ Determine desire public uses
- ☐ Review topographic data against future sea level rise projections
- ☐ Conduct a shoreline inspection
- ☐ Determine if communities can benefit from park-based coastal protection measures
- ☐ Consider conducting a cost-benefit analysis

Conduct a shoreline inspection.

Coastal processes are dynamic. Understanding the shoreline's current physical conditions at a given project site is a critical part of the planning process. Any coastal project should make it a priority to inspect the shoreline and tailor plans and design approaches based on findings. Results from inspections can help shape large-scale project phasing, determine whether interim or emergency repairs are necessary, and, ultimately, influence design approaches. Inspections are also essential in generating accurate cost estimates for often "invisible" capital needs associated with coastal projects.

Determine if communities can benefit from park-based coastal protection measures.

Since many of New York City's waterfront parks are situated adjacent to low-lying communities that are also vulnerable to flooding, there may be opportunities to integrate parks with coastal flood protection infrastructure. In these instances, parks and open spaces themselves can become strategic infrastructure and a part of the citywide network of urban coastal protection.

Parks are public assets unto themselves. When proposed projects include protective barriers or significant structures, the planning process should prioritize accessibility of the park and quality of user experience, as well as examine impacts on nature of the built environment.

If flood protection measures are desired, careful consideration should be given to their integration with and contribution to park use. The taking of parkland for non-park use in New York State is known as Parkland Alienation, which requires State legislature approval, and is then signed into law by the governor. As such, careful consideration should be given to flood protection features as they may be considered non-park use in certain circumstances.

Site constraints will determine the feasibility and effectiveness of incorporating flood protection measures within a given project. For example, raising an existing bulkhead edge and adding interior drainage may be an appropriate solution on a narrow waterfront esplanade. This approach may increase upland protection and improve drainage in an area prone to nuisance flooding and future sea level rise-related tidal flooding. In natural areas, a coastal forest could be restored to increase its protective function and buffer upland communities.

Consider conducting a cost-benefit analysis.

Assessing costs and benefits is an essential component of the planning process. There are several approaches, varying in formality and added cost to a project.

The expected benefits of the interventions should be evaluated against probable costs, to facilitate discussion in the decision making process, which may influence whether certain elements are included in a design—or whether it is feasible to pursue project implementation at all. Examples of project benefits may include: protected parkland, infrastructure, or other upland assets; protected or improved functioning of ecosystems; or protection of vulnerable coastal communities. Cost-benefit analysis provides the rationale for taking specific planning and design action because it compares project benefits with project costs, thereby providing perspective on effectiveness of investments.

For large or high-expense projects, and those slated for federal funding, a formalized approach to the balancing of desired inputs and outcomes may be advantageous and should be built into a project's scope of work. A cost-benefit analysis (BCA) or index (BCI), a systematic process for calculating and comparing benefits and costs of a project, may be a useful approach to make investment decisions. BCAs are typically necessary for federally-funded mitigation projects.

3.3 // **Design Process**

NYC Parks' designers are responsible for the creation and renovation of 30,000 acres of public land, with over 5,000 individual properties encompassing everything from natural shoreline to basketball courts.

Hundreds of active individual design and construction projects are underway at one time, with hundreds of millions of dollars invested in parks and public space infrastructure every year (see Resource 21). Design projects build on the planning process described in the previous section. NYC Parks projects also follow some essential design principles, including: incorporating community input and context sensitivity; producing thoughtful design concepts using standard materials; enhancing greening; increasing accessibility; creating opportunities for play; and designing for diverse demographics. Design decisions in every NYC Parks project reflect these principles. In the floodplain, park design should also always include the considerations outlined in this section.

Site high cost amenities outside the floodplain.

During the planning phase, we will have assessed site-specific flood risks, including current and projected tidal and sea level rise-associated flooding. At that stage a project scope determination will have been made regarding the need of any high-cost or critical features with respect to flood risk. Amenities such as restrooms, recreational centers, playgrounds, and sports fields are often desired features in a park, but they require a high initial cost and may require specialized protection against nuisance and storm-related flooding. Their need should be weighed against the risk they face of damage.

If they are determined to be necessary, these features should be situated on higher ground within a site whenever possible to reduce risk. Alternatively, surrounding topography should be adapted to provide protections against flooding. Finally, piles could be used to raise necessary structures. An example of this approach comes from the replacement of the Rockaway Beach lifeguard stations after Hurricane Sandy—more detail can be found in the case study in Section 4.2.

This issue is not isolated to new park construction or renovation projects; many parks in the floodplain already have these features. NYC Parks will need to continue to adapt them to growing climate change and coastal resiliency risks in future park renovation and restoration projects as well. For previously existing high cost features and critical infrastructure, designers should carefully consider short- and long-term adaptation strategies and associated costs. Eventually, critical features nearing the end of their lifecycles can be reconstructed out of high risk areas.

Adapt coastal park edges to account for tidal flooding due to appropriate sea level rise projections.

Whether a waterfront park is undergoing a partial renovation or full reconstruction, adaptation to future sea level rise should be included in relevant coastal projects when appropriate and feasible. Guidance on flood design elevations for coastal edge designs should be acquired during the planning phase, and should be based on the best available data at the time of the project.

There are a range of approaches to adapting coastal park edges to future sea level rise. For sites with hard coastal edges such as seawalls, riprap, or gabions, approaches may include raising the edge itself, raising the adjacent esplanade if present, and/or shifting pathways near the coastal edge to higher ground. For sites with soft edges such as wetlands, landward expansion of high marsh through subtle regrading and replanting may be appropriate.

To be maximally effective, adapting our park edges should be part of a larger city effort to adapt all vulnerable low lying coastlines to account for future sea level rise over time.

Manage water on all sides of coastal protection.

Any intervention to help increase resiliency in parks should consider management of water as integral to its solution. In the floodplain, where the water table is high, the absorptive properties of parks are diminished during extreme storms. Therefore, use of green infrastructure within parks in the floodplain is recommended only for management and detention of water from small frequent precipitation events generated from landside storm water runoff, for which it can be an effective solution.

Ideally, a site should pitch toward the coastal edge and allow storm water to exit the site via surface runoff. In instances where coastal edges, such as seawalls, may be elevated, water management via drainage structures becomes particularly crucial in order to avoid a "bathtub" effect, in which upland storm runoff or water from tidal flooding or wave overtopping becomes trapped behind a barrier, exacerbating damage to anything behind the barrier.

Conduct a life cycle analysis.

Park features within the floodplain may have a shorter lifespan than outside the floodplain. As a result, it is valuable to understand the life cycle costs of materials and components in order to make informed design choices and specifications. For example, when evaluating how to repair a damaged element or structure, it is important to know the repair versus replacement costs, along with their associated frequency and degree of maintenance. Understanding service life, associated costs, and maintenance frequencies can all factor into decision making on materials selection and construction techniques.

DESIGN PROCESS CHECKLIST

- ☐ Site high-cost amenities outside the floodplain
- ☐ Adapt coastal park edges to account for tidal flooding due to appropriate sea level rise projections
- ☐ Manage water on all sides of coastal protection
- ☐ Conduct a life cycle analysis
- ☐ Specify resilient materials and plantings, and utilize durable design details
- ☐ Build a functional ecosystems approach into projects

Specify resilient materials and plantings, and utilize durable design details.

Selecting resilient materials, choosing appropriate native coastal plants, and using durable and appropriate construction methods will help enable parks and open spaces to withstand the major risks associated with climate change. Understand that delicate design elements may not be appropriate in the context of the floodplain. Likewise, a palette of durable, salt-tolerant plants will contribute to a more resilient and beautiful park environment. Additionally, parks that incorporate natural areas with plants adapted for coastal environments and, when appropriate, include freshwater wetlands or tidal marsh are better adapted to manage and rebound from flooding. Turn to Chapter 5 of these Guidelines for detailed coverage of resilient materials and components for use in NYC Parks within the floodplain.

Build a functional ecosystems approach into projects.

Functional ecosystems—robust, self-sustaining biological communities comprised of interacting organisms and their physical environments—are inherently sustainable, economically practical, and resilient. Therefore, whether designing shoreline treatments or determining how to address constant inland flooding of low-lying areas, a functional ecosystem-based approach can be a highly beneficial practice. For example, along the city's beaches and bluffs, which are subject to erosion, a dune or vegetated shoreline may be a more resilient approach than installing a seawall edge, as dunes and vegetation have the added benefit of creating and/or restoring habitats and supporting ecological functions while also attenuating wave action and buffering against storm surge.

In some locations, introducing or maintaining hard structures can impact shorelines by altering water flow and natural sediment transport. As such, coastal shoreline designs should take care not to exacerbate or deflect erosion down-shore from the project site. Any installation of hard shore structures or groins should include considering the consequential impacts they might inflict on nearby ecosystems. As an alternative to use of hard structures, vegetated shorelines can provide wave attenuation benefits and reduce impacts from coastal storms. In low-lying areas, which constantly flood and experience great and frequent damage, returning the shoreline to a natural area might be the better approach to take if possible. Even when a full-scale natural ecosystems approach is not possible, design solutions should integrate coastal species that are tolerant of flooding, salt intrusion, and disturbance regimes into park design. No matter the approach, the potential effects on surrounding ecosystems, including sedimentation and scour, should be considered when designing built structures or natural systems at any site.

CASE STUDY:
BUSHWICK INLET PARK

Formerly a parking lot located in Brooklyn along the East River waterfront, Bushwick Inlet Park's first completed phase now hosts a multipurpose athletic field, a playground, and NYC Parks' North Brooklyn Headquarters. Planning and design for this completed portion of the park exemplify the ideals and considerations set forth by these Guidelines. Coastal concerns and environmental goals for the site facilitated a design that withstood flooding in the face of Hurricane Sandy, even though the park was still in construction when the storm made landfall in October 2012. Despite the vulnerabilities that an active construction site presents, the park sustained minimal damage in the face of storm surge due primarily to the design of the park and siting of the key features.

When contemplating desired public use, NYC Parks sought to meet important recreational goals while also incorporating high performance environmental and sustainability features, such as engineered storm water management measures. The completed portion of this park is now 85% permeable open space. It captures storm water from onsite plazas and the North Brooklyn Headquarters' 17,500 square foot green roof, and collects it in a 15,000 gallon cistern beneath the synthetic turf field. The collected storm water is then reused for irrigation. Overflow is filtered through a storm water quality treatment unit and discharges through a headwall into a constructed wetland, designed to hold approximately one foot of water and then flow into the East River. Storm water not collected by the cistern infiltrates the soil and surrounding bioswales.

Located on the waterfront, an additional goal was to restore and reclaim wetland adjacent to the shore at Bushwick Inlet. As the result of a shoreline inspection, decrepit piers, failing bulkhead, and concrete rubble were dismantled and removed and the coastal edge was stabilized with 260 feet of riprap revetment.

Approximately an acre of Bushwick Inlet Park Phase 1 is within New York State Department of Environmental Conservation (NYS DEC) tidal wetland jurisdiction, and the park's development restored approximately 1,700 feet of intertidal wetland and open water. These wetlands and nature-based onsite features support a functional ecosystem approach that restores habitats for marine and avian wildlife. Furthermore, due in part to NYS DEC wetland regulations, recreational assets and amenities are strategically placed around the project site. The LEED Platinum certified North Brooklyn Headquarters building is sited at the most upland portion of the site, outside the 100-year flood zone. The synthetic turf is partially buffered by a berm and the tidal wetland, which keep floodwaters at bay as the park slopes gently upward from the river to the top of the green roof.

Restored littoral zone plantings, Bushwick Inlet Park, Brooklyn

4

Guidelines by Site Type

Guidelines by Site Type

This chapter of the Guidelines describes various waterfront park site types that make up the vast majority of parkland in the coastal floodplain.

Each site type section includes an overview and best practices, and should be cross-referenced with Chapter 5: Guidelines for Materials and Components. Case studies with relevant NYC Parks examples are included for further clarification and information.

A few notable concepts discussed in this chapter include:

- Siting high-cost/high-value amenities at higher elevations.
- Grading sites carefully and avoiding steep slopes when possible to minimize erosion.
- Using native vegetation to stabilize dunes, bolster coastal marine habitats, and provide shade.
- Directing foot traffic and trails in natural areas and on dunes to allow access while minimizing compaction and negative ecological impact.
- Considering playground designs that encourage use of low maintenance landforms, plantings, and resilient materials.
- Utilizing natural turf for athletic activity.
- Appropriately locating marinas, floating docks, and piers and designing them for environmental exposure.

Rockaway Beach, Queens

4.1 // WATERFRONT ESPLANADES AND GREENWAYS

Overview

Waterfront esplanades and greenways are characterized by having a "hard" waterfront edge. A hard waterfront edge is one that meets the water as a vertical face or structure such as a seawall or pier, or one that meets the water with a more gradual transition such as a riprap or gabion edge. Many of these parks have pedestrian esplanades near the water's edge.

In addition to providing unique recreational spaces adjacent to the city's water bodies, waterfront esplanades and greenways also serve as corridors for non-automotive transportation. These facilities allow pedestrians, cyclists, and other modes of human-powered transportation to travel along the waterfront. New York City's many waterfront esplanades and greenways are heavily used pedestrian and bicyclist thoroughfares. Protecting these parks from flood damage is critical to maintain access.

The greatest flood risks to waterfront esplanades and greenways are overtopping by floodwaters and constant wave action against the shoreline structure. These forces can cause erosion or damage to the structure and destabilization of the shoreline. During Hurricane Sandy, many stretches of the city's waterfront esplanades and greenways were inundated due to storm surge, causing destabilization of riprap edges as well as damage to pavements, in-ground infrastructure, furnishings, and sea rails. In order to better protect these facilities, the following best practices are recommended.

Best Practices

- Raise elevations of high-cost/high-value amenities, and use topography and landforms to help alleviate flooding impacts and/or protect against storm surge.
- Grade carefully—avoid steep slopes to minimize possible erosion during flood events.
- Investigate existing drainage patterns and groundwater elevation in order to best determine which storm water management strategies to employ.
- Adapt park edges to account for relevant sea level rise projections.

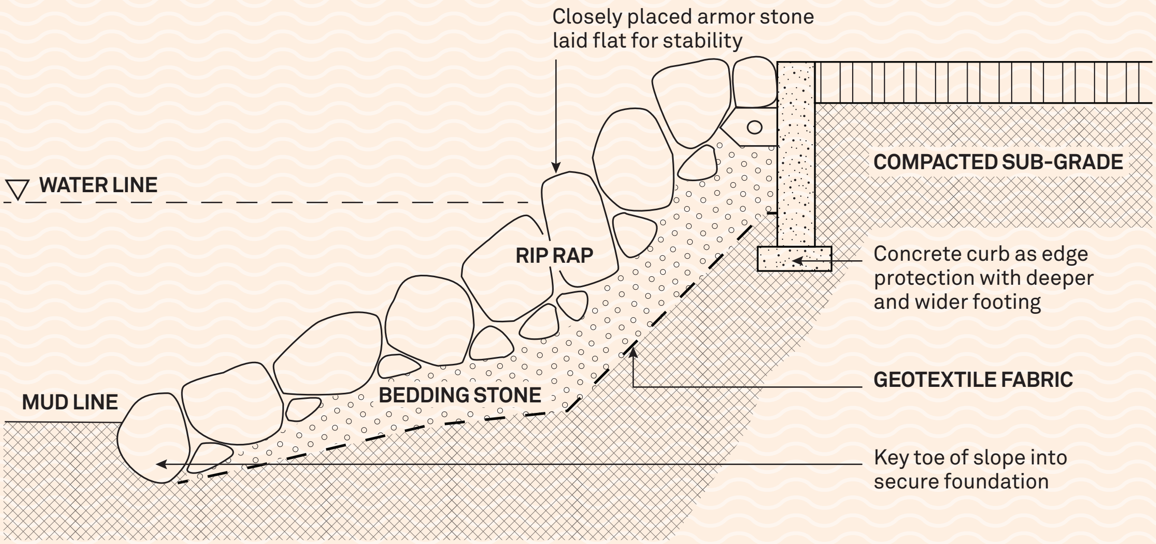
Esplanade at Riverside Park, Manhattan

CASE STUDY:
RIVERSIDE PARK SOUTH

Riverside Park South is located on former New York Central Railroad facilities. The first phase of this park opened in 2000. Prior to Hurricane Sandy, the wooden bulkhead that spanned the length of the rail yard was replaced by a concrete bulkhead in some locations, and riprap in others. Shoreline paths and fishing piers were developed where the industrial infrastructure existed before.

As a part of the park is low lying, it is subject to periodic inundation from large storm events. In-ground infrastructure, such as lighting and irrigation, was damaged by prolonged flooding caused by Hurricane Sandy. Prior to Hurricane Sandy, some deterioration of the riprap edge had been observed, but the hurricane exacerbated this deterioration. In one particular area, near the southern park entrance, much of the riprap was displaced, the concrete curb washed out, and the pedestrian pathway undermined.

To mitigate future problems, key design features of the FEMA-funded restoration of Riverside Park South included reconstruction of the riprap shoreline protection and the inclusion of a deeper footing in the pathway's curb edge. A relocation of the pedestrian pathway from the water's edge was not possible due to topographic restrictions and existing adjacent shoreline uses. However as a response to this limitation, the new shoreline edge was engineered for enhanced stability by utilizing a flat, base layer of stone, revetment for protection, and an engineered top layer to hold these various components in place. These resilient design improvements will be accompanied by a palette of shore-friendly plantings, which help stabilize the upland area.



SECTION: DESIGN FOR FUTURE RECONSTRUCTION OF RIVERSIDE PARK SOUTH SHORELINE

An appropriate plant palette sustained minimal damage from Hurricane Sandy, Riverside Park South, Manhattan

4.2 // BEACHES AND BOARDWALKS

Overview

Many of New York City's most iconic beaches have been re-nourished and enlarged for decades using millions of cubic yards of sand dredged from nearby waterways. Their beachfronts have also been built with boardwalks to allow scenic views and access along the shore, as well as amenities such as seating and concessions. Not all beaches in the city have boardwalks, but beaches that include newly built or re-built boardwalks can provide additional benefit by incorporating a barrier against flooding. Beaches and boardwalks that have sustained the greatest damage in past storms include Coney Island, the Rockaways, and Staten Island's East Shore. The greatest risk to beaches and boardwalks comes from large waves and storm surge that erode the beach and cause boardwalk plank uplift. The guidelines presented here can minimize these risks from future storms.

In addition to their use as recreational destinations, NYC beaches and boardwalks can serve as protective features for areas upland from the shore. A wide, sandy beach acts as a natural buffer for incoming wave action during high tides and major storm events. Erosion and accretion occur naturally along stretches of NYC beaches. In some areas, this reduces the natural buffer between the sea and developed land, while in other areas sand is deposited along the shoreline. This process, called longshore drift, is a result of the incoming waves that wash sand back out to sea to either displace it further down the beach, or remain in the ocean. It is important to monitor the movement of sand along the city's beaches to understand where erosion is occurring at a rate that creates greater flooding risk for upland areas. When a beach erodes to the point where there is a minimal buffer between the ocean and the developed upland area, beach re-nourishment—the placement of new sand to widen the beach—should be considered.

To minimize the amount of naturally eroding sand on the beach, groins, jetties, and sand retaining walls can be constructed to reduce the displacement of sand. Groins and jetties extending from the beach into the ocean should be located in areas that will capture and retain the sand laterally shifting down the beach, though erosion will still occur on the opposite side of the groin or jetty. Sand retaining walls can be built underneath boardwalk structures to prevent sand from traveling further upland due to wind, abnormally powerful wave action, or heavy pedestrian activity on the beach. A sand retaining wall does not need a boardwalk above it, but a boardwalk helps to conceal the retaining structure while providing additional amenities to beachgoers.

Best Practices: Beaches

- Recognize that beaches and sand dunes are complex systems that migrate over time. Analyze the complete coastal reach area before making any modifications to the shoreline.

- Design and construct native-vegetated sand dunes with relevant experts (e.g., landscape architects, ecologists, botanists, engineers, etc.) to help protect the beach against wave action and erosion. Use native vegetation adapted to the coastal environment, as invasive species may also inhibit sand accretion.

- Reinforce critical back dune habitats to help stabilize dune complexes. Where space allows, dunes should be allowed to migrate and back dunes should be protected and preserved. Sand fence erected at the toe of the dune can help preserve the plantings and promote the back dune establishment.

- Foot traffic across dunes should be limited to designated access routes in order to minimize deterioration of the dune.

- Develop a plan for necessary beach nourishment and maintenance of dunes and dune plantings to ensure the best possible performance during and after a storm event.

- Limit structures on beaches to those that provide crucial waterfront uses such as bathrooms and lifeguard stations. If deemed necessary, those structures should be designed for vertical and lateral loads due to floods and storm surge. See Section 4.5 for further guidance.

- Sheet drain toward open waters as much as possible. Avoid drainage structures that can easily clog with sand, such as catch basins and drop inlets, on beaches and adjacent properties. When catch basins are needed, regularly clean catch basins and pitch property toward the street when pitching to the beach is not an option.

- Extending groins perpendicular to the shoreline can minimize impact of sand shifting due to lateral wave action, thus reducing the amount of sand accumulation and loss on the beach.

Best Practices: Boardwalks

- Understand costs and benefits when evaluating appropriateness of new boardwalks; the risk may be too great to justify the cost. On-grade pathways are favored over boardwalks because of their lower capital and maintenance costs. New York State DEC may have additional requirements for on-grade paths near beaches and should be consulted.
- Instead of using traditional tropical hardwoods for boardwalk surfaces, concrete planks set on top of concrete and steel piles create stronger, more resilient boardwalks. For more information see Section 5.4.1.
- Build stairs and ramps below the scour line to account for standard sand fluctuation and erosion of the beach.
- Furniture, playground equipment and railings should use stainless steel, aluminum, or hot dipped galvanized steel. Powder-coated or painted steel will rust in the high salinity environment.
- To allow for increased water drainage in flood prone areas, permeable surfaces should be considered where possible.
- Consider elevating boardwalks. Elevations should be determined during the planning phase. The Rockaway Boardwalk was raised to 3′ higher than the 100-year floodplain ranging from +17 to +21 elevation along the peninsula.

Facing page: New boardwalk at Rockaway Beach, Queens

CASE STUDY:
ROCKAWAY BEACH AND BOARDWALK

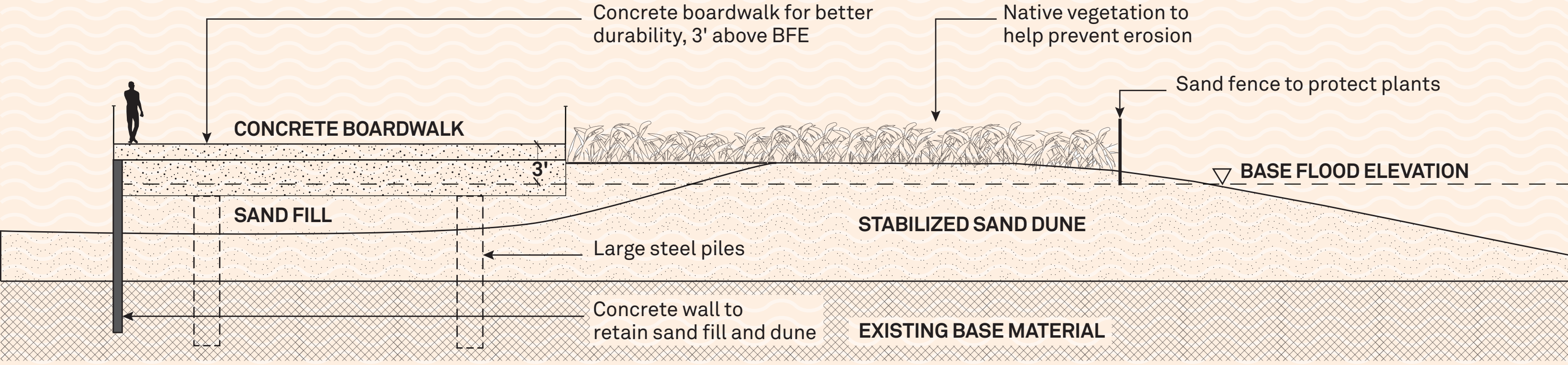
The original boardwalk at Rockaway Beach in Queens was constructed from old-growth domestic woods in the 1930s and reconstructed over the years with tropical hardwoods. Most of its infrastructure had not been redesigned until Hurricane Sandy hit the New York region, fracturing and displacing pieces of the boardwalk into the surrounding neighborhood. Although Hurricane Sandy largely destroyed the old boardwalk, the storm provided NYC Parks an opportunity to rebuild this infrastructure with flood and storm surge resilience in mind. It also provided the opportunity to make targeted enhancements to the beach to further minimize the risks to Rockaway neighborhoods during future storms.

NYC Parks and the New York City Economic Development Corporation (NYC EDC) worked together to design the new boardwalk and incorporate the features listed below. The United States Army Corps of Engineers (USACE) assisted in sand re-nourishment.

Boardwalk: The new boardwalk is elevated approximately three feet above the BFE, equivalent to two to seven feet higher than the old boardwalk. The original wood boardwalk design was replaced with more durable, 30-foot-long concrete planks designed with both durability and aesthetics in mind. Old concrete piles were replaced with new, larger steel pipe piles.

Stabilized dune: A large vegetated sand dune was constructed on the ocean side of the new boardwalk, rising 16 feet above sea level. The native beach grasses planted along the dune enhance the dune's stability, and sand fences erected along its perimeter protect the plants until the beach grasses are well established.

Retaining walls and sand fill: Concrete retaining walls were added beneath the boardwalk on the landside to prevent sand from moving, blowing, and washing through the underside of the boardwalk. Sand fill was placed beneath the boardwalk to augment the sand dune in front.



ROCKAWAY BEACH BOARDWALK SECTION

Damaged boardwalk at Rockaway Beach, Queens

4.3 // WETLANDS AND NATURAL AREAS

Overview

Coastal wetlands and maritime grasslands, shrublands, and forests make up thousands of acres of New York's waterfront parkland. These natural areas provide habitat for fish and wildlife, facilitate biological diversity, and enhance water quality by removing excess nutrient loads, suspended sediments, and pollutants from coastal waterways. They also provide aesthetic value and educational opportunities for all ages while simultaneously serving as places for reflection and reprieve from the city.

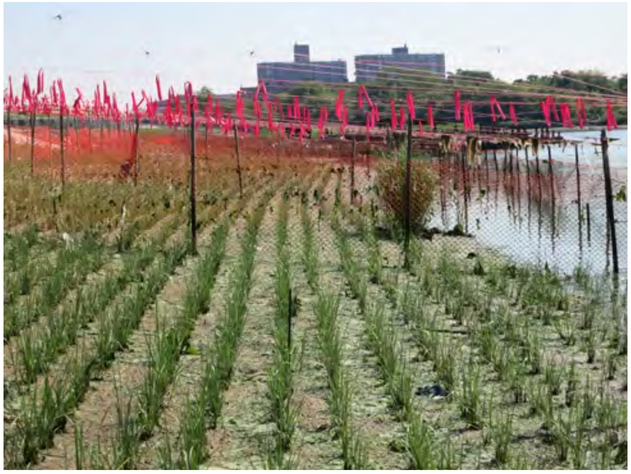
Wetlands and coastal maritime habitats are critical buffers between upland areas and open water. The gradual slope of a natural shoreline and the height and structure of intertidal and coastal vegetation can act as barriers between coastal storms and upland assets by attenuating wave action and capturing debris. Differing natural coastal typologies present varied levels of storm surge protection, erosion control, and ecological biodiversity. Any coastal wetland or marine habitat project should carefully consider ecological objectives and vulnerability to sea level rise. Projects located adjacent to or within these natural systems should minimize negative impacts and disturbance to preexisting features. Strategies can include pre-treatment of storm water runoff or enhancement of off-shore structures for increased habitat value.

Natural shorelines, though generally resilient, are still vulnerable to erosion, both sudden and gradual, particularly in the face of climate change. Shoreline erosion has resulted in a loss of more than 100 acres of salt marsh over the last 30 years. As sea level rise accelerates, the city is at risk of continuing to lose large areas of salt marsh, which converts to mudflat. This risk is heightened along unprotected ocean-facing shorelines by high wave energy, high fetch, and steep slopes. Salt marshes may be able to migrate inland where slopes are sufficiently low and land remains undeveloped. Sites like these should be protected from development whenever possible. New wetlands should be constructed where possible and eroded wetlands should be prioritized for restoration to protect existing coastal resources.

In May 2017 NYC Parks in conjunction with the Natural Areas Conservancy (NAC) released a salt marsh management plan (see Resource 30) to address declining levels of salt marsh due to development, erosion, and sea level rise. The plan recommends measures to protect, restore, and manage salt marsh on NYC parkland. Prior to the aforementioned plan's release, NYC Parks and NAC developed an inventory of coastal wetland restoration opportunities in NYC (see Resource 9), which identifies and prioritizes wetland restoration opportunities on NYC parkland throughout the five boroughs. NYC Parks is also releasing Salt Marsh Restoration Design Guidelines (see Resource 27), which should be referenced for wetland design when made publicly available.

Best Practices: Tidal Wetlands

- Locate wetlands in protected areas of the coastline, or behind a protective barrier.
- Design wetlands to be wide and flat.
- Survey established tidal and salt-tolerant vegetation at a nearby reference site to determine suitable planting elevations.
- Plant low marsh with smooth cord-grass (*Spartina alterniflora*) between the mid-tide and the mean high tide, but closer toward the higher end of this range to account for sea level rise. Plant high marsh with a wider range of native rushes and sedges between the mean high tide and mean higher high tide, which is the average of the higher high tide heights of each tidal day.
- Reference local tide gauge data to determine low and high marsh elevations. Proposed elevations should include an increase above observed tide levels to account for sea level rise.
- Grade slopes to the upland as gradually as possible to reduce risk of erosion and to allow for a transition as sea levels rise and allow absorption of wave energy.
- If exposed to wave action, design the edge of tidal marsh systems with a revetment or erosion-resistant structure or material, as needed, to assure sediment retention and protection from wave energy.
- Consider integrating inter- and sub-tidal habitat structures that can provide surfaces for oyster establishment into protective revetments. These can vary from highly designed and engineered structures to durable recycled materials used as a surface for oyster proliferation.
- Seek opportunities for beneficial re-use of clean dredge material through coordination with the New York State Department of Environmental Conservation (NYS DEC) and USACE.



Wetland planting at Calvert Vaux Park, Brooklyn

Goose Creek Marsh at Pelham Bay Park, Bronx

Best Practices: Coastal Adjacent Areas

- Grade adjacent upland slopes 3:1 or shallower. Where steeper grades are unavoidable or susceptible to erosion from runoff, increase soil cohesion by including fine, inorganic material in the soil, and select plant forms and seed mixes aimed at providing rapid plant cover.
- Plant a dense native scrub-shrub buffer with woody salt tolerant species to transition between coastal wetlands and upland areas to help protect upland sites from high waves.
- Control invasive plant species and restore native coastal woody species following NYC Parks' "Guidelines for Urban Forest Restoration" (see Resource 13).
- Select erosion control and other materials appropriate for the site's hydraulic and energy conditions. Biodegradable materials are suitable where vegetation can be expected to rapidly establish a dense root network.
- Design swales and channels for drainage using nature-based elements to reduce site erosion.
- Consider the removal, replacement, or elevation of assets or infrastructure that may prevent wetland migration.
- Identify and consult with non-city parcel owners adjacent to wetlands to inform best natural resource management practices or investigate for potential acquisition.

Best Practices: Trails

- Trails within the intertidal marsh, across natural stream channels, or on active shorelines should not contribute to compaction, adjacent erosion, sedimentation, storm water runoff, or habitat degradation.
- Trails should be designated as informal with erosion-resistant materials (i.e., stepping stones across active stream channels). In wetlands, if site conditions and budgets allow, consider constructing elevated boardwalks.

CASE STUDY: GERRITSEN CREEK ECOSYSTEM RESTORATION AT MARINE PARK

Marine Park, located along Jamaica Bay, is Brooklyn's largest park, containing 530 acres of grassland and salt marsh, which are protected as a Forever Wild preserve. A large portion of Marine Park was created on landfill containing construction rubble, debris, and waste from the 1940s. Before it was a landfill, the area contained hundreds of acres of salt marsh and open water. From 2009 through 2011, NYC Parks worked to restore wetland and grassland habitat along Gerritsen Creek, a waterway running through Marine Park.

The Gerritsen Creek project involved reconstructing a salt marsh ecosystem by excavating fill placed on the historic wetland, and converting adjacent invasive plant-dominated landfill to a native coastal grassland. To maximize salt marsh area with the available project budget, the shallowest landfill areas, which were adjacent to the east side of the creek, were excavated to a depth that allowed for tidal inundation to restore salt marsh. The lowest elevations became low salt marsh, which transitioned into high salt marsh added near the upland edge. The excavated fill was added to the nearby upland area, which was capped with clean sand and soil to create grassland. The completed project resulted in 20 acres of restored salt marsh, 23 acres of restored grassland, and half an acre of restored upland transitional slope area.

The restored ecosystem now serves as a line of defense against storm surge while providing aesthetic respite for park visitors and habitat for waterfowl and grassland birds, fish, and other wildlife.

Salt marsh restoration at Gerritsen Creek in Marine Park, Brooklyn

COASTAL PLANT COMMUNITIES

In the New York City area the coastal maritime plant communities are represented in the following habitats:

1. Maritime beach: This sparse plant community is dominated by only a few salt grasses and herbaceous species, causing sand to be relatively unstable and subject to erosion within the intertidal zone.

2. Maritime dune: A hill or ridge of sand formed by waves or wind, often stabilized by vegetation. The frontal system is subject to ephemeral erosion and complete destruction during large storm events, protecting the back dune system.

3. Maritime grassland: The maritime grassland community is characterized by low-lying areas near the coast that are subject to wind and occasional salt spray. It is formed on sandy or gravelly deposits with less than 25 percent canopy cover and influenced by maritime climate.

4. Maritime shrubland: This community is subject to salt spray and offshore winds, dominated by patches of dense shrubs and open areas of low growth or bare ground.

5. Maritime forest: A maritime forest will naturally succeed a maritime shrubland if left undisturbed. A minimal amount of herbaceous material at ground level will be able to survive. Maritime forests consist of narrow bands of defined canopy on sand or peat, subject to and resistant to storm salt spray, high winds, and estuarine waters.

6. Low salt marsh: This community is found along shores in bays or inlets protected from high-wave energy action, ranging from mean sea level up to mean high tide in saline water. In NYC low marsh is dominated by one plant: *Spartina alterniflora.*

7. High salt marsh: This community is found slightly inland from low marsh, ranging from mean high tide up to the limit of spring tides and storm surges tolerating saline and brackish waters.

Native plant species found within each of these plant communities can also be effectively used outside the floodplain as species that will tolerate harsh conditions such as salt, drought, high winds, or low nutrients.

1. Maritime beach, South Beach, Staten Island
2. Maritime dune, Rockaway Beach, Queens
3. Maritime grassland, Marine Park, Brooklyn
4. Maritime shrubland, Oakwood Beach, Staten Island
5. Maritime forest, Conference House Park, Staten Island
6. Low salt marsh, Pugsley Creek Park, The Bronx
7. High salt marsh, Arlington Marsh, Staten Island.

4.4 // PLAYGROUNDS AND OUTDOOR FITNESS AREAS

Overview

NYC Parks is dedicated to providing playgrounds and outdoor fitness areas to promote active recreation for children and adults. These facilities can either be stand-alone sites or be part of a larger park, and traditionally include steel equipment and water features such as spray showers and drinking fountains. Because playgrounds serve as important fitness and educational environments for children and provide social opportunities for families, it is important to balance the needs of the neighborhood with the risks that these site types face when located in a floodplain.

Proposed view of Brigham Playground, Brooklyn / Credit: Hargreaves Associates

Best Practices

- Locate playgrounds and outdoor fitness areas outside the floodplain where possible.
- Consider playground designs that rely less on standard play equipment structures and more on landforms, plantings, and resilient materials that are easy to maintain.
- Consider using loose parts for free play as described in the “High Performance Landscape Guidelines” (see page 42 of Resource 14). Plan for skilled playground supervision, storage, and maintenance of the play pieces.
- Increase subsurface drainage around the site.
- Do not install sandboxes in the floodplain. Sand as safety surfacing should be used only in sites directly on the beach, as those sites do not require drainage.
- Consider lowering fence heights or using less fencing around play and fitness facilities to minimize the repair or replacement costs if damaged by a storm.
- Provide shade around playgrounds and outdoor gyms. The selection of trees should be carefully considered given the potential for damage to these facilities from trees and branches falling during storms. Trees used for shade should be wind tolerant, adapted to dry and flood conditions, salt tolerant, and elevated wherever possible. Provide a generous root zone to increase root stability and reduce the chance of the tree falling in a storm. See Section 5.1 for a list of floodplain appropriate shade trees.
- Select materials with light colors to help keep the playground cooler.

CASE STUDIES: **PLAYGROUNDS**

NYC Parks is renovating several playgrounds as a result of damage from Hurricane Sandy. A number of the resilient elements found at Conch Playground, Queens, Sandpiper Playground, Queens, and Asser Levy Park Playground, Brooklyn are highlighted below.

- NYC Parks-approved materials that are easy to maintain
- Saltwater-resistant furniture made of recycled plastic lumber slats and galvanized ductile steel stanchions
- Native coastal plants that have a proven resistance to drought and saltwater inundation
- Play equipment decks with recycled plastic lumber slats, slides and small roofs with colored polyethylene, galvanized steel supports, and aluminum posts where feasible
- Galvanized steel trough-style and stainless steel drinking fountains
- Anodized aluminum shade structures
- Durable precast concrete seating and spray shower features
- Steel panel fencing coated with marine-grade paint
- Reduced Pressure Zone (RPZ) device located higher than the BFE by raising grades
- Raised playground grades closer to BFE without compromising accessibility by raising grades

Clockwise from top: Proposed view of Conch Playground, Queens; proposed site section for Asser Levy Park Playground, Brooklyn; proposed view of Sandpiper Playground, Queens.

4.5 // RECREATION CENTERS AND OTHER BUILDINGS

Overview

NYC Parks' buildings in the floodplain range from large, complex facilities such as the Red Hook Recreation Center, which was damaged by high floodwaters during Hurricane Sandy, to less complex but still vulnerable comfort stations, lifeguard stations, and field houses. This category also includes historic structures for which there are special considerations. These buildings, like all buildings in the floodplain, contain utilities that can be vulnerable to flood damage if low-lying and not flood-proofed. There are multiple ways of increasing resiliency of buildings; new requirements from the NYC Department of Buildings (NYC DOB) and NYC Department of City Planning (NYC DCP) provide details, as do recently released guidelines from the NYC Mayor's Office of Recovery and Resiliency (NYC ORR).

Best Practices

Refer to the following documents when planning and designing a building in the floodplain:

- "Rebuilding NYC After Hurricane Sandy: A Guide to New Code and Zoning Standards for Professionals," NYC DOB (February 2015) [see Resource 24]
- "Retrofitting Buildings for Flood Risk," NYC DCP (October 2014) [see Resource 25]
- "Designing for Flood Risk," NYC DCP (June 2013) [see Resource 10]
- "Climate Resiliency Design Guidelines" NYC ORR (April 2017) [see Resource 6]

Elevated Comfort Station at Coney Island, Brooklyn

4.6 // ATHLETIC FIELDS, COURTS, AND OTHER OUTDOOR RECREATION FACILITIES

Overview

Active recreation amenities such as athletic fields and courts are prevalent in waterfront parks. Natural turf and synthetic turf fields are subject to different forms of flood damage and should be considered separately (see Sections 5.5.1 and 5.5.2). Hard surface courts in the floodplain undergo increased wear and tear but are unlikely to see catastrophic damage.

Some outdoor athletic facilities involve significant capital investments. Because some equipment or material such as synthetic turf for fields may require total replacement, even if there is only partial damage, the choice of material and construction should be evaluated closely against the risk of capital loss.

Best Practices

- New synthetic turf or track surfacing is generally not recommended within or near the 100-year Zone VE, especially in areas adjacent to open ocean that are most vulnerable to high velocity wave action and storm surge. However, in-kind replacement for synthetic turf fields already located in the flood zone should be considered on a case-by-case basis.
- Athletic fields using natural turf can be installed in the floodplain if no electrical amenities such as lighting or a scoreboard are required.
- Consider lowering fence heights or using less fencing around courts and other athletic facilities to minimize the repair or replacement costs if damaged from a storm.
- Refer to Chapter 5: Guidelines for Materials and Components for additional recommendations on synthetic turf, track surfacing, and other typical materials and components found in athletic areas.

Athletic field at Bushwick Inlet Park, Brooklyn

4.7 // MARINAS, FLOATING DOCKS, AND PIERS

Overview

Across the five boroughs, the shoreline properties of NYC Parks are home to 13 marinas, more than 40 boat launches, and numerous other docks, piers, and waterfront facilities. All of them are within the floodplain.

In addition to providing vessel dockage, water access and amenities to all types of boaters, marinas, and waterfront structures can, under the right circumstances, actually help mitigate the impact of floods and severe storms by incorporating breakwaters, wave attenuators, and other such elements into their design.

The resilience of marinas and waterfront structures depends as much on the characteristics of the body of water they are built on as it does proper design and construction. For example, sites facing the open ocean may be subject to strong waves, which can threaten the structural stability of docks and piers. Alternatively, marinas and docks located in more protected coves and bays may be subject to damage by heavy ice in the winter and accumulation of floating debris after storms.

Thus, it is important that marinas and piers be properly sited, well-constructed, and maintained to high standards. Not only will these considerations minimize the damage these sites suffer during floods and severe weather, but they may also help reduce potential hazards to the upland communities adjacent to these sites.

Steeplechase Fishing Pier at Coney Island Beach, Brooklyn

Best Practices

- Conduct a comprehensive water-dependent use assessment of the site. Analysis of environmental conditions such as currents, water depth, exposure to wakes, fetch, storm conditions, and boat traffic should determine the appropriateness and feasibility of design components for a particular site.
- Take into consideration winter ice conditions when siting. Freshwater and brackish bodies of water freeze more often than salt water. If possible, incorporate ice breakers or breakwaters at sites that are leeward of the dominant wind direction to block drifting ice. Note that federal bulkhead lines, which restrict seaward development of land, may make offshore breakwaters infeasible.
- Consider proximity to combined sewer overflows (CSOs), water depth, and upland access when siting.
- Design piers so that they are able to withstand submergence, uplift, and lateral wave forces.
- Use the strongest and most durable pilings possible including concrete or concrete-encased pilings. Steel pilings should be coated or employ cathodic protection to resist corrosion. Avoid wood pilings, which weaken over time and are highly susceptible to damage.
- Use larger than standard structural elements such as pilings, pile caps, cross member bracings, and stringers to mitigate against pile section loss over time due to corrosion and impact damage.
- For pier decking material, refer to Boardwalk and Decking in Section 5.4.1.
- Use taller pilings when designing floating docks to prevent them from floating free of the piles as floodwaters rise.
- Design and install gangways and ramps that can be manually raised up off, or lowered down onto, the floating dock in advance of a storm surge or heavy wave action.
- Install wave screens for wave attenuation.
- See Resources 5 and 28 for further information on planning and design for marinas.

CASE STUDY:
79TH STREET BOAT BASIN

The 79th Street Boat Basin was constructed in 1937 as the "Recreational Boating Gateway to New York City." The 370-foot-long fixed dock and all associated support structures were built from timber. In 2012 during Hurricane Sandy, large sections of the decking separated from the pier substructure and collapsed on top of the pilings when storm waters receded.

Reconstructed 79th Street Boat Basin A-Dock

The pier was demolished and reconstructed in 2016. All pilings were replaced with concrete-filled steel pilings. Wooden piling caps and stringers were replaced with concrete and fiberglass respectively. The replacement of wooden pilings by concrete-filled steel support pilings resulted in a 40 percent decrease in total piling count from the original pier construction. The pier reconstruction project also incorporated an anchoring system to prevent uplift of decking planks and additional batter piles to resist the lateral movement of the pier. NYC Parks also installed a continuous vertical wave screen along the northern and eastern faces of the pier. Finally, the entire deck was replaced along with new curbs, railings, access gates, lights, and vessel power and water pedestals.

The pier was designed to concurrently support a range of boating and non-boating activities alike. Removable bollards and safety chains along the westernmost section enable the pier to remain open for unobstructed vessel access or closed for classrooms and other public events. Self-closing gates lead from the fixed pier down to low-freeboard floating docks that support power, sail, and human-powered vessel dockage as well as environmentally beneficial oyster cages.

5

Guidelines for Materials and Components

Guidelines for Materials and Components

This section outlines recommendations for materials and components used in an array of park types in the floodplain.

Before determining and designing uses for a specific site, it is important to consider the conditions of surrounding facilities and landscapes. This practice will help to better understand if and how resiliency measures are incorporated nearby, and which resiliency measures on site might best benefit surrounding and upland assets. After analyzing the site and surrounding areas at a broader scale, this section can be employed to help determine which uses and materials might be best suited for a particular park project in the floodplain.

As a general rule of thumb, expensive and/or intricate equipment might be vulnerable to damage and loss in low lying areas susceptible to flooding. Consequentially, depending on the site, it is often beneficial to install certain assets, such as synthetic turf sports fields or traditional playgrounds with complex spray showers, further upland. In areas where open space is limited, relocation of assets to upland sites can prove difficult. These situations become opportunities for unique design solutions that employ resilient materials or creative incorporation of recreational resources, as discussed throughout this chapter. Playgrounds, for example, might shift away from traditionally structured play areas, and may instead feature sturdily constructed landforms or natural areas for free play or environmental education.

NYC Parks has a robust portfolio of time-tested standard details for park elements, and well researched and tested material specifications. Generally, these standard materials and structural details are inherently resilient for day-to-day use in most locations. However, floodplain locations provide the unique challenges of exposure to higher volumes of water and salinity. Various materials that are sufficiently durable and easily maintained on upland sites become impractical in the floodplain. Powder-coated steel, for example, is ideal for use in upland parks, but is highly vulnerable to rusting in salty environments. NYC Parks continues to test various materials, designs, and details for resiliency. As such, the information presented in this chapter will continue to evolve as new learned best practices are discovered.

Baretto Point Park, Bronx

5.1 // **PLANTINGS**

Plants play an integral role in preventing damage in the floodplain, and in many situations, appropriate planting can provide significant and cost-effective protection. This is especially true for projects that increase planted surface onsite, thereby buffering wave action and minimizing erosion.

Selecting site-appropriate plants is crucial to project success. Planted species should be tolerant of salt, sediments, high seasonal water flow, and, in areas with sandy soil, drought. Fortunately, the robust palette of citywide coastal plant communities have evolved to thrive under the harsh conditions of New York City's waterfront and flood prone areas.

Planting trees for shade is also becoming an increasingly important practice in the face of climate change. Not only does shade provide comfort and sun protection to park users, it also keeps paved surfaces cool and minimizes urban heat island effect. While maximizing shade is important, designers should look beyond traditional shade trees and instead consider native trees that will survive well in high wind and salt environments. These native species will likely have a more natural and windswept form.

NYC Parks' capital project timelines and funding typically cannot accommodate contracted growing of plant material. However, contract grown native species may be a viable option for projects with long timelines and flexible funding. In either case, NYC Local Law 11 (see page 100) requires the use of locally sourced native plants in all naturally occurring ecosystems. NYC Parks' Greenbelt Native Plant Center is focused entirely on the production of species native to New York City and maintains a seed bank of over 2,000 accessions of wild seed from the City's native ecosystems. By coordinating project planning, development, and implementation with the Greenbelt Native Plant Center, virtually any native species can be made available, from locally-sourced stock to plants precisely tailored to site conditions. See page 101 for a selected list of species appropriate for projects in the floodplain.

Greatest Threats from Coastal Storms and Flooding

- Toppling of trees and broken limbs during storms and strong winds can shorten the lifespan of trees and surrounding park features.
- Salt spray and flood water inundation can damage plants and shorten plant life span.
- Sandy soil conditions can cause plants to dry out.
- Soil saturation alters soil structure and reduces the availability of oxygen to plants. When soil is continuously saturated, even healthy and structurally sound trees are more likely to become uprooted.
- Erosive forces can uproot, dislodge, or damage plants before they have time to develop a strong root layer that anchors the soil.
- Sediment deposition from storms can smother plants and create disturbance conditions that favor exotic invasive plants.

Recommendations

- Select locally sourced coastal native plant species that are adapted to periodic saltwater intrusion, flooding, and disturbance.
- Plant to promote biodiversity in all naturally occurring ecosystems. When possible use true species grown from wild collected seed, which are more resilient than horticultural varieties.
- Plant dunes with grasses, shrubs, and trees to help prevent oceanfront drying effects of plantings further inland.
- Test in-situ soil conditions and carefully specify imported soils to assure best conditions for native plants. Many native coastal plants are adapted to low-nutrient sandy soils and can best compete with undesirable exotic invasive plants under these conditions.
- For existing planting areas that may be prone to tidal flooding and future sea level rise flooding, consider raising plant beds in key areas to ensure plants will survive flooding and continue to provide shade. This will likely be challenging where mature trees and plantings exist given their sensitivity to transplanting.
- Plant new trees within raised topography to prevent future inundation by tidal flooding and future sea level rise.

Wetland plantings in Pugsley Creek Park, Bronx

LOCAL LAW 11 AND RESILIENCY

In 2013 City Council passed Local Law 11 to increase native biodiversity in public landscapes. Increased biodiversity positively affects the health and sustainability of natural systems.

The Council acknowledged that it was in the best interest of the City to require greater native biodiversity, specifically through the use of native plantings, the use of salt tolerant plantings and the use of locally sourced native plant materials (local genotypes) in the public landscape. This requirement further facilitates the inclusion and increased focused on the planting of resilient coastal plant communities in floodplains.

Typical Native Plants for Ecologically Sensitive Design by Site Type

Below are examples of typical species to be considered in designs for park infrastructure in coastal environments. These lists are not exhaustive, and selection should always consider the position of the plant relevant to the tide (inundation frequency), the degree of salt tolerance of the plant, the plant growth and rooting form and best planting options (seed versus container), among other considerations. The NYC Parks Native Species Planting Guide (see Resource 17) should also be consulted when picking plant species for different site types.

Grasses:

- *Ammophila breviligulata* (American beachgrass)
  Salt Tolerant
- *Bolboschoenus robustus* (sturdy bulrush)
  High Salt Tolerance
- *Calamagrostis canadensis* (bluejoint)
  Low Salt Tolerance
- *Carex silicea* (beach sedge)
  Salt Tolerant
- *Cyperus grayi* (Gray's flatsedge)
  Salt Tolerant
- *Distichlis spicata* (saltgrass)
  High Salt Tolerance
- *Eragrostis spectabilis* (purple lovegrass)
  Intolerant of Salt
- *Hierochloe odorata* (sweetgrass)
  Low Salt Tolerance
- *Juncus gerardii* (saltmeadow rush)
  High Salt Tolerance
- *Panicum amarum* (bitter panicgrass)
  Salt Tolerant
- *Panicum virgatum* (switchgrass)
  Moderate Salt Tolerance
- *Schizachyrium littorale* (shore little bluestem)
  Moderate Salt Tolerance
- *Spartina alterniflora* (smooth cordgrass)
  High Salt Tolerance
- *Spartina cynosuroides* (big cordgrass)
  High Salt Tolerance
- *Spartina patens* (saltmeadow cordgrass)
  High Salt Tolerance
- *Spartina pectinata* (prairie cordgrass)
  Low Salt Tolerance
- *Spartina X caespitosa* (cordgrass)
  Salt Tolerant

KEY

Waterfront Esplanades and Greenways

Beaches and Boardwalks: Dune

Beaches and Boardwalks: Back Dune

Tidal Wetlands: Low Marsh

Tidal Wetlands: High Marsh

Playgrounds and Outdoor Fitness Shade

Herbaceous

- *Asclepias syriaca* (common milkweed)
  Intolerant of Salt
- *Cakile edentula* (American searocket)
  Salt Tolerant
- *Cenchrus tribuloides* (sanddune sandbur)
  Moderate Salt Tolerance
- *Hibiscus moscheutos* (rose mallow)
  Low Salt Tolerance
- *Lathyrus japonicus* (beach pea)
  High Salt Tolerance
- *Lechea maritima* (beach pinweed)
  Salt Tolerant
- *Oenothera biennis* (common evening primrose)
  Intolerant of Salt
- *Pluchea odorata* (sweetscent camphorweed)
  High Salt Tolerance
- *Polygonella articulata* (coastal jointweed)
  Undetermined
- *Solidago sempervirens* (seaside goldenrod)
  High Salt Tolerance
- *Teucrium canadense* (Canada germander)
  Moderate Salt Tolerance
- *Tradescantia virginiana* (Virginia spiderwort)
  Intolerant of Salt
- *Xanthium strumarium* (common cocklebur)
  Undetermined

From top: Ammophila breviligulata *(American beachgrass),* Solidago sempervirens *(seaside goldenrod)*

KEY

Waterfront Esplanades and Greenways

Beaches and Boardwalks: Dune

Beaches and Boardwalks: Back Dune

Tidal Wetlands: Low Marsh

Tidal Wetlands: High Marsh

Playgrounds and Outdoor Fitness Shade

Vines

- *Parthenocissus quinquefolia* (Virginia creeper)
  Moderate Salt Tolerance

- *Strophostyles helvola* (amberique-bean)
  Undetermined

Shrubs

- *Baccharis halmifolia* (Eastern baccharis)
  Salt Tolerant

- *Hudsonia tomentosa* (woolly beachheather)
  Salt Tolerant

- *Iva fructescens* (Jesuit's bark)
  High Salt Tolerance

- *Morella pensylvanica* (northern bayberry)
  Salt Tolerant

- *Prunus maritima* (beach plum)
  Salt Tolerant

- *Rhus copallinum* (winged sumac)
  Salt Tolerant

- *Rosa Carolina* (Carolina rose)
  Intolerant of Salt

- *Rosa virginiana* (Virginia rose)
  Salt Tolerant

Trees

- *Celtis occidentalis* (common hackberry)
  Salt Tolerant

- *Juniperus virginiana* (eastern redcedar)
  Moderate Salt Tolerance

- *Nyssa sylvatica* (blackgum)
  Salt Tolerant

- *Pinus rigida* (pitch pine)
  Salt Tolerant

- *Populus deltoids* (eastern cottonwood)
  Low Salt Tolerance

- *Prunus serotine* (black cherry)
  Moderate Salt Tolerance

From top: Morella pensylvanica *(northern bayberry)*, Juniperus virginiana *(eastern redcedar).*

- *Quercus bicolor* (swamp white oak)
  Intolerant of Salt

- *Quercus coccinea* (scarlet oak)
  Intolerant of Salt

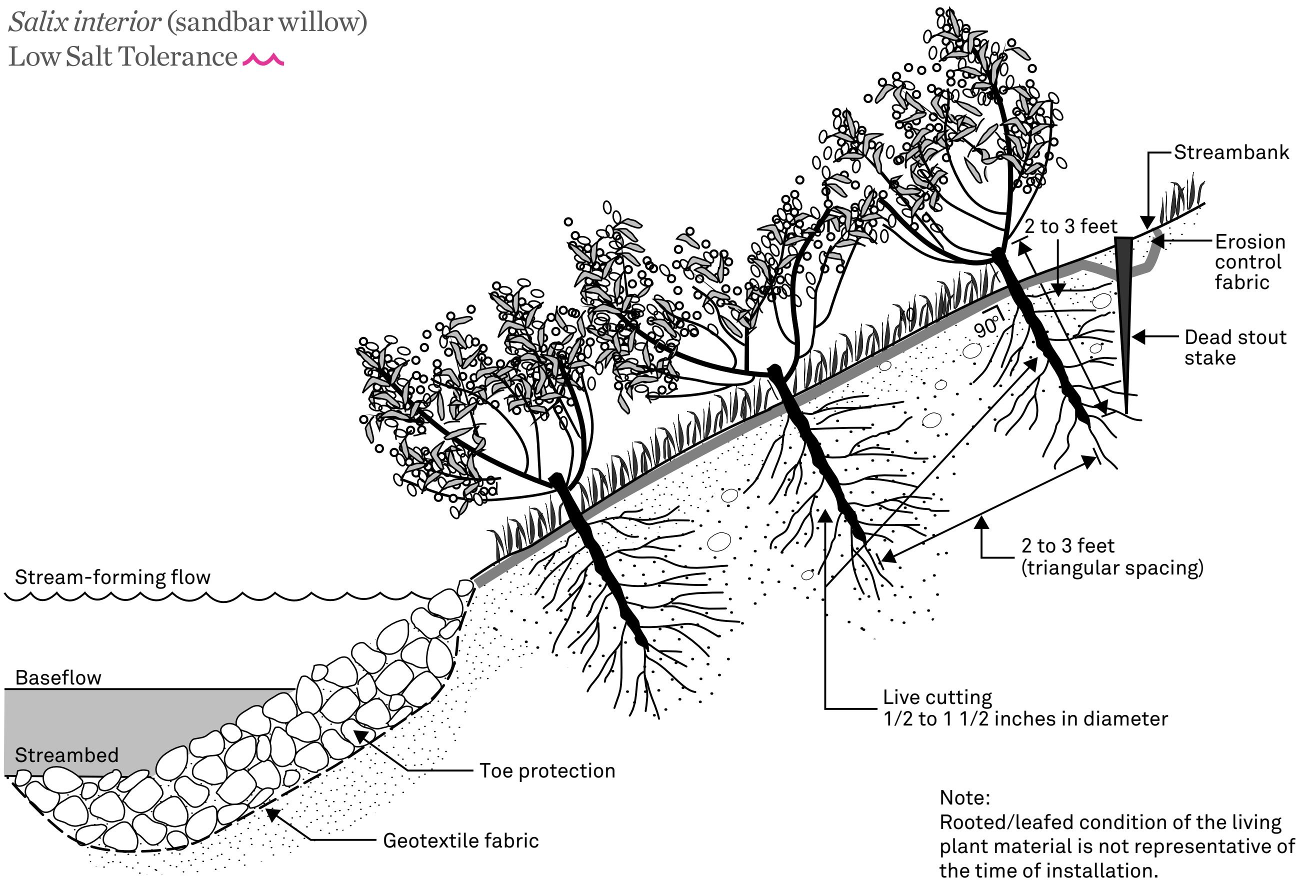
- *Quercus palustris* (pin oak)
  Salt Tolerant

- *Quercus rubra* (northern red oak)
  Salt Tolerant

- *Quercus velutina* (black oak)
  Salt Tolerant

Live stakes

- *Cephalanthus occidentalis* (common buttonbush)
  Low Salt Tolerance
- *Populus deltoides* (eastern cottonwood)
  Low Salt Tolerance
- *Salix discolor* (American pussy willow)
  Low Salt Tolerance
- *Salix eriocephala* (Missouri river willow)
  Intolerant of Salt
- *Salix interior* (sandbar willow)
  Low Salt Tolerance
- *Salix nigra* (black willow)
  Intolerant of Salt
- *Salix sericea* (silky willow)
  Low Salt Tolerance
- *Sambucus nigra* (black elderberry)
  Intolerant of Salt
- *Viburnum dentatum* (southern arrowwood)
  Intolerant of Salt



CROSS SECTION OF LIVE STAKES AS BANK STABILIZATION

KEY

Waterfront Esplanades and Greenways

Beaches and Boardwalks: Dune

Beaches and Boardwalks: Back Dune

Tidal Wetlands: Low Marsh

Tidal Wetlands: High Marsh

Playgrounds and Outdoor Fitness Shade

5.2 // **COASTAL EDGES**

Sand Dunes and Biotechnical Erosion Control

Sand dunes are complex natural systems that can protect park property, upland communities, and infrastructure. Sand dunes naturally migrate over time and can be severely eroded during major storm events, thereby reducing their ability to serve as coastal protection. However, biotechnical erosion control, which is comprised of plants and plant materials (or brush) can help prevent erosion of soft shorelines and serve as an extra line of defense alongside hard edges. With thoughtful design and proper care, sand dunes can be an aesthetically pleasing natural way to protect our city.

Greatest Threats from Coastal Storms and Flooding

- Erosion of dunes by strong winds, high tides, and flood events, reducing their protective capacity. Dunes without planting or other erosion control features, e.g., jute mesh and sand fencing, are more susceptible to erosion.
- Migration of sand upland if dunes are breached by storm surge, causing damage and requiring major cleanup efforts to upland sites.
- Erosion of soil and vegetation by strong waves and upland runoff. Prolonged inundation in brackish or contaminated water can harm plants.

Best Practices to Alleviate Threats

- Dunes should be re-nourished periodically as they are shifted by wind and water.
- Where boardwalks are present, dune edges should be flush with boardwalks to prevent sand scouring beneath boardwalk.
- Use site-appropriate plantings (see Section 5.1 for planting resources).
- Use alternative forms of erosion control, such as fencing or erosion fabric, while plants are establishing.
- In beach areas with residential or commercial infrastructure near the shore, a stone-core sand-capped dune may provide longer term shoreline stability. While the sand-cap may erode over time if plantings are not sufficiently established, the stone-core will remain in place to provide shoreline stability.

Dune planting at Conference House Park, Staten Island

Riprap and Gabions

Riprap and gabions can serve as viable alternatives to seawalls if space is not constrained. They fare well in the floodplain if properly sited and constructed. As with most shoreline treatments, riprap and gabions can serve as a first line of defense against coastal erosion and should be kept in good repair. Riprap can play an important role in wave attenuation when properly used. A dedicated program of regular inspection is key to their continued functionality. Riprap and gabions are not recommended for replacing a softer shoreline due to loss of habitat.

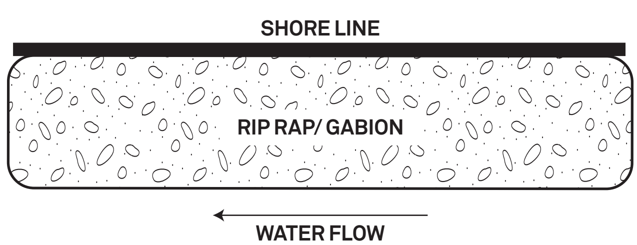
Greatest Threats from Coastal Storms and Flooding

- Overtopping by floodwaters.
- Destabilization by strong waves.
- Scouring of underlying materials (beneath the bottom edge of the riprap) can occur over time, especially in tidal areas, causing destabilization.
- For gabions, breakage of the mesh wire basket, causing the stones inside to be washed away.

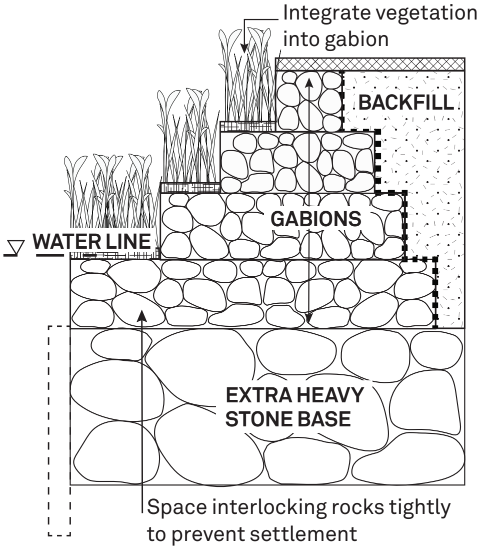
Best Practices to Alleviate Threats

- Use riprap and gabions where water flow is parallel to the shoreline, such as a river bank. For example, during Hurricane Sandy, gabions fared well along Harlem River and East River, where wave action was limited. Gabions failed on a site along the Belt Parkway, where wave action was strong and perpendicular to the gabions.
- Rocks should be sized to withstand the shear stress they will experience at the site so they will not be frequently mobilized.
- Rocks should be carefully and tightly spaced so that they interlock and cannot shift along a riprap slope or settle within gabion baskets.
- Key the toe of a riprap slope into a secure foundation.
- Plans for and installation of revetment should carefully consider and try to alleviate down-current erosional effects and general habitat disruption.
- Integrate vegetation in riprap and gabions to provide coastal habitat when possible. Native live stakes, cuttings, or seeding can be used, with careful and detailed specifications, and careful construction oversight.

PLAN: RIRAP/GABION



SECTION: GABION



SECTION: RIPRAP

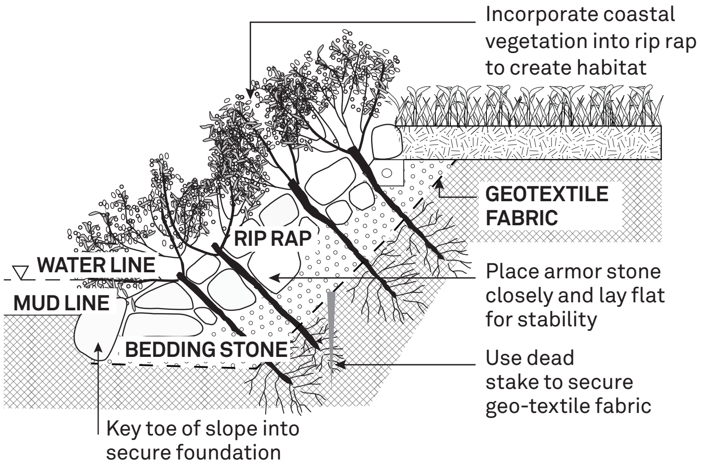


Photo: Riprap shoreline at Harlem River Park, Manhattan

CASE STUDY:
HARLEM RIVER PARK

In 2010, NYC Parks, the Waterfront Alliance, and the Harlem River Park Task Force collaborated on a project to replace a segment of degraded steel sheet pile wall along the Harlem River. The wall was substituted with an edge condition that employs greater ecological value and facilitates public access to the water for recreational use. The resulting design incorporates gabions, riprap revetment, plantings, and steps for waterfront access. Various resilient design elements of Harlem River Park survived Hurricane Sandy.

These resilient features include:

Stainless steel gabion baskets with stone (4" to 8" diameter in size): The gabion edge protection at Harlem River Park was able to absorb wave energy and minimize wave reflection. The gabion was particularly durable because it sits on a very stable tremie concrete and boulder foundation that is about 10 feet deep. The gabion also has a back-up mesh wall 15" from the front edge in case the front edge becomes compromised.

Riprap with Granite Steps: Riprap withstood the storm surge and wave energy without any displacement or disturbance to the structure along Harlem River's edge. The armor-stones were appropriately sized and were placed by fitting the stones tightly together, like pieces of a puzzle, on a bed of 1½" diameter gravel.

From top: Gabion baskets in Harlem River Park, Manhattan; riprap with granite steps in Harlem River Park, Manhattan

Seawalls

Seawalls make up a significant portion of the shoreline. The success of seawalls in major flood events has varied widely, contingent upon the location, condition, and the angle at which the floodwall was hit by waves. Seawalls generally fare well if properly designed and in good condition.

Greatest Threats from Coastal Storms and Flooding

- Exacerbation of cracked and aging seawalls compromising structural integrity.
- Damage to the seawall caused by receding storm surge and upland flooding.
- Damage to sea rails along the top of seawalls.

Best Practices to Alleviate Threats

- Seawalls should be used as edge protection only where space is very limited.
- Conduct a life cycle analysis to determine when to repair or reconstruct the seawall.
- Design seawalls for full hydrostatic load, plus surcharge.
- Where possible, design waterfront sites to sheet drain directly to open water without the use of a drainage system.
- If curbs or parapets are installed at site edges to address sea level rise or flooding, design drainage structures to prevent water from collecting behind the elevated edge.
- Plans for and installation of seawalls should carefully consider and try to alleviate down-current erosional effects and general habitat disruption.

Seawall at Beach 108th Street, Rockaway, Queens

5.3 // EDGING AND CURBS

Edging and curbs are essential in preserving the structural integrity of pavement in the floodplain. In many instances where pavement fails, it is due to a failure in edging that is weak, not well attached, or missing entirely. Concrete curbs are the recommended form of edge protection, but even they can be susceptible to wave damage if not designed appropriately.

Greatest Threats from Coastal Storms and Flooding

Concrete curb:

- Strong wave action, uplift, and scouring.
- Shallow curbs and curbs adjacent to damaged pavement are at a greater risk.

Steel edging:

- Detachment of steel from pavement and subsequent undermining of pavement base due to wave action.
- Corrosion due to prolonged periods of saltwater inundation.

Timber edging:

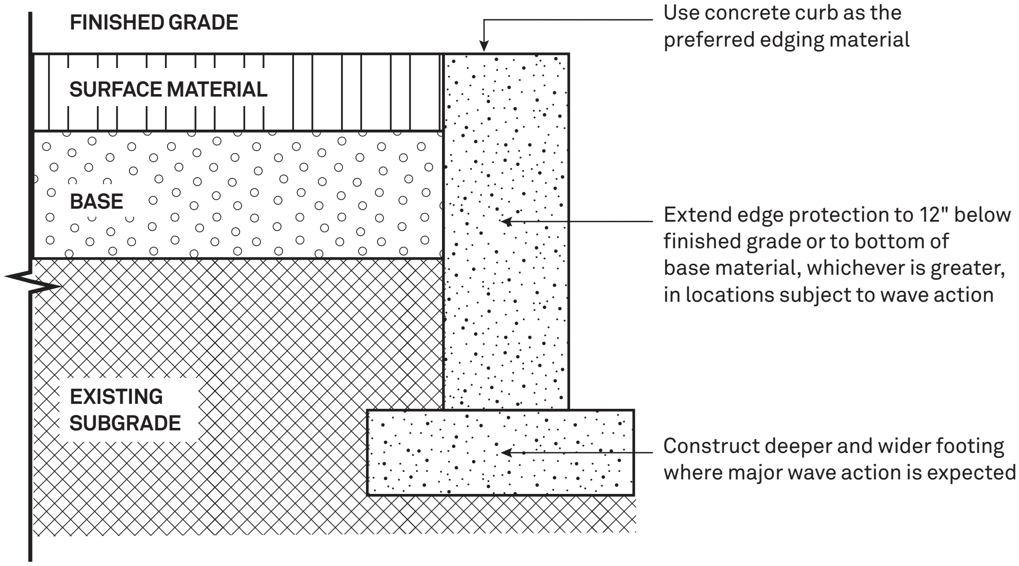
- Warping, damage, and subsequent undermining of pavement base due to prolonged inundation.
- Detachment and floating away.

Other materials:

- Aluminum and high density polyethylene are structurally weaker compared with concrete and steel, and face threats similar to the edging types listed above.

Best Practices to Alleviate Threats

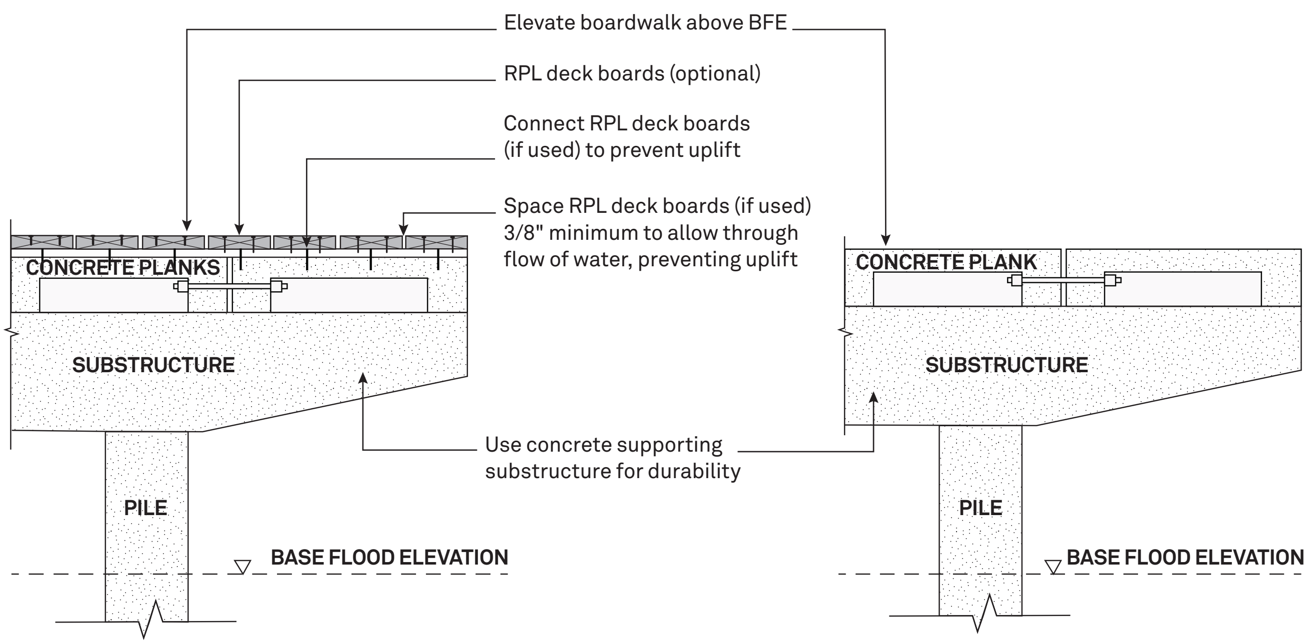
- Use concrete curbs as edge protection where possible. Concrete is the most costly material of all edging options, so project budget should be taken into account when selecting this material.
- In locations subject to wave action (Zone VE, Coastal Zone A), edge protection should be installed to a depth of 12 inches minimum or to the bottom of the base material, whichever is greater, to prevent erosion of base material. Some site-specific conditions may require an even deeper edge protection with a wider footing to prevent toppling.
- Limit use of steel edging. It can be used conditionally where installing concrete curbs is cost-prohibitive. Its use should be limited to higher elevations where wave action and prolonged inundation are less likely.
- Do not use timber, aluminum, or high density polyethylene edging in the floodplain; the risk of failure is too great.



DETAIL: EDGING/CURB IN THE FLOODPLAIN

Boardwalks and Decking

Boardwalks in parks range from the large waterfront variety that can carry vehicles, to small elevated trails for pedestrian-only use through woodlands and wetlands. Boardwalks have different structural requirements depending on size, use, and location. When located in the floodplain, boardwalks require additional structural measures to account for flood and storm related factors. Design and construction detailing is a critical aspect to the durability of boardwalk structures and decking. Severe wave action may loosen or detach individual deck boards or complete sections of decking still attached to the substructure. The threat can be reduced with careful boardwalk siting, design, and construction.



SECTION: CONCRETE PLANKS WITH RECYCLED PLASTIC DECKING

SECTION: CONCRETE PLANKS AS DECKING

Greatest Threats from Coastal Storms and Flooding

- Detached sections of boardwalk becoming dangerous when lifted by water or wind.
- Erosion of subgrade and scour around deck footings, compromising the deck support structure.
- Poor structural integrity of aging boards, contributing to unsafe conditions.

Best Practices to Alleviate Threats

- Evaluate boardwalk elevation relative to FEMA flood zones, lifespan for existing boardwalks, and surrounding context and topography.
- Precast concrete planks are the recommended decking material because it is the longest lasting and most resilient to wave action.
- For aesthetic purposes, if wood-like deck boards are desired, recycled plastic lumber (RPL) can be used as a top surface above precast concrete planks. Mechanically connect deck boards to concrete planks in a manner appropriate to lateral and uplift forces.
- Ensure appropriate drainage to prevent uplift of wood-like deck boards, such as RPL, if used. This can be achieved by including slightly larger gaps between deck boards to allow through flow of water, thereby reducing uplift forces.
- Utilize light colored surface materials wherever possible to help reduce heat.

Concrete boardwalk at Rockaway Beach, Queens

JUSTIFICATION FOR CONCRETE BOARDWALKS

NYC Parks and other NYC agencies no longer use tropical-derived woods in new construction.

To alleviate the harmful effects associated with utilizing tropical hardwoods, including the destruction and deforestation of tropical rainforests and the resulting impacts on climate change, other materials such as concrete and recycled plastic lumber (RPL) are substituted for use on boardwalks. After evaluating non-tropical hardwood and other synthetic decking materials, NYC Parks determined that concrete planks or concrete planks with RPL as a top surface are the preferred materials for large waterfront and floodplain boardwalks. As seen on the boardwalk in the Rockaways, concrete planks are long lasting, can handle typical boardwalk use, and can support vehicles without concern for slipping or poor wear. Concrete's durability and long lasting structural stability are of high value in the floodplain. Concrete planks with RPL as a top surface are also employed, as seen at the Coney Island boardwalk. Coney Island's local community felt strongly about maintaining the aesthetics of the previous traditional wooden boardwalk, and therefore, RPL was installed as a top surface atop concrete planks to achieve the desired look.

Concrete Pavement

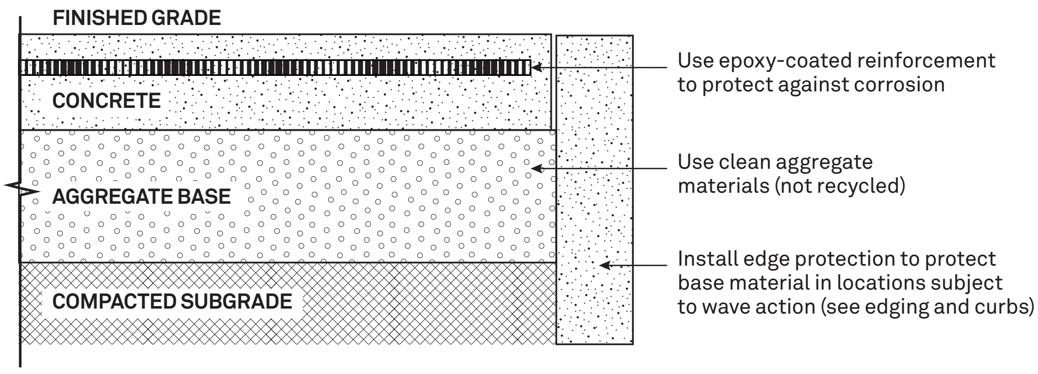
Concrete is recommended as pavement material in the floodplain. When properly sited and installed, concrete pavement can survive inundation and moderate wave action. Concrete is less susceptible than other materials to salt and chemical corrosion. While concrete is not totally resistant, following these best practices will help lessen the impacts of flooding.

Greatest Threats from Coastal Storms and Flooding

- Erosion of base material can cause structural weakness, cracking, or collapse.
- Salt and corrosives in floodwaters can prematurely wear the concrete finish.
- Recycled concrete aggregate may react to floodwater and lose structural integrity.

Best Practices to Alleviate Threats

- Site concrete pavement at elevated locations, or where protected from wave action and water runoff.
- Install adequate edge protection in locations subject to wave action to avoid base material erosion. See Section 5.3 Edging and Curbs.
- Use clean aggregate materials as base material in the floodplain.
- Use epoxy-coated reinforcement to limit corrosion where steel reinforcement is required.



DETAIL: CONCRETE PAVEMENT IN THE FLOODPLAIN

Asphalt Pavement

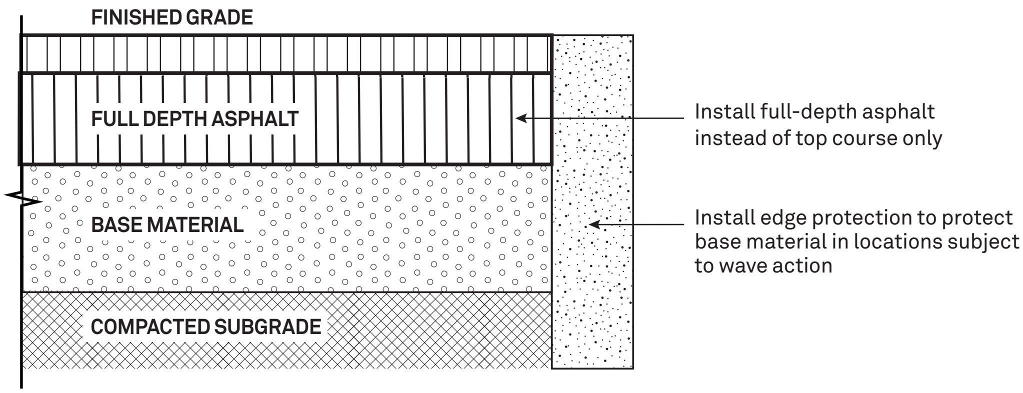
Asphalt is another material that can be successful in the floodplain. Asphalt can withstand periodic inundation provided the subgrade or base material is well compacted and the pavement is contained with permanent edging. Asphalt is more vulnerable than concrete to cracking, which can allow water to travel to the foundation material and cause pavement failure. While asphalt is not totally resistant, following the below best practices will help lessen the impacts of flooding.

Greatest Threats from Coastal Storms and Flooding

- Erosion of base material.
- Cracking of aged asphalt and subsequent failure.
- Salt and corrosives in floodwaters can accelerate pavement deterioration.

Best Practices to Alleviate Threats

- Limit use of asphalt pavement to higher elevations. The lower the elevation, the less likely asphalt will last for its usual projected lifespan.
- Install full-depth asphalt instead of top course only.
- Install adequate edge protection in locations subject to wave action to avoid base material erosion. See Section 5.3 Edging and Curbs.



DETAIL: ASPHALT PAVEMENT IN THE FLOODPLAIN

Porous Pavement

Porous pavement—asphalt or concrete—is not recommended for NYC Parks within the floodplain due to maintenance concerns and vulnerability to storm damage. To maintain porosity, the pavement requires periodic sweeping, power washing, and/or vacuuming. Designers need to carefully weigh the risks versus benefits of porous pavement before using it.

Greatest Threats from Coastal Storms and Flooding

- Debris in floodwater can clog the pavement and compromise permeability.
- Base material can erode, compromising pavement integrity.
- Salt and corrosives in floodwaters can seep into porous pavement, leading to more accelerated deterioration when compared to standard pavements.
- Back up of water through pavement due to high water table during flooding.

Best Practices to Alleviate Threats

- Design alternative drainage measures, such as sheet draining to a natural area or an overflow catch basin, to eliminate ponding water when the permeability of the pavement is compromised.
- Install adequate edge protection in locations subject to wave action to avoid base material erosion. See Section 5.3 Edging and Curbs.

Non-Permeable Unit Pavers

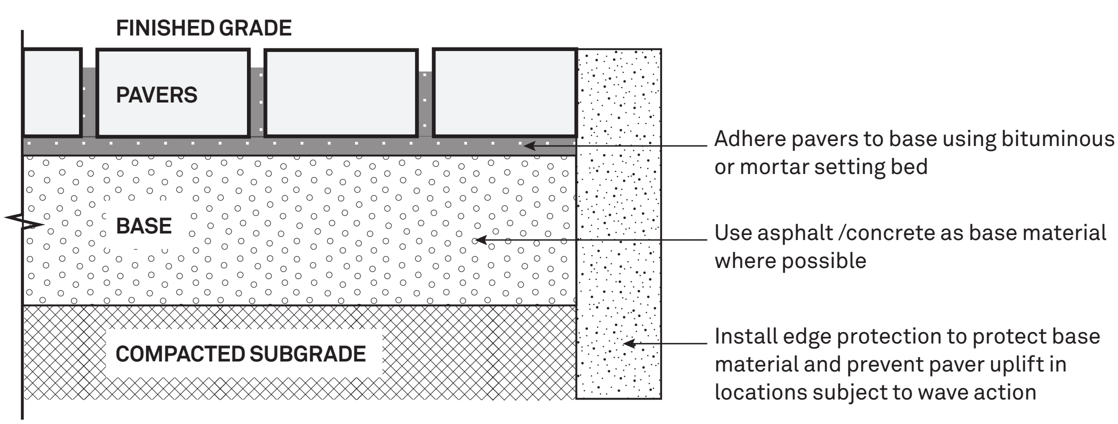
Non-permeable unit pavers—such as asphalt, concrete, and brick pavers—are an aesthetically pleasing pavement material that can be successful in the floodplain. However, non-permeable unit pavers become more vulnerable to flooding over time due to degradation of the setting bed. As long as the base material remains intact, individual pavers displaced by wave action can be quickly reset. Past flood events have shown that choosing an asphalt or concrete base material can reduce the rate of failure.

Greatest Threats from Coastal Storms and Flooding

- Erosion of base materials.
- Missing pavers increase the vulnerability of the remaining pavement.
- Uplifting of large areas of pavers, often due to setting beds that have lost cohesive properties with age. Most unit pavers that failed were installed more than ten years ago.

Best Practices to Alleviate Threats

- Install unit pavers on an asphalt or concrete base instead of a compacted aggregate base. Pavers set on sand or other types of compacted aggregate base have failed at a far greater rate than those set on asphalt or concrete.
- Adhere unit pavers to the base material by using a bituminous setting bed with tack coat or a mortar setting bed.
- Install adequate edge protection in locations subject to wave action to avoid base material erosion. See Section 5.3 Edging and Curbs.



DETAIL: NON-PERMEABLE
UNIT PAVER IN THE FLOODPLAIN

Permeable Unit Pavers

Permeable unit pavers consist of solid paving units with small, stone-filled joints that allow water to drain through into a highly permeable aggregate base material. Unlike traditional pavers, the paving units are not adhered to the base material. Permeable unit pavers are recommended for upland sites with deep water tables (minimum 2 feet below the sub-base course). Increased permeability in upland sites can reduce flooding due to heavy rain events. However, permeable unit pavers are not recommended in the floodplain because the individual pavers may uplift if subjected to wave action.

Greatest Threats from Coastal Storms and Flooding

- Paver uplift due to wave action.
- Loss of permeability due to inundation of debris-filled water.

Best Practices to Alleviate Threats

- Use permeable unit pavers in upland sites to help reduce flooding.
- Replace base aggregates if permeability is compromised. The unit pavers can be reinstalled if still in good condition.
- Install adequate edge protection in locations subject to wave action to avoid base material erosion. See Section 5.3 Edging and Curbs.

5.5 // FIELDS, PLAYGROUNDS, AND COURTS

Natural Turf (Passive and Sports)

Natural turf is a resilient surface for the floodplain. Grass can survive even under prolonged inundation. The success of this surface in the floodplain may depend on how well the subsoil drains and can withstand erosion. In general, natural turf sports fields require more maintenance (e.g., mowing, fertilizing, etc.) compared with synthetic turf. Natural turf under heavy athletic use will require more maintenance and may be more susceptible to erosion during storm events. Natural turf is, however, inexpensive to restore and is better to use in floodplain parks than many costlier materials.

Greatest Threats from Coastal Storms and Flooding

- Standing water caused by inadequate drainage can damage roots and erode soil.
- Clogged irrigation and drainage systems due to displaced soil and debris.
- Development of sinkholes when subsoil erosion becomes advanced.
- Saltwater inundation leading to grass die-off.

Best Practices to Alleviate Threats

- Use natural turf for passive and active recreation in the floodplain.
- Properly grade lawns to avoid pooling of water during rain events. Proper drainage is important to a lawn's ability to withstand flooding and for recovery afterward.

From left: Passive natural turf at Riverside Park, Manhattan; active natural turf sports field at Highland Park, Brooklyn.

Synthetic Turf

The two types of synthetic turf systems used in NYC Parks are carpet-style and in-fill style (see Section 1.4 for definitions). Both systems are likely to incur heavy damage from flooding and wave action. Synthetic turf is generally not recommended for installation in the floodplain. However, in-kind replacement of existing synthetic turf fields already located in the floodplain should be considered on a case-by-case basis.

There are a number of considerations that should be weighed when determining whether synthetic turf is appropriate for use in a floodplain project. When high volume sports usage is expected and the use meets community needs, the high initial cost of synthetic turf installation should be weighed against the risk of flood damage. Synthetic turf has a high initial capital investment from the initial excavation, new drainage systems, new stone for base material, and edging required. NYC Parks' "High Performance Landscape Guidelines" includes a useful section titled "Use Synthetic Turf Wisely" (see page 80 of Resource 14). Designers may find this resource helpful when determining whether synthetic turf is appropriate. Stakeholders should always consult with NYC Parks to determine the feasibility of a project before any commitment is made to use synthetic turf in flood-prone sites.

Greatest Threats from Coastal Storms and Flooding

- **Carpet-style synthetic fields:** Tearing can be caused by wave action. Once the turf tears, water can get under the turf, causing the shock pad to be buoyant, ripping the turf above it. Seams can also weaken due to improper drainage and standing water.
- **Infill-style synthetic fields:** Tearing can be caused by wave action. Washing away of infill is likely. If inundated, the infill often becomes contaminated and nearly impossible to clean. Seams can also weaken due to improper drainage and standing water.
- **Synthetic field turf** is difficult to patch and/or re-attach once it has been displaced during a flood event and usually needs to be completely replaced.

Best Practices to Alleviate Threats

- New synthetic turf construction is generally not recommended in Zone VE and Coastal Zone AE. However, in-kind replacement for synthetic turf fields in these zones should be considered on a case-by-case basis. In areas of high use or when natural turf fields would prove too difficult to maintain, new synthetic turf fields should be installed above BFE within Coastal Zone AE when possible.
- Protect synthetic turf fields from wave action with a berm or other protective barriers.
- Carpet-style synthetic turf is preferable to infill-style. Infill-style is not recommended in any areas where standing water may be a frequent occurrence.

Track Surfacing

The majority of NYC Parks' running tracks are constructed from a prefabricated synthetic material adhered to full depth asphalt pavement with a polyurethane adhesive. Though this material has historically fared well in flood events, there is the potential for damage. This is especially the case for older installations, as water can compromise the adhesive and detach the material from its base. Prefabricated synthetic track material is recommended for installations in the floodplain over other material options.

Greatest Threats from Coastal Storms and Flooding

- Separation of the prefabricated track material from the underlying base material.
- Poor edge connections are susceptible to uplift and damage by water.
- Avoid other types of track material, which are less used in parks, such as poured-in-place rubber, which is more porous and susceptible to becoming brittle, and loose material such as cinder and stone screenings, which wash away.

Best Practices to Alleviate Threats

- Attach prefabricated track surfacing to the underlying base, perform regular inspections.
- Attach prefabricated track surfacing to concrete curb edging.
- Replace other types of track surfacing with prefabricated synthetic track surfacing.

Running track at PS 203, Brooklyn

Safety Surfacing

NYC Parks' standard safety surfacing is a vulcanized, molded rubber tile. The majority of molded rubber safety surfacing uplifted and was displaced during Hurricane Sandy. However, due to its longevity, universal accessibility, and ease of maintenance, the benefits of molded rubber surfacing outweigh the risks posed by the floodplain. Parks is currently researching other types of molded safety surfacing that can be long-lasting and flood resistant.

Greatest Threats from Coastal Storms and Flooding

- **General:** Damage to pavement beneath safety surfacing when water and debris get beneath the safety surfacing, leaving it uneven and vulnerable to further damage.
- **Molded Rubber Tiles:** Warping, peeling up, and floating away of tiles.

Best Practices to Alleviate Threats

- Analyze initial cost, longevity, and ease of maintenance when considering various types of safety surfacing.
- Consider ADA accessibility when selecting safety surfacing.

Sports Court Coatings

Sports courts are often coated with acrylic or thermoplastic paints for game playing. In general, siting of these courts is a more important factor than material choice when seeking increased resiliency. Color seal coat is recommended in the floodplain, because it is relatively inexpensive compared with colored concrete, despite its shorter lifespan.

Greatest Threats from Coastal Storms and Flooding

- Weathering and deterioration of coatings.

Best Practices to Alleviate Threats

- Clean and reapply color seal coat after a flood event, if necessary.
- Expect coatings to weather faster and be re-applied more frequently in the floodplain.

Sports courts at PS 9, Brooklyn

Sports Equipment

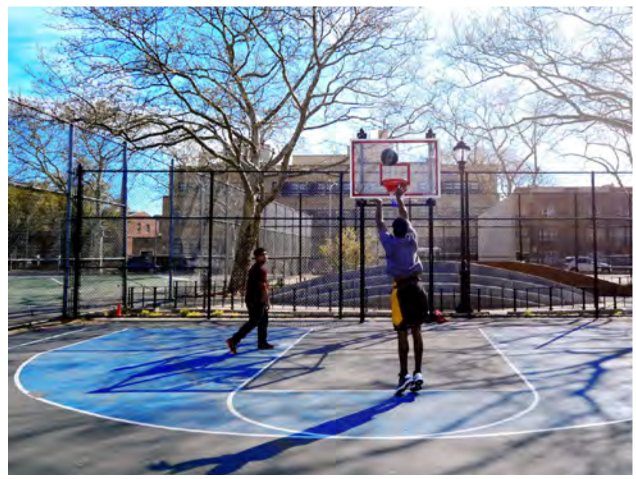
Sports equipment, such as goal posts, basketball backstops, scoreboards, and other features in the floodplain, faces less of an immediate threat from flooding than from downed trees and tree limbs.

Greatest Threats from Coastal Storms and Flooding

- Fallen trees, tree limbs and other debris.
- Erosion and scour of footings, increasing the likelihood that they will topple.
- Corrosion of metal due to saltwater intrusion.

Best Practices to Alleviate Threats

- Use sturdy footing and anchoring details for sports equipment and amenities to withstand erosion and scour.
- Carefully locate new trees to balance need for shade and risk of damage near fences and/or backstops.
- Sports equipment with electrical components, such as an electric scoreboard, are not recommended in the floodplain.



Basketball furnishings in Betsy Head Park, Brooklyn

Playground and Outdoor Fitness Areas

Playgrounds and fitness areas in the floodplain typically face a high risk of flood damage because they contain so many built features, such as play equipment. This section includes recommendations on how material and component selection can reduce damage, or at least replacement costs, to playground and outdoor fitness equipment.

Greatest Threats from Coastal Storms and Flooding

- Accelerated corrosion of steel playground components and outdoor gym equipment due to prolonged exposure to salt water and sea air. Once equipment is inundated with salt water, even if no initial damage is observed, the steel components will start to rust, decreasing the life span of the equipment.
- High winds and erosion causing toppling of trees and limbs onto equipment.

Best Practices to Alleviate Threats

- Consider alternative playground designs, such as net climbers and glass fiber reinforced concrete (GFRC) components, limiting the use of modular steel equipment.
- Use alternative materials, such as aluminum and recycled plastic lumber, instead of steel for posts and components.
- If steel components are unavoidable, use durable coating, such as PVC coating or hot-dipped galvanizing.

Proposed view of Sandpiper Playground, Queens / Credit: Quennel Rothschild & Partners

Loose Fill

Loose fill surfaces, such as wood fiber, stone screenings, and gravel are not appropriate materials in the floodplain for accessible pathways or safety surfacing. Loose fill surfaces easily wash away and can become contaminated during flooding events. Loose fill is extremely difficult to keep accessible to wheelchair users. NYC Parks is researching various plastic grids, reinforcements, and other installation methods that may allow for easier maintenance and therefore more reliable accessibility.

Greatest Threats from Coastal Storms and Flooding

- Washing away by floodwater, especially in areas with wave action.
- Lighter materials such as wood fiber can accumulate in storm drains, exacerbating drainage problems.
- Contamination: Loose fill is difficult to clean once contaminated, and may need to be entirely replaced after inundation with floodwater.

Best Practices to Alleviate Threats

- Generally not recommended in the floodplain because it is vulnerable to washing away.
- Do not reuse loose fill contaminated by floodwater in areas where the public comes in contact with it, such as pathways or playground areas.

Sand Boxes

Sand boxes are not recommended in the floodplain, because they are at risk for damage and contamination by even moderate, periodic flooding. Sand can easily be washed away or inundated by contaminated water, leading to unsafe conditions. Sand boxes are difficult to clean and require replacement after even moderate flooding.

5.6 // **WATER AND DRAINAGE SYSTEMS**

All water utility system components are at risk for damage from corrosion, debris, and other threats associated with flooding. While one solution may be to elevate these systems above the base flood elevation (BFE), this is rarely cost-effective or practical, particularly in very low-lying sites where the BFE can be 10 feet or higher. Prior to building these systems, an analysis should be conducted to quantify the possible losses to these components in the floodplain, and a plan should be made for their rapid replacement.

Drinking Fountains

Drinking fountains are indispensable amenities in active recreation areas. All structures that include connections to utilities are at risk for damage by inundation, wave action, and being clogged by debris, including drinking fountains. Surface-mounted components are more likely to pull up from their base. Drinking fountains should be carefully sited in the landscape to minimize potential damage.

Greatest Threats from Coastal Storms and Flooding

- Inundation of drainage lines with contaminated water; these lines can be difficult to clean and may need full inspection and replacement.
- Clogging of drainage lines with sand, gravel, and other debris, rendering them inoperable.
- Corrosion of metal components due to inundation.

Best Practices to Alleviate Threats

- Install trough-style drinking fountains that function without a drain in the fountain bowl. This is recommended in beach areas to prevent the sand entering and clogging drainage lines.
- Locate drinking fountains, or any components that include connections to utilities, at higher elevations to minimize wave impact and inundation.

Trough-style drinking fountain at Bushwick Inlet Park, Brooklyn

Irrigation Systems

Irrigation systems, especially in-ground types, are not recommended for the floodplain as they are vulnerable to destruction by inundation. Quick coupler valves and ground hydrant systems are the recommended alternative in the floodplain. Automatic in-ground irrigation systems should be installed only in upland sites where proper system maintenance and budgets allow.

Greatest Threats from Coastal Storms and Flooding

- Damage of backflow prevention systems if not properly protected or sited.
- Damage to electrical and mechanical components if inundated.

Best Practices to Alleviate Threats

- Select plants that do not require extensive irrigation to reduce site complexity.
- In-ground irrigation systems should be avoided, except to help plant establishment.
- Install ground hydrant or quick coupler valves where needed. Hydrants or quick coupler should allow 50-foot hose used by maintenance staff to reach all areas.

Spray shower at Morningside Park, Manhattan

Spray Showers and Decorative Fountains

Mechanical components for spray showers and decorative fountains are typically sub-grade and therefore at high risk for flood damage. Construction is also relatively complex and costly. In most cases, the risk to these systems and the high cost of repairing or replacing them indicates that use of these systems should be carefully considered in the floodplain.

Greatest Threats from Coastal Storms and Flooding

- Inundation and damage of subgrade mechanical/electrical equipment by floodwaters.
- Blocked water and drainage lines by debris, causing fountains to stop working.
- Premature corrosion and shortened lifespan of the equipment.

Best Practices to Alleviate Threats

- For new parks and renovations, spray showers and decorative fountains are not recommended. For park retrofits, consider removing existing spray showers and decorative fountains if there is a high risk of damage.
- Cast concrete spray elements and ground-level or small spray features are a good choice in high salt locations.
- Design spray showers with non-electrical control systems, such as hydraulic or mechanical bollard activators. Electrical components are not recommended in the floodplain.
- If electrical control systems cannot be avoided, locate controllers in comfort stations where they can be raised instead of in an underground or at-grade vault.
- If a mechanical/electrical vault is essential to a site's design, the vault should be installed at grade or raised to a higher elevation where possible.

Backflow Prevention Devices

Reduced Pressure Zone (RPZ) devices, water meters, and backflow prevention devices are often essential components to water systems in parks. Therefore, it is important to site these at higher elevations where possible.

Greatest Threats from Coastal Storms and Flooding

- Premature corrosion and shortened lifespan of equipment due to inundation.
- Clogging of backflow prevention devices (though infrequent), and extensive damage to the water and drainage systems for the entire site.
- Trapped floodwaters within waterproofed vaults can actually exacerbate damage if they are not maintained.

Best Practices to Alleviate Threats

- Elevate these components at least one foot above the BFE to prevent damage and maintain water potability, especially in new construction. If the vault cannot be elevated above the floodplain, it should be above the mean water table at minimum to avoid frequent inundation.
- For sites where there is no building in which to install the backflow prevention device, the external concrete vault may need to be significantly higher or taller.

Drainage Lines

Drainage lines are an important component to overall site resiliency in the floodplain. Drainage lines can be blocked with debris, exacerbating flooding on the site and causing damage to other components due to prolonged inundation. The risk of blocked drain lines also exists at upland sites prone to site flooding.

Greatest Threats from Coastal Storms and Flooding

- Drainage lines blocked by debris.
- Back-up of water through drainage lines, causing site flooding.
- Drainage outfalls become weak points in seawalls, causing soil to erode, leading to sinkholes and eventual collapse of pavements upland of the seawall edge.

Best Practices to Alleviate Threats

- In upland sites outside the floodplain, the use of bio-retention systems can lessen the load on drainage systems during normal flood events and reduce flood damage.
- Ideally, design waterfront sites to sheet drain directly to open water without the use of a drainage system.
- However, if curbs or parapets are installed at site edges to address sea level rise or flooding, design drainage structures to prevent water from collecting behind elevated edge.

Bioretention Systems

In the floodplain, bioretention systems will not reduce or alleviate flooding because they will be inundated by floodwaters. However, bioretention systems in upland sites can reduce storm water flooding by intercepting runoff and retaining or detaining it. It should be noted that the main purpose of bioretention is to capture and treat runoff from frequent events of one inch of rain or less, which can be done in both upland and floodplain areas.

Greatest Threats from Coastal Storms and Flooding

- Damage of plantings due to erosive flows and prolonged ponding and saturation.
- Compromised permeability of the bioretention system due to compaction from deep floodwaters or clogging from high sediment loads.

Best Practices to Alleviate Threats

- Bioretention systems should be considered in upland and floodplain sites, but will not achieve flood mitigation goals when sited in the floodplain.
- Bioretention systems should always have a safe overflow design for major storm events.
- Select appropriate plantings that can tolerate inundation, salt, and drought conditions.
- Bioretention systems should be designed with awareness of depth to groundwater and functional goals of the system, such as water quality improvement, detention, and/or infiltration.

Bioretention at Far Rockaways, Queens

5.7 // ELECTRICAL MECHANICAL, AND TELECOMMUNICATION SYSTEMS

Electrical, mechanical, and telecommunications systems are particularly vulnerable in the floodplain. However, many park components rely on these systems (e.g., lighting and irrigation) and they are essential for parks. Therefore, the balance of risk and benefits is required when designing for electrical utilities. Where possible, explore using off-grid electrical components, such as solar- or wind-powered lighting.

Greatest Threats from Coastal Storms and Flooding

- Corrosion and damage from saltwater inundation.

Best Practices to Alleviate Threats

- Raise the elevation of electrical boxes and conduits or install solar-powered alternatives to light poles and other electrical equipment.
- Electrical, mechanical, and telecommunications components should be raised above BFE, designed to be waterproof, or otherwise considered sacrificial and designed for easy replacement.

Lighting

Lighting is an important component of a functioning safe park. As with other utilities, lighting systems are at risk for damage to electrical components being corroded by inundation. Lighting in the floodplain should be installed on separate circuits from upland lighting to reduce power loss following a flood event. Where regulation allows, solar lighting and other fixtures not reliant on a central electric line should be incorporated to reduce risk of damage.

Greatest Threats from Coastal Storms and Flooding

- Inundation of below-grade electric lines and conduits; these lines can be difficult to access for replacement if conduits are centralized and access points are limited, adding to the cost and time spent repairing systems.
- Toppling of light poles due to high wind or scour at their foundations.

Best Practices to Alleviate Threats

- If typical electric lighting is used, design upland lighting to be on separate circuits from floodplain lighting. This will allow upland lighting to remain functional should a flood event damage the electrical lines in the floodplain.
- Install non-wired lighting, such as solar or wind powered lighting, where possible.

Conduits

Sub-grade conduits in the floodplain are at risk for inundation by water, which can lead to corrosion of wires and damage to the park's utility systems. In cases where it is not feasible to relocate conduits above the floodplain, these components should be made easily accessible for inspection and replacement if needed.

Greatest Threats from Coastal Storms and Flooding

- Corrosion of electrical lines and damage to the conduits themselves from saltwater inundation.
- Sub-grade conduits can be difficult to access, requiring full replacement rather than replacement of a single damaged section.

Best Practices to Alleviate Threats

- Locate conduits at higher elevations on the site.
- Explore solar- or wind-powered components to avoid subsurface conduits.

6

Additional Resources

1 / Advancing urban ecosystem governance in New York City: Shifting towards a unified perspective for conservation management

Natural Areas Conservancy, NYC Parks (2016)

This report details a comprehensive ecological assessment of natural areas in NYC conducted by NAC and NYC Parks, which should be used to help guide decision-making and prioritization of natural area management.

naturalareasnyc.org/content/3-in-print/2-research/esp.article.pdf

2 / Alley Creek Watershed Management and Habitat Restoration Plan

NYC Parks, Natural Resources Group (2015)

This document provides a plan to protect and restore the resources of the Alley Creek and Little Neck Bay watershed. The plan characterizes existing conditions, identifies threats, articulates the goals, and suggests comprehensive management strategies and specific actions to address issues of concern.

nycgovparks.org/download/nycdpr-exec-summary-alley-creek-plan-2015.pdf

3 / The Biology of Coastal Sand Dunes

M. Anwar Maun, Oxford University Press, New York (2009)

This book provides an introduction to the formation, dynamics, maintenance, and perpetuation of coastal sand dune systems. A particular emphasis is placed on conservation and management issues due to the habitat's increasingly endangered status. This book includes a global range of coastal sand dune examples.

4 / Building the Knowledge Base for Climate Resiliency

New York City Panel on Climate Change (February 2015)

A report produced by the New York City Panel on Climate Change that provides climate projections for the City through the end of the century. These projections form the basis of an assessment of the resilience of the City's infrastructure, as well as suggestions for how that resilience can be improved.

onlinelibrary.wiley.com/doi/10.1111/nyas.2015.1336.issue-1/issuetoc

5 / Clean Marina Guidebook

National Park Service (March 2012)

This guidebook is intended to help marinas develop practices that go beyond required regulatory and contractual compliance and implement best management practices to create cleaner, more environmentally-friendly facilities.

nps.gov/commercialservices/docs/concessioner%20tools/National_Clean_Marina_Initiative_2012.pdf

6 / Climate Resiliency Design Guidelines

NYC Mayor's Office of Recovery and Resiliency (2017)

Guidelines for New York City capital projects which incorporates more specific, regional, and forward-looking climate science than historic sources of this data. The Guidelines provide a consistent methodology for engineers, architects, and planners to design facilities that are resilient to changing climate conditions.

nyc.gov/html/planyc/downloads/pdf/publications/ORR_ClimateResiliencyDesignGuidelines_PRELIMINARY_4_21_2017.pdf

7 / Cloudburst Resiliency in New York City

Ramboll and the NYC Department of Environmental Protection

This report analyzes best-available data related to NYC rainfall, recommends methodologies for incorporating findings into ongoing resiliency planning initiatives, and identifies best practices for considering climate change in future neighborhood-specific planning studies. Opportunities for intervention are identified within the designated study area in southeast Queens.

issuu.com/ramboll/docs/nyc_cloudburst_resiliency_planning_

8 / Coastal Green Infrastructure Plan for New York City

Arcadis (December 2014)

In 2014 the New York State Department of Environmental Conservation Hudson River Estuary Program, the New England Interstate Water Pollution Control Commission, and NYC Department of City Planning released a Coastal Green Infrastructure (CGI) research plan, which defined CGI as nature-based strategies for protecting shorelines from coastal flooding. The strategies include such things as constructed wetlands and breakwaters to ecologically-enhanced bulkheads and revetments. The plan summarizes the latest scientific understanding of ecological and risk reduction benefits of various CGI strategies, as well as knowledge gaps and research priorities.

dec.ny.gov/lands/100057.html

9 / Coastal Wetland Restoration Opportunity Inventory (ROI) in NYC

Natural Areas Conservancy (2016)

This document identifies and prioritizes restoration opportunities within NYC, totaling over 275 acres, which can be incorporated into local waterfront redevelopment and resiliency planning.

naturalareasnyc.org/content/3-in-print/2-research/roi-project-summary-august-2016_final.pdf

10 / Designing for Flood Risk

NYC Department of City Planning (June 2013)

This report identifies key design principles to guide flood-resistant construction in urban area. It provides an overview of regulatory requirements for construction in flood zones under the National Flood Insurance Program, and explores the impacts of flood-resistant construction standards on built form and the creation of a vibrant streetscape and public realm. The report also lays out recommendations for how zoning can incorporate these principles to enable more versatile and desirable design solutions for flood-resistant construction.

www1.nyc.gov/assets/planning/download/pdf/plans-studies/sustainable-communities/climate-resilience/designing_flood_risk.pdf

11 / FEMA FIRMs and PFIRM Data Viewer

Federal Emergency Management Agency

FEMA's Region II office has prepared a coastal flood study to update Flood Insurance Rate Maps (FIRMs) for communities in coastal New Jersey and New York. The flood hazards shown on the FIRM are used to determine flood insurance rates and requirements and where floodplain development regulations apply. The updated maps will help communities plan for and reduce the risk from flooding in the future. A sites' location relative to the 100-year, 500-year flood zones, as well as BFE can be found in the second link below:

region2coastal.com

region2coastal.com/view-flood-maps-data/view-preliminary-flood-map-data

12 / Flood Hazard Mapper

NYC Department of City Planning

The NYC Flood Hazard Mapper is a tool which provides a comprehensive overview of the coastal flood hazards that threaten the city today, as well as how these hazards are likely to increase in the future due to climate change.

nyc.gov/floodhazardmapper

13 / Guidelines for Urban Forest Restoration

NYC Parks, Natural Resources Group (2014)

These guidelines are a collection of the forest restoration theories and practices developed, implemented, and tested during thirty years of natural area restoration by NYC Parks' Natural Resources Group.

nycgovparks.org/pagefiles/84/guidelines-to-urban-forest-restoration.pdf

14 / High Performance Landscape Guidelines: 21st Century Parks for NYC

Design Trust for Public Space and NYC Parks (2010)

This is a comprehensive manual for the design and construction of sustainable parks and open space. It contains best practices for water management, resilient plantings, durable materials, and efficient operations within parks.

nycgovparks.org/greening/sustainable-parks/landscape-guidelines

15 / Louisiana's Comprehensive Master Plan for a Sustainable Coast

Coastal Protection and Restoration Authority of Louisiana

The Master Plan is a list of projects that build or maintain land and reduce water-related risk to Louisiana's coastal communities.

coastal.la.gov/wp-content/uploads/2017/01/DRAFT-2017-Coastal-Master-Plan.pdf

16 / National Oceanic and Atmospheric Administration Tides and Currents Station Map

National Oceanic and Atmospheric Administration

NOAA's Center for Operational Oceanographic Products and Services (CO-OPS) gathers oceanographic data, such as water-level and current measurement data, along the nation's coasts, and publishes the data on a Tides and Currents Station Map that can be accessed through their website.

tidesandcurrents.noaa.gov/map

17 / Native Species Planting Guide for New York City

NYC Parks (2014)

This guide is written primarily to assist those doing restorations, or plantings in natural areas in the New York City metropolitan area, with the goal of preserving genetic diversity within the New York region. Planting recommendations are provided for low and small salt marsh, and maritime beaches, dunes, grassland and shrublands.

nycgovparks.org/pagefiles/92/nrg-native-species-planting-guide.pdf

18 / New York City Resiliency and Recovery Project Tracker

NYC Mayor's Office of Recovery and Resiliency

The Mayor's Office of Recovery and Resiliency's interactive project tracker map allows users to explore different active and completed resiliency projects throughout the five boroughs of New York City undertaken by various agencies and affiliated organizations.

maps.nyc.gov/resiliency

19 / NYC Construction Code

NYC Department of Buildings

The NYC Department of Buildings (DOB) ensures the safe and lawful use of over a million buildings and properties by enforcing the City's Building Code, Electrical Code, Zoning Resolution, New York State Labor Law and New York State Multiple Dwelling Law. All New York City construction should comply with the requirements detailed in the Construction Code. Following Hurricane Sandy, DOB issued several documents relating to resiliency including recently enacted resiliency legislation and guidance on rebuilding to meet flood standards.

www1.nyc.gov/site/buildings/homeowner/storm-update.page

20 / NYC Office of Emergency Management Know Your Zone

NYC Office of Emergency Management

The NYC OEM Know Your Zone website provides resources on the city's hurricane evacuation zones.

www1.nyc.gov/assets/em/html/know-your-zone/knowyourzone.html

21 / NYC Parks Capital Tracker

NYC Parks

This tool provides general information for NYC Parks' capital projects. Information displayed includes a project timeline, funding sources, project location, and a status tracker for each capital project.

nycgovparks.org/planning-and-building/capital-project-tracker

22 / NYS CEHA Zones

New York State Department of Environmental Conservation

New York State's Coastal Erosion Hazard Area (CEHA) Zone Permit Program provides written approval of regulated activities or land disturbance to properties within the coastal erosion hazard areas within DEC's jurisdiction.

dec.ny.gov/lands/28923.html

23 / One New York: The Plan for a Strong and Just New York City

NYC Mayor's Office (2015)

This report is a groundbreaking effort to address New York City's long-term challenges: the forecast of 9 million residents by 2040, changing climate conditions, an evolving economy, and aging infrastructure.

nyc.gov/html/onenyc/downloads/pdf/publications/OneNYC.pdf

24 / Rebuilding NYC After Hurricane Sandy: A Guide to New Code and Zoning Standards for Professionals

NYC Department of Buildings (February 2015)

This guide provides design professionals with important information on changes in Code and Zoning standards that affect how building damaged in Hurricane Sandy may be repaired or reconstructed. The guide addresses flood zones, zoning, permitting, elevations, surveys and plans, substantially damaged or substantial improvements, freeboard, tidal and freshwater wetlands, coastal erosion hazard areas, City-owned waterfront property, maritime commerce, and the NYC Fire Code.

www1.nyc.gov/assets/buildings/pdf/rebuilding_after_hurricane_sandy.pdf

25 / Retrofitting Buildings for Flood Risk

NYC Department of City Planning (October 2014)

This document is the most comprehensive analysis of retrofit options available for buildings in the New York City floodplain to date.

www1.nyc.gov/site/planning/plans/retrofitting-buildings/retrofitting-buildings.page

26 / Room for the River Program, Netherlands

Room for the River Partners

This national program creates tailor-made design and infrastructure measures to provide Dutch rivers with more physical space to facilitate naturally occurring floods in a safe manner.

ruimtevoorderivier.nl/english

27 / Salt Marsh Restoration Design Guidelines

NYC Parks (2018)

This document will provide updated guidelines for restoring urban salt marshes in NYC.

28 / Standard 24-05 for Flood Resistant Design and Construction

American Society of Civil Engineers (July 2015)

This document is a referenced standard in the International Building Code®. Buildings and structures within the scope of the IBC proposed to be constructed in a flood hazard area should be designed in accordance with these standards.

fema.gov/media-library-data/20130726-1643-20490-4974/asce24_highlights_dec2010.pdf

29 / A Stronger, More Resilient New York

New York City's Special Initiative for Rebuilding and Resiliency (June 2013)

This a comprehensive plan that contains actionable recommendations both for rebuilding the communities impacted by Hurricane Sandy and increasing the resilience of infrastructure and buildings citywide.

nyc.gov/html/sirr/html/report/report.shtml

30 / Towards a Salt Marsh Management Plan for NYC: Recommendations for Restoration and Protection

NYC Parks (2017)

This report utilizes data obtained during a 2013-2014 assessment of the city's marshes to create an inventory of potential threats and appropriate management responses to assist in the conservation and management of these sensitive wetlands.

naturalareasnyc.org/content/3-in-print/3-partner-publications/nycparks_saltmarshstrategyreport_2017.pdf

31 / Urban Waterfront Adaptive Strategies

NYC Department of City Planning (June 2013)

This is a resource to help guide planners and policy makers in New York City and beyond in identifying and evaluating potential coastal protection strategies. The report lays out a framework by which communities can narrow the list of strategies to consider for a given geography and identify which strategies provide the greatest range of benefits with respect to direct and indirect costs. This information is intended to provide guidance for the challenging decisions coastal communities face about how to foster resilient communities that can withstand and recover from climate hazards with minimal harm, while retaining a vibrant economy and a high quality of life for their residents.

nyc.gov/html/dcp/html/sustainable_communities/sustain_com7.shtml

32 / Visionmaker NYC

Wildlife Conservation Society

This interactive platform allows users to develop and share climate-resilient and sustainable designs for Manhattan based on rapid model estimates of the water cycle, carbon cycle, biodiversity, and population.

visionmaker.us/nyc

33 / Waterfront Edge Design Guidelines (WEDG)

Metropolitan Waterfront Alliance (2015)

These guidelines include a voluntary, incentive-based ratings system for waterfronts. WEDG is a tool to encourage waterfront innovation and best practices and allow developers, property and business owners, and design professionals to differentiate themselves in the marketplace.

waterfrontalliance.org/WEDG

34 / Waterfront Revitalization Program: Sea Level Rise Planning Tool

NYC Department of City Planning

The New York City Waterfront Revitalization Program (WRP) is the city's principal coastal zone management tool. It establishes the City's policies for development and use of the waterfront. Most City, State and Federal discretionary actions in the Coastal Zone should be reviewed for consistency with these policies. DCP has developed a sea level rise planning tool to help meet new policies on resiliency and climate change.

NYC.gov/wrp

35 / Woody Shrubs for Stormwater Retention Practices

Cornell University Department of Horticulture

This document summarizes results of a three-month study in Ithaca, NY, focused on testing the flood and drought tolerances of six shrub species. This list should be cross-referenced with the Native Species Planting Guide for New York City to rule out species that are more appropriate to upstate climates and higher elevations.

hort.cornell.edu/uhi/outreach/pdfs/woody_shrubs_stormwater_hi_res.pdf

THANKS

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NYC Parks

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