# SANDY SUCCESS STORIES

New York, New Jersey
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# SANDY SUCCESS STORIES

Like many in the New York and New Jersey region, we – the coordinators of a group of NYC civic organizations who have come together to support the city's sustainability initiatives – were saddened and horrified by the devastating destruction that Superstorm Sandy inflicted on many East Coast communities. We were left wondering how this much damage could occur. Why were we not more prepared for this type of disaster? How will we protect our communities moving forward? How can we ensure efforts to make us more resilient do not cause more harm than good?

Our elected officials were quick to provide statements to assure the public we would rebuild smarter and make our region more resilient to future storms. At every level of government, new commissions and task forces were created and the rush to develop rebuilding and resiliency plans began. Like them, we wanted to contribute to the strengthening of this region's resiliency – but we also wanted to make sure decision-makers made thoughtful decisions based on the best available information and developed plans that would tangibly strengthen our communities, our natural environment, and our relationship with the waterfront.

As we discussed this desire amongst ourselves, we heard of many local examples where protective designs made parts of the region better able to weather the storm and quickly resume normal operations. To learn more, we reached out to professional associations, such as the Real Estate Board of New York and the American Society of Landscape Architects, as well as to building owners, businesses, and community organizers. As we began to compile these stories, we also talked to experts in the fields of energy, infrastructure, waterfront development, ecological restoration, landscape architecture, and green infrastructure – to better understand what worked and why.

To date, we have assembled twenty case studies that document the successes of particular planning and design strategies, ranging from a small educational center that was able to provide electric charging for its neighbors to a local artist who had dedicated time over decades to building and planting dunes to protect his historic neighborhood. The subjects of these stories range from high-end residential properties and former landfills to new state-of-the-art facilities and small community parks.

The people responsible for these projects were extremely enthusiastic about sharing their stories. Many sent us photos, offered us tours, called us regularly with updates, drafted academic white papers, and put us in touch with experts. They too wanted to be part of the solution and wanted others to learn from their successes and failures. They wanted their projects to be part of the narrative that reveals what Sandy taught us – not just about destruction, but also about the forms of resiliency we will need to embrace going forward.

As we put these stories together, we were struck by the fact that a number of the interventions that mitigated damage during the storm were part of the city's sustainability agenda – initiated to help achieve various sustainability goals, such as providing all New Yorker's with access to quality open space, cleaning the city's waterways, increasing the city's natural biodiversity, and achieving aggressive energy efficiency and climate action targets. But many others were serendipitous – accidents of history that served communities and businesses well. This latter group of case studies has as much to teach us as the former, and we have done our best here to tease out the lessons we might learn from these strokes of good fortune.

In closing, we owe a large debt of thanks to all those who put time and effort into providing us with the information compiled here – many of whom are themselves still struggling to recover from the impacts of Sandy. Their experiences, their successes, and their willingness to allow us to document both will prove invaluable as we work as a community toward preventing this level of devastation from occurring here again.

Sincerely yours,

Michael Northrop
Rockefeller Brothers Fund

Andrew Darrell
Environmental Defense Fund


20 miles
Eastern Long Island
Waterfront parks
Beaches
Building sites
3 miles

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# I. EXECUTIVE SUMMARY

## Background

On Monday, October 29th, Superstorm Sandy hit New York and New Jersey with sustained winds of approximately 80 miles per hour and storm surges reaching over thirteen feet. It wreaked havoc on the region, causing dozens of deaths as well as power failures, destruction of homes and businesses, and the prolonged shut-down of New York City's subway system and financial district.

Sandy occurred just one year after Hurricane Irene, at the time the fifth costliest hurricane in US history. Both of these storms serve as part of a trend of global climate change defined most notably by shifts in temperatures, precipitation patterns, and sea levels. Many scientific experts and governmental officials project that these changes will continue, putting more lives and property at risk and impacting health, water quality, infrastructure, and coastal ecosystems.

Following Sandy, there is a sense of urgency about making the New York metropolitan area better able to cope with the impacts of climate change and policymakers are rightfully looking at how other global cities are coping with similar challenges. But some of these best-practice lessons are here at home, in models of resilient planning, design, and operations that successfully provided protection against Sandy-related damage. These projects exist at a variety of scales and employ a variety of techniques, but the lessons we can draw from them – both collectively and individually – can and should inform the ongoing rebuilding and resiliency-planning efforts.

## Sandy Success Stories Project

Sandy Success Stories is a compilation of case studies on designs, technologies, and natural features that helped a building, site, or neighborhood in the New York and New Jersey region fare relatively well during the storm. The stories highlight pre-existing solutions that, for the most part, did what they were supposed to do and as a result made some part of the region more resilient by minimizing damage or allowing normal operations to resume more quickly.

The stories fall into four locational categories: waterfront parks, building sites, beach dunes, and citywide initiatives. These stories are mostly based on interviews with the individuals responsible for the design or management of the highlighted locations. While by no means a scientific or quantitative analysis, the interviewees' qualitative assessments of their site's performance during and after Superstorm Sandy provides a strong foundation for further research and investigation.

As a compilation of stories, the Sandy Success Stories demonstrate the cumulative impact of numerous policy and investment decisions made by the City of New York over the past two decades, and how these decisions are transforming the city's landscape. Although there is a long way to go to true resiliency, changes to building codes, stormwater management plans, park designs, and new forms of housing and real estate development are making the City better able to absorb and recover from the shock of a major natural disaster.

## Successful Solutions

Two things helped determine the extent of damage from Superstorm Sandy: luck and strategic planning. Luck—or was often the case, bad luck—was dependent on location, timing, geological conditions underwater, meteorological factors, existing elevations, and history. But in some cases, careful planning mitigated the impact of bad luck in areas otherwise vulnerable to flooding through elevation of sites and equipment, creation of floodable and durable buffers, placement of landscaping and structures, treatment of the waterfront edge, incorporation of durable building materials and waterproof finishes, and the preparation of clear operational procedures for emergency situations such as Sandy.

***Land use at the water's edge***

Land use at the waterfront edge was a key determinant of the extent of incurred damage. Waterfront areas that were designed, either naturally or artificially, to flood and handle salt inundation, such as strategically-designed waterfront parks and wetlands, not only acted as a buffer to surrounding areas but also helped upland areas drain floodwaters more quickly, sometimes even filtering the water in the process. One of the greatest benefits of well-designed waterfront parks and restored wetlands going forward may simply be in protecting flood-prone sites from the siting of more vulnerable uses.

***Waterfront buffers***

Neighborhood buffers took a variety of forms during the storm. In many places, waterfront parks and wetlands acted as buffers. Along the ocean, however, the existence of landscaped beach dune systems, similar to those near the Beachfront Bungalow Neighborhood of Far Rockaway and in Westhampton, New York, often determined which neighborhoods were devastated and which were not. The most successful beach protection was found where there was a double dune system, usually with a primary dune closer to the ocean and a secondary dune closer to adjacent residential areas, both landscaped with beach grasses, shrubs, and trees.

***Elevation and building design***

Strategic site planning and building design also played a central role in mitigating storm damage in floodplain areas and near the waterfront. One common element across the case studies was the elevation of a site above the floodplain, accompanied by varying topography to protect structures from flooding and storm-related debris. These strategies were employed at the Sims Recycling Center as well as the buildings in Battery Park City and Arverne by the Sea.

For certain buildings, including 200 Water Street and Solar 1, elevated mechanical and electrical equipment (above the buildings' first floors) protected equipment from flood and salt damage, allowing operations to resume more quickly after the storm. Waterproofing structures also played a critical role at Solar 1. Many developers and operators are now emphasizing their desire to ensure that spaces with critical equipment are flood-proof going forward.

***Clean, distributed energy***

Damage from Superstorm Sandy was not limited to flood and surge damage; the impact of widespread power outages cost the region tens of billions of dollars, and left millions of residents without light and heat. However, where clean, distributed generation technologies (e.g., solar or cogeneration) were installed and designed to work when the central power grid is down, residents had power, heat, and hot water, and businesses were able to more quickly resume work. This was the case for the buildings connected to the Co-op City plant and the NYU cogeneration plant, whose unfortunate neighbors were left without power for days.

***Operational plans***

In addition to strategies to avoid damage, these case studies highlight the importance of operational procedures to prepare for and recover from an extreme storm. At Brooklyn Bridge Park, staff removed all moveable equipment (such as fencing and canopies) prior to the storm to ensure they did not blow away or trap debris; after the storm, staff implemented remedial procedures to ensure their plantings would survive intense salt intrusion. The Lower East Side People's Mutual Housing Association had clear emergency response procedures in place and was able to minimize flood-related damage, reducing costs and allowing building services to resume quickly.

## Key Findings

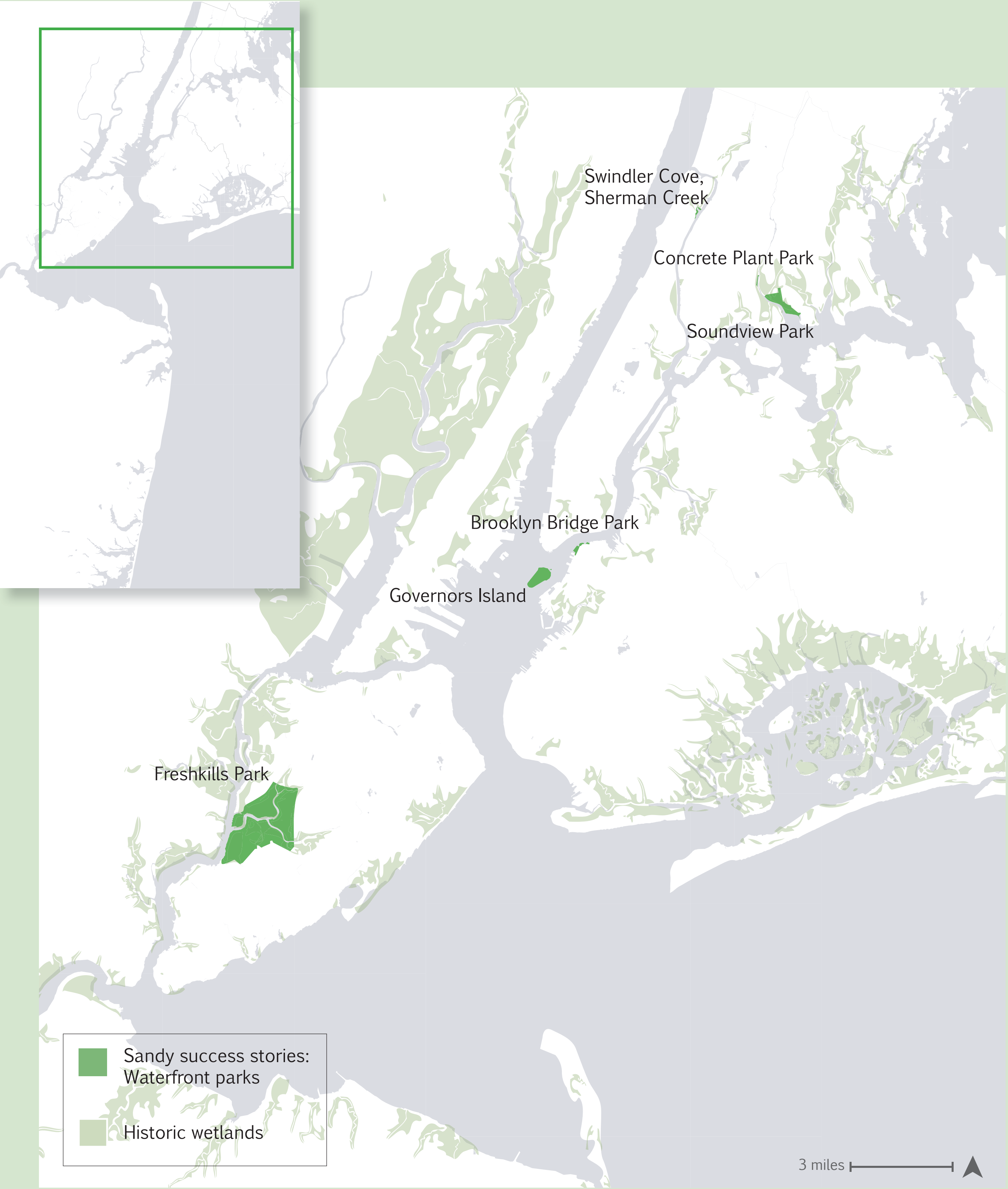
In a very direct and tangible way, the lessons learned from each "successful" site can help to inform future site-specific planning involving decisions relating to landscaping and building design. At the same time, the lessons learned in aggregate across the collection of these case studies can help to both identify appropriate city and regional policies regarding the built environment and to guide investment priorities.

Most of what proved to be successful design solutions were not the result of deliberate decisions made in anticipation of storm surges and flooding. For example, while elevation proved to be the key factor that determined whether a building flooded or not, many of the sites that were elevated above the floodplain had been raised simply to make formerly contaminated sites clean enough to accommodate residential uses. Waterfront parks were created to provide access to recreational and green spaces and to increase land values for residential development, not necessarily to provide a buffer between the water and buildings. Likewise, restoration of wetlands has historically been prompted by a desire to restore the ecological health and biodiversity of the region, not to attenuate wave action and support the draining of upland areas. That many of these actions grew out of the pursuit of social, economic and environmental sustainability – rather than from fear of storm surge – suggests a strong tie between the current sustainability agenda and physical resiliency.

These case studies also demonstrate the need for multiple levels of protection. Wetlands alone will not protect communities from storm surges, storm barriers may not be able to handle flooding from intense rainfalls, and beach dunes at some level of pounding will breach – any one of which could mean water reaching homes and businesses. Moving forward, as decision-makers decide which initiatives to pursue and which investments to prioritize, it is critical to keep in mind that there is no silver bullet for resilient communities, but rather a combination of thoughtful land use, design, regulation, and investment decisions by the private sector and government at the regional, neighborhood, and building scales.

Nearly half of New York City's waterfront is part of a network of parks and public spaces. Since 2002 alone, 373 acres of waterfront land have been turned into parks. The design of these parks has typically involved historic wetlands restoration and the integration of flood protection strategies.

# II. WATERFRONT PARKS



# II. WATERFRONT PARKS

# BROOKLYN BRIDGE PARK

## BROOKLYN, NY

***"During the early stages of the Brooklyn Bridge Park design process, careful thought was given to shoreline conditions and site location. Sandy was the first true test as to whether these design elements were successful"* – Regina Myer, President Brooklyn Bridge Park Corporation**


### Summary

During the planning and design phases of Brooklyn Bridge Park (BBP), the design team made a conscious effort to conceptualize a park capable of withstanding the impacts of storms and major floods. With this thinking in mind, the park's elevation, soil types, vegetation, edge design, and materials were all carefully selected and constructed. Superstorm Sandy was the first true test as to whether these design elements were successful in protecting Brooklyn Bridge Park during an extreme weather occurrence – which they were.


### Background

BBP is an 85-acre ribbon park along 1.3 miles of the East River shoreline, running from just north of the Manhattan Bridge to the foot of Atlantic Avenue in Brooklyn. The site once housed industrial warehouses. In 2002, Brooklyn Bridge Park Development Corporation (BBPDC) was established to oversee the planning, construction, maintenance and operation of the park. In 2004, BBPDC hired Michael Van Valkenburgh Associates (MVVA) and directed the firm to preserve the dramatic experience and monumental character of the industrial waterfront while reintroducing self-sustaining ecosystems to the site and investing it with new social and recreational possibilities. The role of planning, construction and park operations was transferred to the Brooklyn Bridge Park Corporation (BBPC) in 2010.

The multi-phased development of BBP began in 2008 and is expected to be complete by the end of 2013. In March 2010, Pier 1 and a portion of Pier 6 opened featuring a new park with playgrounds, lawns, a waterfront esplanade, and walking paths through dramatic changes in topography. Since then BBP has opened over 32 acres, including sections of Pier 5 and the area north of the Brooklyn Bridge. Another twelve acres of lawns, promenades, sports facilities, and waterfront beach access at Piers 2, 3 and 4 are currently under construction. When completed, BBP will include a waterfront greenway for pedestrians and cyclists, playgrounds, flower gardens, sport facilities, and numerous waterfront access features.

### Design Details

MVVA embraced sustainability in all of its guises and applied it across a range of spheres – ecological, structural, cultural, and economic. The park design includes a variety of salvaged materials and repurposed existing marine infrastructure, simplifying engineering solutions and reducing construction and maintenance costs. Guided by the concept of "post-industrial nature," the design uses bold man-made landscapes to kick-start new site ecologies that can thrive and evolve in a heavy-use urban setting.

*Topography*

The park design employs dramatic increases in topography to transform the site. By using hundreds of thousands of cubic yards of fill imported from the East Side Access excavation in Sunnyside Yards, the park's elevation has been increased throughout, reaching as high as 30 feet on Pier 1.

In addition, MVVA utilized a layered landscape design with multiple berms to create a new topography that acts as a barrier to flooding. MVVA took into


*Pier 1, Brooklyn Bridge Park*


*Granite from the Willis Avenue Bridge as terraced seating a*

consideration the water level predictions for 2045 and selected a minimum elevation of eight feet for root plantings. The elevation ensures that plants are more secure against sea level rise and salt intrusion. At the same time, the plants are able to protect the park from other storm impacts, such as wind.

*Horticulture*

In concert with the landscape shape, the plant selection varies with changes in topography and the distance from the water. In general, because of the proximity to a tidal estuary (the East River), the plant palette was specifically selected for salt tolerance. Plants such as rosa rogusa, pitch pine, and cottonwood are coastal plants that were chosen because they thrive in high-salt environments and have fared well against spray from the East River in the past. In addition, the soil profile selected for park use has a high sand content, which helps salts drain quickly.

Plants were also selected to enhance the reconstruction of a natural edge along parts of the park, including those that comprise the salt marsh at the southern edge of Pier 1. Smooth cordgrass, formerly very prominent along the Northeast coastline, has also been planted along the edges to provide habitat for ducks and other waterfowl who eat and live in the saltmarsh. With a high salinity tolerance, the cordgrass roots itself easily in this environment.

*Shoreline Stabilization*

The design for BBP includes several different edge types. As part of the park's construction, the designers replaced weakened bulkheads with rip rap, a natural looking edge made of big stones and rocks. Stone rip rap is much more durable than solid walls and does not fracture or break the way vertical-wall bulkheads may. Once complete, 4,045 linear feet of BBP's waterfront will have a gradual slope – or revetment slope – made of rip rap to help protect the coastline against wave action.

*Structural Stability*

Brooklyn Bridge Park's piers are the original structures built by the Port Authority of New York and New Jersey in the 1950s. Due to the constant tidal action, dry-rot fungus has degraded the timber piles. In order to extend the life of the piers, BBP is restoring the structures through pile encapsulation. By encapsulating the timber piles with concrete, they are protected from tidal shifts preventing fungus from thriving and further deteriorating the piles. To date, BBP has encapsulated over 1,900 timber piles, greatly extending the life of these piers.

*Sustainable Materials*

BBP's design includes materials that are not only salvaged, but also durable. Longleaf yellow pine wood, known for its tensile strength and salvaged during the deconstruction of the cold storage warehouses on the uplands of Pier 1, was used to build park benches and cladding for park buildings. Salvaged granite from nearby bridge reconstruction projects was used at Pier 1 as the seating material for the Granite Prospect as well as for a seating area above the rip rap at the marsh garden. Landscaping around portions of the Empire Fulton Ferry near "Jane's Carousel" also incorporated elements of salvaged granite. In addition, BBP used salvaged materials from the original Port Authority piershed frames as structural support at Pier 5 and Pier 6.

## Impact of Sandy

Brooklyn Bridge Park's strategic design elements and durable design materials along with some operational preparations allowed it to fare very well during and after Superstorm Sandy.

*Topography*

The topographical design enhancements of BBP brought the park out of the floodplain and helped protect the site from the debris and floodwaters that impacted surrounding and similar sites. At Pier 1, the Squibb Bridge and related construction equipment, which was along the ground waiting to be erected, was protected by the multiple-berm system of the park's topography, preventing serious damage before this park connection could be installed.

*Horticulture*

Careful landscaping choices of resilient, salt-tolerant species allowed BBP's horticulture to hold up against floodwaters and river spray. The plants at BBP ap-

rea for park visitors


*Underground stormwater recirculation tubes at Pier 6*

pear to be doing well in the months after the flooding from Superstorm Sandy. Thoughtful design placement and post-storm management contribute to BBP's optimism that the park's horticultural losses will be minimal.

While the long term effect of the salt water inundation during Sandy remains to be seen, BBP staff hope that their post-storm work will contribute to the survival of the park's horticulture. Immediately following the storm, BBP's horticulture team began flushing salt from the soils using the park's irrigation system. While salinity levels were high immediately after the storm, these levels quickly declined and staff believe the selection and maintenance of these plants was sufficient to ensure their ability to survive. Further, the nor'easter storm that followed Superstorm Sandy was a benefit for the park's plants, as the rain facilitated the flush of salt out of the soils.

*Shoreline Stabilization*

BBP staff believe that the park's natural and stabilized rip rap edge types were major factors in its ability to diminish the force of waves and withstand the storm. In addition to protecting the upland area, the salt marsh played an important role in filtering the stormwater while also allowing stormwater to quickly drain off the site.

*Structural Stability*

All of BBP's piers remained stable despite the storm surge and wave action produced by the storm. The encapsulation of the piles may have contributed to the piers' ability to withstand the storm and will likely aid in their long-term durability.

*Sustainable Materials*

Salvaged materials selected for durability proved to be resilient. Salvaged granite used as rip rap proved successful in protecting and stabilizing the landscape against storm impacts.

## Lessons Learned

BBP's performance during and following Superstorm Sandy has made it a model for waterfront developments around New York City to protect against future storms. Its combined strategies of elevated and varying topography, appropriate plantings, durable materials, and soft edges are key ingredients for the creation of more resilient waterfronts.

The park plan includes a handful of residential and commercial development sites along the park's urban edge to generate funds that will fulfill BBPC's mandate of being financially self-sufficient with respect to park maintenance and operational expenses. Many of the development sites are located at, or slightly below, the 100-year floodplain and experienced flooding during Superstorm Sandy. In addition to the park design elements already discussed, BBPC will work with developers of the sites to ensure that each of these projects incorporates the most up-to-date flood protection measures in their design to further enhance the site's flood resiliency.

Working together with the City of New York and the development community, BBPC has been closely monitoring waterfront developments around the City and has identified a series of flood prevention measures that have been most effective in minimizing negative impacts of the recent storm. BBPC is encouraging all developers of park development sites to incorporate as many of these measures into their designs as are feasible. These flood prevention measures include:

- Raising the ground elevation above and beyond the floodplain levels
- Placing mechanical and electrical equipment on higher floors
- Adding redundant mechanical and electric systems
- Adding flood-proof enclosures to minimize the penetration of water
- Using damage-resistant materials on the ground floor and basement.

The design for the Pier 1 hotel and residential development, recently awarded to Toll Brothers City Living and Starwood Capital Group, has already incorporated many of these measures. Going forward, BBPC will continue to track the latest building technology improvements to ensure that development projects in the park are at the forefront of flood resiliency.

# II. WATERFRONT PARKS

# BRONX RIVER PARKS: *Concrete Plant Park Soundview Park*

## BRONX, NY

***"The park is a floodplain, and it served the function of a floodplain very well during the storm. It absorbed floodwaters and in time released them back into the river, far better than the one-time concrete yard would have."* – Jim Mituzas, NYC Department of Parks & Recreation**


### Summary

Along the Bronx River, which flows 24 miles from Westchester County through the Bronx, there are various parks that together constitute the spine of the Bronx River Greenway. Many of these newly constructed parks have utilized effective design strategies not only for providing open space and recreational activities for neighboring residents, but also for essential flood mitigation and protection from storms like Superstorm Sandy. During Sandy, the parks did flood, as designed, and functioned as buffer zones for the surrounding neighborhoods - helping to protect them from flooding and debris. Meanwhile, the structures and landscaping within the park weathered the storm well, proving it is possible to program spaces that are designed to flood.


### Background

The Bronx River is the only freshwater river in New York City. The water that runs through it was once so "pure and wholesome" that during the 1820s and 1830s the New York City Board of Aldermen debated ways to tap into it to supply the growing city with drinking water.[1] When the New York Central Railroad was created in the 1840s, it turned the valley through which the Bronx River flows into an industrial corridor, causing the degeneration of the river into what one official at the time called 'an open sewer.' Starting at the end of the nineteenth century, reclamation projects began to prevent further industrial degradation. In 1888, Bronx Park was created, which includes the Bronx Zoo and the New York Botanical Gardens, and it was followed later by the creation of the Bronx River Parkway, which served as a means of buffering the Bronx River area from the impacts of urbanization.

Community groups began to rally around the river and work towards its restoration beginning in the 1970s. Building on these efforts to reclaim the river, the Bronx River Alliance, established in 2001, now coordinates a wide range of initiatives to restore the greenway and create a recreational, educational, and economic resource for Bronx communities. In partnership with the New York City Department of Parks & Recreation (DPR), the Bronx River Alliance manages programs to clean and restore the river and to create the Bronx River Greenway. Once complete, the Greenway will include a continuous bike and pedestrian path and provide opportunities for other recreational activities, such as canoeing and kayaking, along the entire expanse of the river. To date, the Alliance and DPR have developed eight miles of the Greenway and have added ten acres of parkland along the river.

Two of the parks, Concrete Plant Park and Soundview Park, provide good examples of how the Bronx River Parks are designed and constructed to restore the natural ecology, manage floodwater, and dissipate wave energy.

*Concrete Plant Park*

Concrete Plant Park sits along the western shore of the Bronx River in the Crotona Park East section of the Bronx, between Westchester Avenue to the north and Bruckner Boulevard to the south. The park opened to the public in October 2009 on a formerly abandoned site that had been home to a concrete batch mix plant from 1945 to 1987. In 1999 the site was saved from the auction block by community residents, led by Youth Min-

Source: NYC DPR

*Concrete Plant Park*

istries for Peace and Justice (YMPJ). Their efforts were supported by The Point Community Development Corporation, Bronx Community Board Two, elected officials and others who saw the site's recreational and environmental potential. Their efforts proved successful and DPR received jurisdiction for the property in August of 2000.

Since 2001, DPR and the Bronx River Alliance, in collaboration with community and public agency partners, have re-established salt marshes on riverbanks that were once strewn with trash and tires. Local organizations, such as the Alliance, YMPJ, Rocking the Boat, Sustainable South Bronx, and the Fannie Lou Hamer Freedom High School, support on-going activity at the park, including boating, youth workshops, water quality monitoring, and film screenings. The park received a $10 million capital renovation from 2005 to 2009.

*Soundview Park*

According to DPR, Soundview Park has been called the "Gateway to the Bronx River." The Park is located where the Bronx River opens into the East River. When the City of New York acquired the original 93 acres of land for this park in 1937, the entire area was composed of wetlands. Soundview Park, which was never completely developed after it first opened, was built on a landfill that buried the natural open water and marshland.

## Design Details

The design objectives for the parks of the Bronx River Greenway are to create beautiful spaces and recreational opportunities for the neighboring communities, clean the river and restore its natural ecology, including wetland habitats, and provide flood management for the parks and their surrounding neighborhoods. To achieve these goals, the land adjacent to the Bronx River has been cleaned, reshaped, and replanted.

The new shapes, created through excavation of fill and the building of berms (landscaped hills), allow the park to act as a floodplain that can hold and absorb floodwaters, while also filtering stormwater runoff from upland areas before it enters the river. Along the river's edge, hard surfaces have been replaced where possible with rock groupings (also called rip rap) and wetland areas. The rip rap and wetlands create softer river banks with slopes that are less steep than the concrete walls they replace; these two characteristics allow the river bank to absorb the energy from storm surges, making them less damaging to upland areas, and allow upland stormwater to more quickly drain away from the park and surrounding communities.

Plant species were chosen based on their flood and salt tolerance as well as their ability to mitigate soil erosion and absorb stormwater. The landscape architects have strategically placed these species so that those that are the most salt-tolerant are located along the river and low-lying areas, and those with greater water absorption properties that are less salt-tolerant are located higher up the slope.

Finally, to ensure the entire park is resilient, park amenities such as benches were located away from the river and constructed of durable materials.

*Concrete Plant Park*

Prior to construction, DPR's design team worked closely with community residents to develop a vision for the park, which centered on the idea of a "learning park" oriented towards passive use. The design objectives for Concrete Plant Park were to create space for community events, provide access to the waterfront for canoeing and kayaking, and re-establish the historic salt marshes on the riverbank. Similar to the other parks along the river, design also included measures to manage both stormwater runoff and river flooding. The design team wanted a minimalist design for the park that would enliven the green space, while maintaining its industrial past. As described by James Mituzas, landscape architect with the Bronx DPR team, the park was intended to be "an intertwining of the man-made and the natural with an on-site urban ruin." Park design elements such as open lawns and lounge chairs grouped in circles reflect this design approach.

In accordance with these objectives, the park now contains pedestrian greenways, bicycle routes, a new canoe/kayak launch, a waterfront promenade, a reading circle, and inviting park entrances at both Westchester Avenue and Bruckner Boulevard. Many of these amenities were set back from the water to limit exposure to potential flooding. The design team also chose materials for these amenities that were extremely sturdy, such as recycled concrete from the original site for the bulkhead of the new shoreline and retaining walls and recycled plastic lumber for the slats of the park benches. For flood mitigation, similar to other parks along the river, the land adjacent to the river was excavated to create a bowl shape and mimic the pre-industrial floodplain. The majority of the hard bulkhead that made up the river's edge was replaced with softer and more shallow slopes, such as rip rap and restored and expanded salt marsh areas. Currently, seventy percent of the shoreline of Concrete Plant Park is now comprised of soft edges, such as rip rap and wetlands. Where existing bulkheads were left in place, open green space was placed adjacent to the existing hard edged bulkhead to both help with flood management and to capture and filter stormwater runoff from upland areas.

Once the land was cleaned and shaped, DPR and the Bronx River Alliance planted greenery that furthered the park's design objectives and was in line with the site's original, pre-industrial landscape. To help capture stormwater and mitigate soil erosion, salt-tolerant beach grasses were placed close to the water and shrubs were placed along the upper slope of the river's edge.

*Soundview Park*

The design of Soundview Park focused on the restoration of the salt marsh. To achieve this, DPR worked with the United States Army Corps of Engineers (USACE) to excavate the existing landfill at the south end of the park to a more appropriate salt marsh elevation. The team then replaced the fill with sand, the ideal marsh wetland plant medium. While the new wetland park edge had a less steep slope than the bulkhead it replaced, the restored wetland was still constructed with a relatively steep grade for longer-term durability given rising sea levels. Finally, to protect the new salt marsh area from intense wave action, the team placed the wetlands within the perimeter of natural rock barricades.

As part of this project, after observing the growth of existing oyster reefs at the mouth of the Bronx River off of Soundview Park, DPR and the Bronx River Alliance built shellfish reefs to provide surfaces for new populations of oysters. Oysters can help clean and filter entering water over the long-term. If the shellfish bed is expanded in the future, the oysters could also help reduce wave energy from storm surges.

## Impact of Sandy

By the time Superstorm Sandy hit the Bronx, it was no longer high tide, which may have helped to minimize the storm's impact on the borough. However, design strategies to hold the water in various spots along the Bronx River nevertheless helped to reduce flooding to surrounding neighborhoods. With very few exceptions, the plants survived undamaged and park structures remained unscathed.

*Concrete Plant Park*

Concrete Plant Park's reshaped and greened topography allowed the park to capture a substantial amount of water from Superstorm Sandy that otherwise may have flooded the adjacent communities. Even more critical than the water capture at the site, parks to the north, such as Old Cricket Field, also provided large areas for floodwaters to be collected, reducing the amount of water flowing downstream. With more water collected upriver, less water flowed downstream into southern Bronx River Parks, like Concrete Plant Park, thus creating a more efficient absorption system all along the riverbank.

*Soundview Park*

Soundview Park experienced only minimal damage during Superstorm Sandy. Despite the newly planted site not yet having thorough vegetative cover, there was relatively minor sand displacement and plant loss on the slope of the Soundview salt marsh. Some upland plants that were not yet thoroughly rooted or were buried by sand were dislodged. Most erosion occurred at the high-water mark during the storm surge and the high tide immediately following the storm. The upland slope at the front edge of the project had been additionally secured with erosion control fabric, and that fabric was partially ripped up during the storm.

Some in the community believe the restored wetland and softer park edge may have reduced the storm surge impact on the surrounding Harding Park neighborhood, located in one of New York City's evacuation zones. The jetty that forms the water side of the Soundview "Lagoon" and the three acres of salt marsh at the toe of the slope may have reduced the wave energy in the Soundview salt marsh, possibly helping to reduce upland damage.

## Lessons Learned

The successful ability of the Bronx River Parks system to capture floodwater following Superstorm Sandy shows the benefits that historic floodplains and wetland restoration projects can provide to surrounding communities. In the case of Concrete Plant Park, this meant creating a space that could flood and detain water without damage, while also providing much-needed recreational opportunities for the community during dry weather. For Soundview Park, this meant restoring the salt marsh wetland to help attenuate wave action, re-establishing the area's original ecological community, and enhancing bio-diversity.

# II. WATERFRONT PARKS

# SWINDLER COVE, SHERMAN CREEK

## MANHATTAN, NY

***"These projects have immediate impact on the hydrology of the region and contribute to building a healthier, more diverse, and more resilient New York."* – Jason Smith, NY Restoration Project**

### Summary

The New York Restoration Project (NYRP) is a non-profit organization dedicated to restoring parks, community gardens, and open space in underserved communities throughout New York City. One of its early projects was to clean the former illegal dumping ground at Swindler Cove, a section of Sherman Creek Park, and transform it into a teaching garden.

After remediating the site, NYRP restored woodlands, wetlands, native plantings and a freshwater pond and built pathways for visitors to experience this natural area located in the dense, urban environment of Upper Manhattan. The strategic planting of trees, coastal scrub, and grass withstood the surge very well and helped retain floodwater and storm water runoff from the surrounding area.

### Background

The Sherman Creek Park is a network of public green spaces, located along the Harlem River on the east side of northern Manhattan, adjacent to the neighborhoods of Inwood and Washington Heights. Through a Memorandum of Understanding with the New York City Department of Parks & Recreation (DPR), NYRP is responsible for the maintenance and improvement of Swindler Cove at Sherman Creek Park.

NYRP's initial project at Swindler Cove began near a local public school, PS 5, where students were embarking on a gardening project. Between 1996 and 1999, NYRP started to remove garbage, rusted-out cars, sunken boats and other debris on this former illegal dumping ground and, in partnership with the Department of Transportation, NYRP embarked on a wetland restoration project and new park construction. As part of this effort, NYRP was able to reclaim five acres along the Harlem River as a recreational park with educational facilities.

Building on the restoration of Swindler Cove, NYRP developed a network of green spaces and facilities, including the renovated Harlem Esplanade, the Peter Jay Sharp Boathouse, and the Sherman Creek Nature Trail. In 2005, NYRP further invested in the revitalization of the area, collaborating with the City of New York Department of City Planning to expand public access and establish the Sherman Creek Center for educational programs.

Today, the site is an oasis of natural habitat. It includes one of the only accessible saltwater marshes on Manhattan's shoreline. Swindler Cove, at the heart of Sherman Creek Park, also contains a freshwater pond surrounded by woodland and wetland areas. The site is used by thousands of children as an outdoor classroom with a wide range of environmental educational programming.

### Design Details

The original objective of NYRP's initial Swindler Cove project was to clean the space and create an ornamental and teaching garden near PS 5, complemented by habitat restoration. However, in addition to garbage from the illegal dumping, the site had a number of environmental challenges that the restoration plan had to consider: topography, degraded vegetation, and confluenced fresh and salt water environments.


*Volunteers planting native perennials in Swindler Cove*


*Swindler Cove walkway with scrub and trees*

The site is very steep, with its topography ranging from sea-level wetland areas to over 13 feet in elevation near the school. Before the project, the site consisted of degraded vegetation and Siberian Elms, effective at limiting erosion but quite vulnerable to wind damage. The site's proximity to the Harlem River also added complexity to the restoration project given the overlap of upland fresh water systems and the low-lying salt marsh areas. Additionally, several riverfront sections of the Sherman Creek area, including Swindler Cove, are tidal and vulnerable to periodic flooding from the river.

Due to the impacts of sea level rise and the projected increases in severity of rain events and storm surges, these challenges will likely escalate. There is already evidence of a decline in health (and area) of the pre-existing and built saltwater marsh. There is also evidence of increased erosion and the appearance of changes in rates and location of siltation.

To improve the ecology and accessibility of the area, the restoration design had to address these challenges, and therefore aimed to mitigate the occurrence and the impacts of erosion, storm water runoff, and flooding. To address erosion, the design included shoreline stabilization and dense planting of native coastal vegetation. As a tidal park, a portion of the park is underwater daily with the change in the tide; as a result NYRP chose plants that are tolerant of water and salt inundation, such as spartina grasses, and manages the site flexibly to allow the most well-adapted native plants to increase in abundance. The landscape design also incorporated the park's existing Siberian Elm trees and new fast-growing ornamental trees including Callary Pear and Quaking Aspen trees.

Building on the success of Swindler Cove, NYRP implemented additional ecological restoration projects in Sherman Creek. For example, to reduce flooding and soil spill-out onto the adjacent Harlem River Drive, NYRP, along with volunteers, installed a swale along the way and introduced meadow plants. These attractive and low-maintenance plants are flood-tolerant and erosion-resistant under major water inundation.

### Impact of Sandy

Sherman Creek Park fared relatively well during Superstorm Sandy due in part to the selection of salt tolerant plants and the inherent tidal nature of the cove. However, it did experience some minor damage, reflecting the integration of some inappropriate plant species and the vulnerability of mechanical equipment.

While 75 percent of Swindler Cove Park was underwater during the storm, the heavy landscaping of traditional coast scrub and salt-tolerant shrubs proved very resilient in such extreme conditions. Physical structures in the park also fared well. The steel viewing area and bridge remained intact, despite being completely submerged in water during the storm, and the Peter J. Sharpe boathouse, built on piers, was able to safely float up and down with the water.

It is unclear whether the restored wetland helped to moderate the flood and damage from the storm surge; however, NYRP does believe the wetland helped to reduce the pollution that would have entered the Harlem River after the storm.


*Post-Sandy: High water on the day following the storm*

The wetlands and park area achieved this by both minimizing storm water runoff from upland areas and by filtering the pollution from the combined sewer overflow pipes that empty storm water and untreated human waste into the city's waterways. This overflow occurs during times of heavy rainfall when the collected water exceeds the capacity of the system.

The park and the nearby NYRP swale installation and plantings also helped to protect the Harlem River Drive from flooding. While the road was closed for a short period after the storm due to fallen trees, the planted swale and meadow vegetation prevented extended road closure due to flooding.

The minor damage incurred included the falling of poplar, elm, and aspen trees. These trees were incorporated into the project either because they already existed, such as the Siberian Elm trees that sprang up in the park decades ago when the park was neglected, or because of their fast-growing and ornamental characteristics, such as the Callary Pear trees. In many instances, the branches of these trees split and fell due to the wind. For others, the shallow roots of the trees could not handle the combination of the water inundation and wind and as a result the trees toppled.

There was also damage to the freshwater pond at Swindler Cove, which was inundated with salt water. As a result, the electrical equipment that recirculates water through the pond was destroyed. Without a working electrical system, the man-made pond could no longer maintain proper water level nor its ornamental waterfall.

### Lessons Learned

In Swindler Cove, tall trees with shallow roots proved inappropriate for this waterfront park. Marsh and other salt-tolerant plants utilized in suitable locations throughout Sherman Creek Park proved resilient to storm conditions and also, in combination with swale creation and wetland restoration, helped to mitigate flooding, erosion, and pollution for the surrounding area.

However, NYRP expects the impacts of climate change to continue to increase in magnitude. Riverfront flooding in areas like Sherman Creek will only become more challenging as the level of precipitation and severity of storm surges escalate. With rising sea levels, the wetlands' very existence is threatened with receding coastlines and the erosion of rip rap exacerbated by storms.

In the short term, NYRP will continue its efforts to improve all of Sherman Creek Park, including Swindler Cove, with the planting of coastal, salt-tolerant vegetation. It will continue to replace the Siberian Elm and Callary Pear trees in Swindler Cove Park with a variety of plants that require minimum levels of maintenance and have a high salt tolerance.

# II. WATERFRONT PARKS

# FRESHKILLS PARK

## STATEN ISLAND, NY

***"During Hurricane Sandy, the Fresh Kills landfill on Staten Island absorbed a critical part of the storm surge. Its hills and waterways spared nearby neighborhoods like Travis, Bulls Head, New Springville and Arden Heights much worse flooding."* – Michael Kimmelman, New York Times**


### Summary

The former site of the Fresh Kills landfill provides two primary lessons for waterfront planning and resiliency. First, it reveals how natural and man-made features, such as topography, wetlands, and open fields can block and absorb floodwaters from entering surrounding communities. Secondly, it underscores the importance of zoning undeveloped waterfront properties as parks and natural areas; these waterfront parks not only serve as buffers, but also ensure that more vulnerable uses are not located in low-lying floodplain areas.


### Background

Fresh Kills is located along the Arthur Kill on Staten Island's western shore and encompasses the Fresh Kill Estuary and the Isle of Meadows. Fresh Kills began operations as a landfill in 1948 and operated as New York City's principal landfill through 2001. Briefly reopened to house materials from the September 11th attacks, the landfill has now been closed for twelve years. Though known for its mounds of debris, the actual landfill footprint covers only 45 percent of the site; the remaining 55 percent is undeveloped and mostly consists of wetlands, creeks, and low-lying open fields.

The NYC Department of Parks & Recreation (DPR) is now converting the entire 2200-acre site into a public park as part of the world's largest landfill reclamation project. When complete, Freshkills Park will provide the region with a vast green space which includes outdoor athletic facilities, rain gardens, space for sustainable education programming, and more.

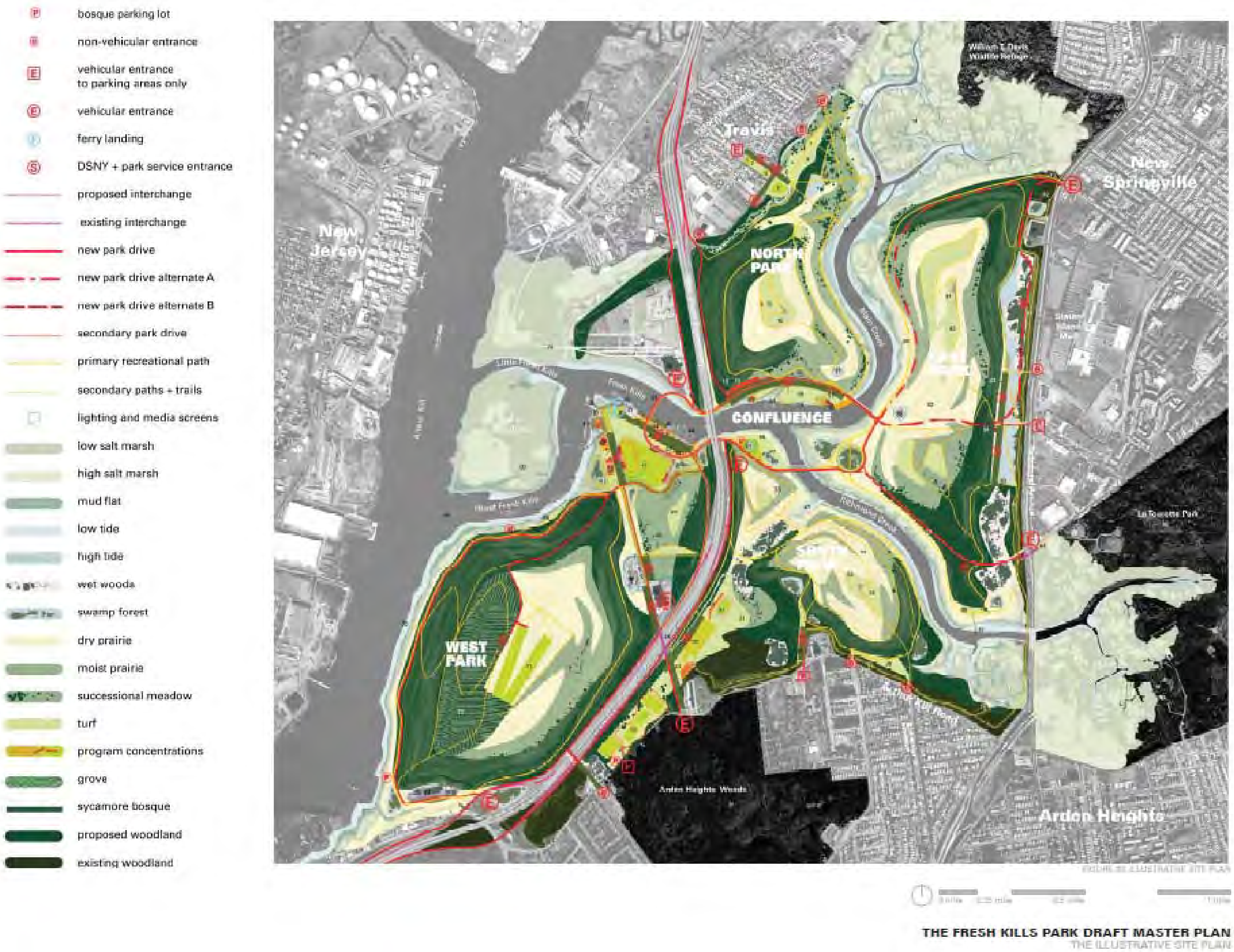
### Design Details

With Freshkills Park, the City aims to improve the quality of life on Staten Island and create a major new regional asset and destination. The Master Plan includes a variety of components to achieve three objectives: create new habitats and landscape types, provide a wide range of park uses and amenities, and facilitate connectivity and access. Existing natural resources and topography governed the planning and programming for the Park.

The creation of Freshkills Park is a multi-phased project that will take three decades to complete. Phase One, which will continue through 2018, focuses on community amenities at the perimeter of the park, public access to the interior of the site and programs that will showcase its natural beauty and stunning views of the New York City region. To date, completed work includes the renovation of two community parks, Owl Hollow Fields and Schmul Park playground, which will serve as entrances to the northern section of Fresh Kills Park. The first on-landfill park development in North Park will be bid in 2013 and a wetland restoration project will be completed in the summer of 2013.[4]

### Impact of Sandy

There was no significant damage to the Fresh Kills site from the storm. Other than a brief power outage, there was no effect on the infrastructure since the site was originally designed to deal with occasional flooding due to its location adjacent to the Arthur Kill. Storm surge debris (flotsam) came onto the shoreline, but did not cause any real damage to



Source: NYC DCP

*Freshkills Master Plan*

structures nor to the site's natural areas, including its wetlands, creeks, and fields.

Some locals credit the elevated height of the landfill mounds with mitigating the damage the storm surges could have caused to the nearby neighborhoods of Travis, Bulls Head, New Springville and Arden Heights.  Freshkills Park acted as a buffer to these communities, with the mounds providing a wall and the wetlands absorbing much of the storm surge floodwaters.[5]

Following the storm, the park temporarily operated as a transfer station to aid officials and relief agencies clearing debris from around New York City. Due to the park's ability to absorb or release much of the floodwater (unlike many of the city's other shoreline areas), it became one of the few large open spaces that could be utilized as a waste management area in clearing debris from severely damaged communities across the five boroughs.

### Lessons Learned

The site's history as a garbage dump and the stigma of the landfill likely kept the residential developments on Staten Island's western shore to a minimum, unlike the eastern and southern shores. Not only did the former landfill site act as a buffer from the storm surge, it also coincidentally helped to prevent dense shoreline development on Staten Island's western shore as compared to its more developed, and damaged, eastern coast. The success of this site provides a valuable lesson about coastal development in floodplain areas and reaffirms the wisdom of converting this closed landfill into a park rather than using it as a site for future commercial or residential development.

In the wake of the storm, DPR does plan to update the design of certain park components to further reduce the risk of flooding and damage to proposed buildings  on the site. Certain structures will be raised above ground, while others, including park concessions and entry areas, will require fortification to protect against any future floodwaters.


*Rendering of Freshkills Park development plan*


*Kayaking in Freshkills Park*


*Outdoor art exhibit at Freshkills Park*

# II. WATERFRONT PARKS

# GOVERNORS ISLAND

## NEW YORK HARBOR

***"Hurricane Sandy brought the future sooner than we expected and the power and height of the storm surge on the Island proved the importance of integrating resistance to the rising waters into the DNA of the park."***
**– Adriaan Geuze, West 8 Urban Design & Landscape Architecture P.C.**

### Summary

The first phase of Governors Island's new park and public space project, designed by West 8 Urban Design & Landscape Architecture, is currently under construction. Being a Netherlands-based company with an awareness of the long-term impacts of climate change, such as sea level rise and the increasing frequency and intensity of storms, West 8 has incorporated key storm-resiliency elements into its design for the Island. Superstorm Sandy put some of these already-implemented design elements to the test. The storm reemphasized the importance that elevation and flood-proofing have on the durability of the project.

### Background

Once just a small hill in New York Harbor, Governors Island was expanded during the early 20th century by the United States Army Corps of Engineers (USACE) to create a military outpost and supply base for the Army's ground and air forces. Depositing nearly 4.8 million cubic yards of fill from the excavation of the Lexington Avenue subway, the USACE created 103 additional acres of flat, treeless land. In 1966, the island was transferred to the Coast Guard for use as a self-contained residential community, with an on-island population of approximately 3,500, and as the base of operations for the Atlantic area. Thirty years later, in 1996, the Coast Guard abandoned the island and left it in the hands of the federal government.

By 2003, 22 acres of the island were declared a National Monument with the remaining 150 acres sold to the people of New York to be developed and operated by what is now the Trust for Governors Island (the Trust). Since that time, the City of New York has committed to investing over $250 million in the redesign and upgrade of Governors Island's park, public spaces and infrastructure. The multi-phase project began in May of 2012, with the initial phase focused on creating 30 new acres of park and public space throughout the island and adding key visitor amenities to the historic North Island.

### Design Details

When West 8 planned the park and public spaces, the designers were aware of rising sea levels and the projection of more frequent and intense storms. Therefore, West 8 designed a park that takes rising waters and storms into account, while allowing people to enjoy Governors Island's waterfront.

Northern parts of Governors Island benefit from higher natural elevation (it was a low hill in the middle of the harbor when explorers first arrived from Europe). This topography protects the historic buildings on this side of the island from flooding. The south side of the island, created with landfill from the excavation of the Lexington Avenue subway line, sits in the floodplain.

To protect the new park and adjacent development zones from flood levels, West 8 proposed the elevation of much of the southern half of the island. To date, construction crews have raised this area by as much as twelve feet above the existing grade and the plan is to add addition-


*Cleanup following Superstorm Sandy*

al feet of topsoil to further elevate the site and allow trees to be planted well above rising waters.

## Impact of Sandy

During the storm, floodwaters peaked at almost 13 feet above the mean sea level, equating to five to seven feet of storm surge over the existing seawall on the southern side of the island. Shipping containers, flotsam, jetsam, and other debris washed over the seawall and could be found throughout the southern end following the storm.

Nonetheless, Governors Island made it through the storm relatively unscathed. The natural topography at the northern end of the islands protected the buildings as expected. The elevation of much of the southern end of the island helped to minimize storm damage. Contractors parked their construction equipment on the elevated fill material, which protected them from flooding.

## Lessons Learned

Measures to address rising sea levels and more intense storms, incorporated into West 8's design strategy, proved to be worthwhile during the storm. The elevation of low-lying areas was crucial to protect the new park site from storm surge, debris, and flooding.

West 8 and The Trust for Governors Island will continue to implement storm-mitigation elements in the design and construction of Governors Island park and public spaces. For example, the Island's landscaping plan will place trees less tolerant of salt intrusions, such as those in Hammock Grove, at the higher elevations and more salt-tolerant species, such as London Plane, at the perimeter. Park amenities able to withstand storm surges and flooding, including street lights and benches, are being selected in order to minimize damage and ensure park safety after a storm.

In order to ease the force of waves during intense storms, the Trust will replace the seawall along the Island's southern and western edges with a new rip-rap revetment, built with large boulders. A second barrier – a precast concrete "seatwall" that will provide both erosion control and seating for visitors – will be constructed along the park's western edge. The seatwall will further mitigate the water's energy in case of a storm surge, thereby minimizing erosion. The softening of the edges will not only aid in mitigating the effects of major storm surges, but will also promote quicker drainage of floodwaters.


Source: West 8

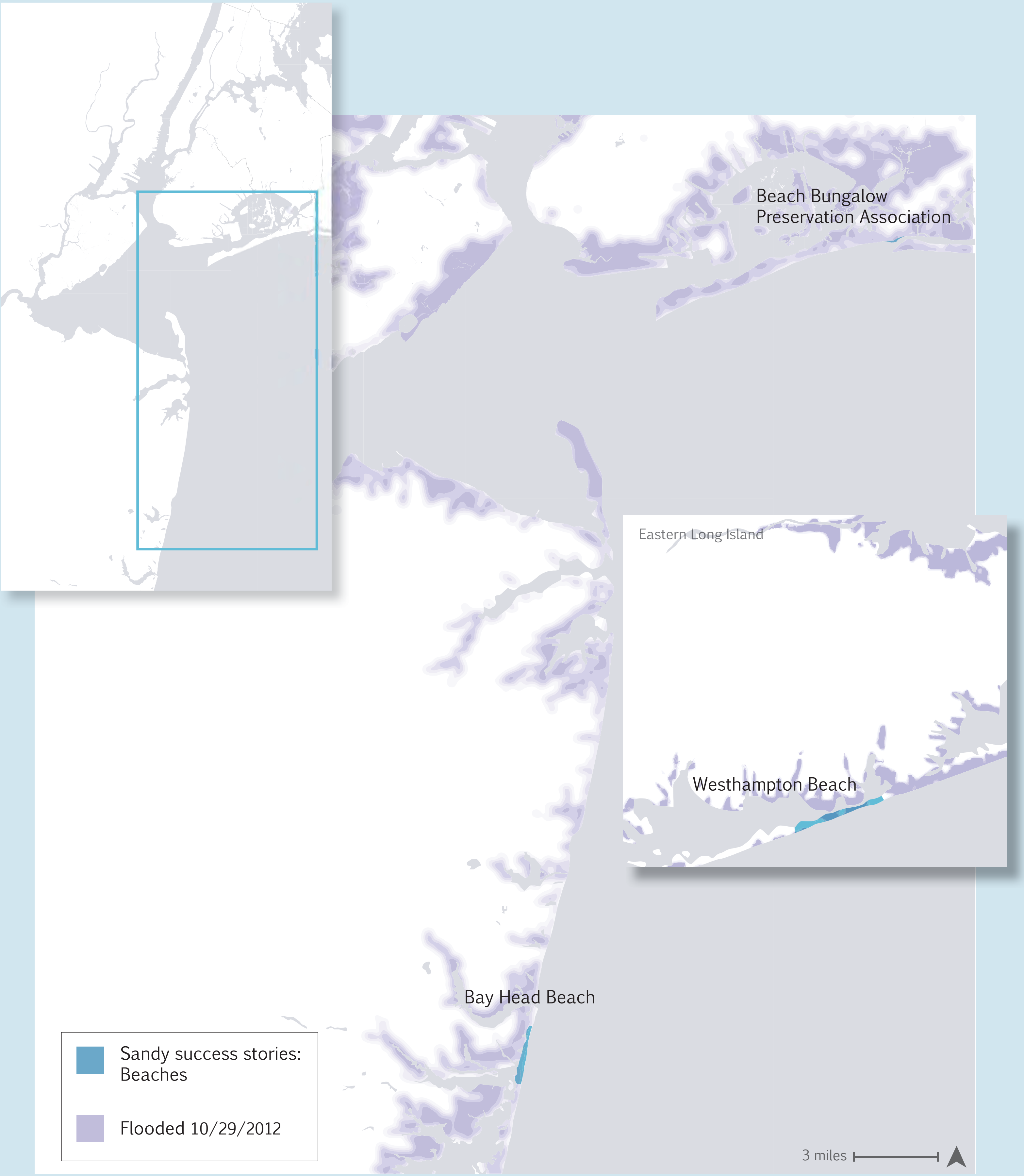
*Raised grade level accounts for 2 feet of sea level rise by 2100, allowing for new tree roots to grow above future flood elevation.*


Source: West 8

*Elevation diagram based upon Sandy Hook datum*

Across the region, proper building and maintenance of beach dunes were a valuable means of protecting beachfront neighborhoods. The building and maintenance of dunes often involves collaboration among multiple stakeholders, including different levels of government and public-private partnerships.

# III. BEACHES



Beach Bungalow Preservation Association
Eastern Long Island
Westhampton Beach
Bay Head Beach
Sandy success stories: Beaches
Flooded 10/29/2012
3 miles

# BEACHSIDE BUNGALOW PRESERVATION ASSOCIATION

## THE ROCKAWAYS, NY

***"The beach plantings multiplied and grew to form large dunes that were instrumental in protecting the bungalow community during hurricane Sandy."*** **– Richard George**

### Summary

The Beachside Bungalow Preservation Association (BBPA) of Far Rockaway implemented a community-based dune building and maintenance program that proved instrumental in protecting the neighborhood from the devastating damage that impacted neighboring communities.

### Background

The Beachside Bungalow Preservation Association in Far Rockaway, Queens, was created to organize and coordinate activities for the improvement of the neighborhood bounded by Beach 24th Street to the east, Beach 27th Street to the west, Seagirt Boulevard to the north, and the boardwalk. The organization is dedicated to the preservation of bungalows which comprise one of the last remaining bungalow colonies in Far Rockaway and along the Rockaway peninsula. The group received funding for neighborhood improvements, including murals and gardens, from the Vincent Astor Foundation in 1991 and, in 1992, received further funding for office space from the New York Foundation.

To protect its bungalow community, BBPA realized it must expand its focus to include beach preservation and storm protection. Nor'easter storms hitting the New York City area in the late 1980s to early 1990s caused significant beach erosion to parts of the Rockaways, reducing the area's protection from future storms. In response, the City of New York funded beach nourishment and dune-planting projects. After observing similar plantings in other neighborhoods, BBPA President Richard George believed that dune plantings in his community would help the dunes grow larger and make them more stable. With only limited city funding for beach plantings and beach nourishment, Mr. George decided to take the protection of his community into his own hands and create a program to plant beach grasses and trees between Beach 24th and Beach 27th Streets.

Between 1992 and 1994, BBPA received a grant from the JM Kaplan Fund and the New York State Department of Environmental Conservation (DEC) to purchase and plant salt-tolerant beach grass, black pine trees, and shrubs that were to be maintained by the bungalow community.

### Design Details

With guidance from the New York City Department of Parks & Recreation (DPR) and DEC as well as training from the Green Thumb program, BBPA decided to use its first grant to plant beach grass. BBPA purchased 100 shoots, at a total cost of $25 in 1992, and gave them to residents, including children, to plant on the dunes adjacent to the neighborhood north of the boardwalk from Beach 24th Street to 26th Street. Within a few months, the fast growing grasses covered the entire dune. The grasses and their roots, which grow fifty feet long in every direction, created a net that captured and held sand, significantly increasing the size of the dune.


*Beach grass transplanted in the mid-1990s*


*Grass and trees on Far Rockaway post-Sandy near Beach 2*

In 1994, building on the success of the first planting, BBPA received additional funding to increase plantings of woody plants, incuding black pine, beach plum, and bayberry trees from Beach 24th Street to Beach 27th Street, to the north of the boardwalk. Again, local residents aided in the planting effort. BBPA paid local residents to water and maintain the plantings through the hot dry summer for the first year. Once this planting was complete, the dune from Beach 24th to 26th Streets had grasses, shrubs, and trees, while the area west of 26th Street to 27th Street only had the shrubs and trees. The dune area with the grasses held the sand in place and, in a short period of time, the sand increased in height to the level of the boardwalk. In contrast, the dunes that did not have the grasses remained much lower than the boardwalk.

With a northern dune along the boardwalk established, BBPA worked with DPR and DEC to create a six-foot sand dune south of the existing dunes and closer to the water. BBPA hired a local contractor to transplant shoots from the northern dune and plant them in the new sand mound roughly every two feet. Thanks to the aggressive and rapid growth of these grasses and the aid of natural nourishment, including seeding from bird droppings, the grasses – along with a few new shrubs and trees – continued to grow and bolster the new dune's growth. This process helped to create a wide southern dune, also known as the primary or sacrificial dune, spanning the entire area between Beach 24th Street to Beach 27th Street and effectively creating a double-dune system.

## Impact of Sandy

According to local residents, during Superstorm Sandy waves were as high as fifteen feet during high tide. The southern dune between Beach 26th Street and Beach 27th Street was mostly washed away. With respect to the original northern dunes between Beach 24th and Beach 26th Street, where the community planted grasses and trees, the northern dune remained strong and protected the neighborhood from ocean flooding. The shorter northern dune area from Beach 26th to 27th Street, constructed later and planted with trees but no dune grasses breached during the storm surges. As a result, water from one ocean wave passed the lower northern dune and came onto Beach 26th and 27th Streets, causing some minimal flooding. By the time the breach occurred, it was the end of high tide, and the exposure to additional large waves had passed.

Ironically, the worst flooding in the area was not from the ocean directly, but rather from water traveling down Seagirt Avenue from neighborhoods to the west of Beachside Bungalow that had no dune protection and were subject to flooding (both from the sea and from Jamaica Bay to the north). According to community residents, the Beachside Bungalow neighborhood received about two feet of flooding from Seagirt Avenue and an additional two feet from the breach of the dune. However, this flooding went

*4th Street*


*Remaining dunes on Far Rockaway beach post-Sandy*

out with the tide, leaving this particular area of the Rockaways relatively unscathed.

In contrast, the ocean completely breached large dunes constructed on Beach 19th Street and flooded a ten-block stretch of streets to the east. This flooding, combined with the high water table from the bay, also flooded the sewer system resulting in water being pushed up into the streets and homes.

### Lessons Learned

In other areas of the Rockaways without any significant dune protection, flooding and sand moved past the beach directly into the neighborhoods. However, the double-dune system with the mix of grasses, shrubs, and trees between Beach 24th and Beach 26th Street did help protect the Beachside Bungalow neighborhood directly behind it. The southern sacrificial dune line met its intended fate after helping to attenuate the power of the waves and allowed the secondary and larger dune to remain strong and hold back floodwaters. Storm flooding that did occur resulted from the bay side and the breach of the dunes west of Beach 27th Street.

After the storm, the Beachside Bungalow neighborhood was grateful that it had invested in the dunes adjacent to its community. Moving forward, BBPA will continue to plant and cultivate dunes. It now knows that it is critical to plant a mix of species on dunes, including both grasses and woody plants. The grasses help the dunes grow larger and its roots help keep the dune in place, while the thicker root system of the shrubs and trees make the dunes stronger and help protect against strong wind gusts. BBPA plans to plant more seeds and grass shoots in spring 2013 so that they will grow in time for the next hurricane season. DPR is planning to work on mounding more sand to help recreate the southern dune, and BBPA intends to plant a mix of species on that new sand as well.

# III. BEACHES

# WESTHAMPTON BEACH

## LONG ISLAND, NY

***"This vulnerable area has been subject to a number of beach erosion control measures… Good stewardship of the beach and dune system will allow these measures to be maintained and provide the storm damage reduction purposes for which they were designed."* – Lynn M. Bocamazo, US Army Corps of Engineers**

### Summary

Due to the damage caused by previous storms, such as the December 1992 Nor'easter, the US Army Corps of Engineers (USACE), in cooperation with the State of New York and the Village of Westhampton, established a coastal storm damage reduction project and management plan that began in 1996 and will continue through 2027. The resulting sand accumulation and dunes were resilient to the intense wave action resulting from Superstorm Sandy, protecting the barrier island and its residents.

### Background

Westhampton Beach is located on the barrier island between Moriches Inlet and Shinnecock Inlet on the south shore of eastern Long Island. As part of the Fire Island to Montauk Point (FIMP) Beach Erosion and Hurricane Protection project initiated in 1965, the New York District of USACE developed a storm damage reduction plan for Westhampton that included construction of a groin field, a grouping of structures built perpendicular to the beach that limits the movement of sand and other material along the shoreline to reduce beach erosion. However, western portions of the Westhampton groin field were never completed and the existing groins were catching too much material, causing greater sand erosion to their west.

During a heavy nor'easter storm in 1992, the barrier island was breached in two locations. In 1994, in response to a long-standing lawsuit filed by local residents demanding that USACE complete the FIMP plan, the agency was mandated to mitigate severe erosion issues west of the existing groin field.

### Design Details

As a result of the lawsuit, in 1996, USACE established the Westhampton Interim Project (WIP) which incorporated a multi-pronged approach to mitigate future storm damage. This new initiative included periodic beach fill nourishment, dune development west of the groin field, and a tapering of the groins at the western edge of the field to support sand accumulation and reduce erosion to the west. The intention of these measures was to hold and accumulate sand along the beach to keep the beach intact and protect nearby properties and infrastructure.

The project included strategic deployment and nourishment of beach fill along the existing groin field. In intervals of four years, over two million cubic yards of sediment were placed throughout the western portion of the groin field and just west of the Westhampton groin field.

The project included the shortening and lowering of the final two groins and the building of an additional groin between them to create a tapered groin field in accordance with USACE procedures. The tapering of the groins on the western edge of the field was a new component intended to prevent these groin areas from trapping too much sand, which chokes off the sand supply for the dunes to their west, causing greater erosion. The tapering would allow the dunes to the west to receive and accumulate sand.

USACE also constructed dunes at the western end of Westhampton's groin field, as dunes had already naturally built up in the area between the more eastern groins. The dunes run 2.2 miles westward from the end of the groin field, reaching heights of 15 feet above the 1929 mean sea level with seaward and landward dunes slopes of 1:5 (1 foot vertical to 5 feet horizontal). In combination with the beach fill, the dune design was intended to withstand a storm occurrence of 2.3 percent, equating to a one in 44-year storm.

The dunes were supported with sand fencing along the crest and seaward slope. Dune walk-over and vehicle cross-over structures were incorporated in order to protect the growth of the dune against pedestrian and construction traffic. American beach grass was planted to trap the sand and allow sand to accumulate to increase dune heights over time. Thanks to seeds in bird droppings and wind, the dune vegetation was naturally seeded with additional grass species as well as shrubs and woody plants. This diversity helped to further fortify the dunes structures. By 2003, the dunes had grown higher than twenty feet above mean sea level in some areas, with widths between 71 to 125 feet. The increased width of the dunes was particularly significant in providing storm protection.

To comply with the conservation easement, the Village of Westhampton put in place zoning regulations in 1996 to require the 25-foot setback from the beach dunes to prevent the infringement of the dunes' landward slope. The regulation covered buildings as well as pools, fences, swing sets, and other accessories. Without this requirement, dunes were in danger of encroachment by property owners, which would result in their destabilization.

## Impact of Sandy

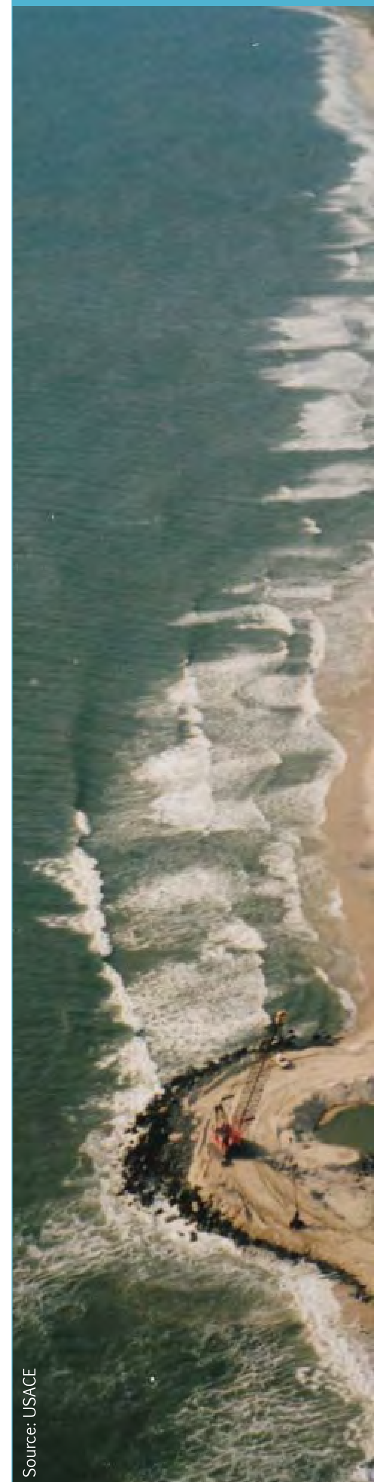
While the intensity of Superstorm Sandy and its surge had lessened by the time it hit eastern Long Island, the waves were still strong and capable of causing significant damage. The Westhampton dunes successfully held off the storm surges, protecting adjacent properties and infrastructure and providing sand to the beach. Although the wave intensity caused the WIP dunes to lose approximately 40 percent of their volume, the dunes did maintain their height. In other areas of the Westhampton beach, where an additional dune system grew independent from the WIP due to the cultivation by residents, the seaward dune – often called the primary or sacrificial dune – lost about 80 percent of the dune volume during the storm. In contrast, in one section of the beach where there is a vehicle access ramp and therefore a smaller dune, the waves overtopped the dune and flooded the adjacent area.

In addition to preventing the storm surge from causing water damage to beachfront properties, the dunes added to the resilience of the barrier island's cross-section, preventing another breach. There was also no damage to the groin field, and the tapered groin field design allowed movement of coastal material. However, the beach did lose a large volume of its beach fill and during the next period of nourishment in fall of 2013 more beach fill than initially planned will be required.

## Lessons Learned

The Westhampton Interim Project will continue until 2027, providing additional beach nourishment west of and within the western portion of the groin field. USACE estimates approximately 750,000 cubic yards of sediment will be added every three to four years or until the FIMP project determines an alternative, permanent solution for storm damage reduction in the area.

USACE, under the Fire Island to Montauk Point Reformulation Study, is also planning to shorten the groins to facilitate a decrease in stored sand material within the groin field. By trapping less sand, more of it can drift westward and act as a source of coastal material for the down drift beaches, potentially reducing the need for offshore nourishment. USACE will also continue to pursue more permanent solutions to reduce future storm damage. In the meantime, the organization anticipates the dune growth to continue due to the town's protective regulations, the diverse vegetation, and periodic nourishment. Continued success of the WIP depends upon continued stewardship in protecting the beach and dunes.


Source: USACE

*Construction of tapered groin field at Gr*

oin 14A, 1997 beach and new dune shown in background


*Groin 14 during re-nourishment in 2008 – vegetation in the background on the dune and berm*

# III. BEACHES

# BAY HEAD BEACH
## OCEAN COUNTY, NJ

***"Bay Head's community experienced varying degrees of damage, based not only on the height of the dunes but also dependent on piling construction, landscaping around the property, and how far the property was set-back from the beach."*** **– Jon Miller, Stevens Institute**

### Summary
A combination of an historic underground bulkhead, an out-dated seawall, and landscaped sand dunes provided varying degrees of protection for the coastal community of Bay Head in New Jersey during Superstorm Sandy.

### Background
Bay Head is located in Ocean County, New Jersey, just south of Point Pleasant. After the Ash Wednesday Storm of 1962, local residents who owned beachfront property along Bay Head's beach commissioned the construction of the seawall. That seawall extends along seventy-five percent of the municipality's coastline. This seawall was built on top of the existing wooden bulkhead whose foundation extends eight feet below the beach's surface. Over time, a dune system has developed above the seawall. The upkeep of the seawall, and of the dunes around it, remains the responsibility of the private property owners.

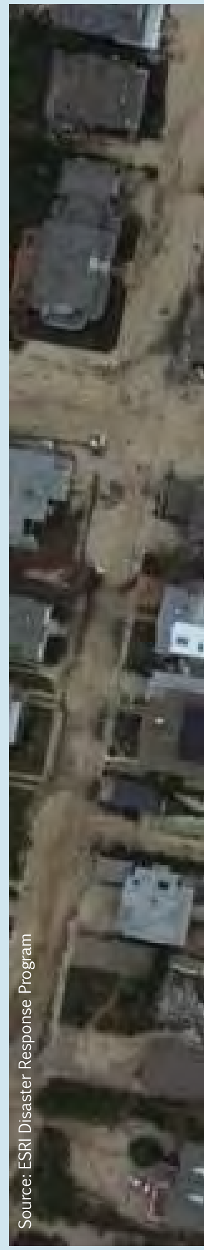
### Design Details
Bay Head's seawall was constructed out of rocks, shaped into a steep vertical wall. Steep seawalls result in strong wave reflection off the wall with a lot of energy, wearing away the sand at the base of the wall. The unstable shape of the Bay Head wall has required local residents to repair the wall over time, usually by patching areas with concrete to stabilize it and make it more pleasant for walking. (Today, seawalls are usually constructed with gradual slopes that have a larger base and smaller top; this design provides stability and helps mitigate beach erosion.)

However, two factors may have enhanced Bay Head's seawall. First, it was built on top of an existing wooden bulkhead that reaches eight feet below the pre-Sandy beach surface; this depth may have helped to provide stability and prevent the wall from tipping over. Second, the development of sand dunes on top of the seawall apparently helped to reinforce the structure. Before Superstorm Sandy, the sand dunes buried the seawall entirely in many places.

Given that upkeep is the responsibility of each property owner, the condition of the seawall and the surrounding dunes is not uniform: not all owners maintain each section to the same degree. Some property owners fortified their sections of the dune by planting grass and allowing the dune to grow up to four feet above the seawall. Others preferred to keep the dunes to a minimum.

### Impact of Sandy
Bay Head was one of the areas hardest hit by Superstorm Sandy. The storm eroded approximately six feet of sand from Bay Head's beach, exposing the entire seawall and all but two feet of the wooden bulkhead infrastructure. It even revealed pilings from a former boardwalk in some areas. The sand dunes were mostly washed away, except for some sections where property owners had planted and maintained them. Bay Head's community experienced varying degrees of damage, based not only on the height of the dunes but also on the nature of piling construction, the type of landscaping around the property, and how far the property was set back from the beach.


*Bay Head Beach, NJ before Sandy*




*Bay Head Beach, NJ a*

after Sandy

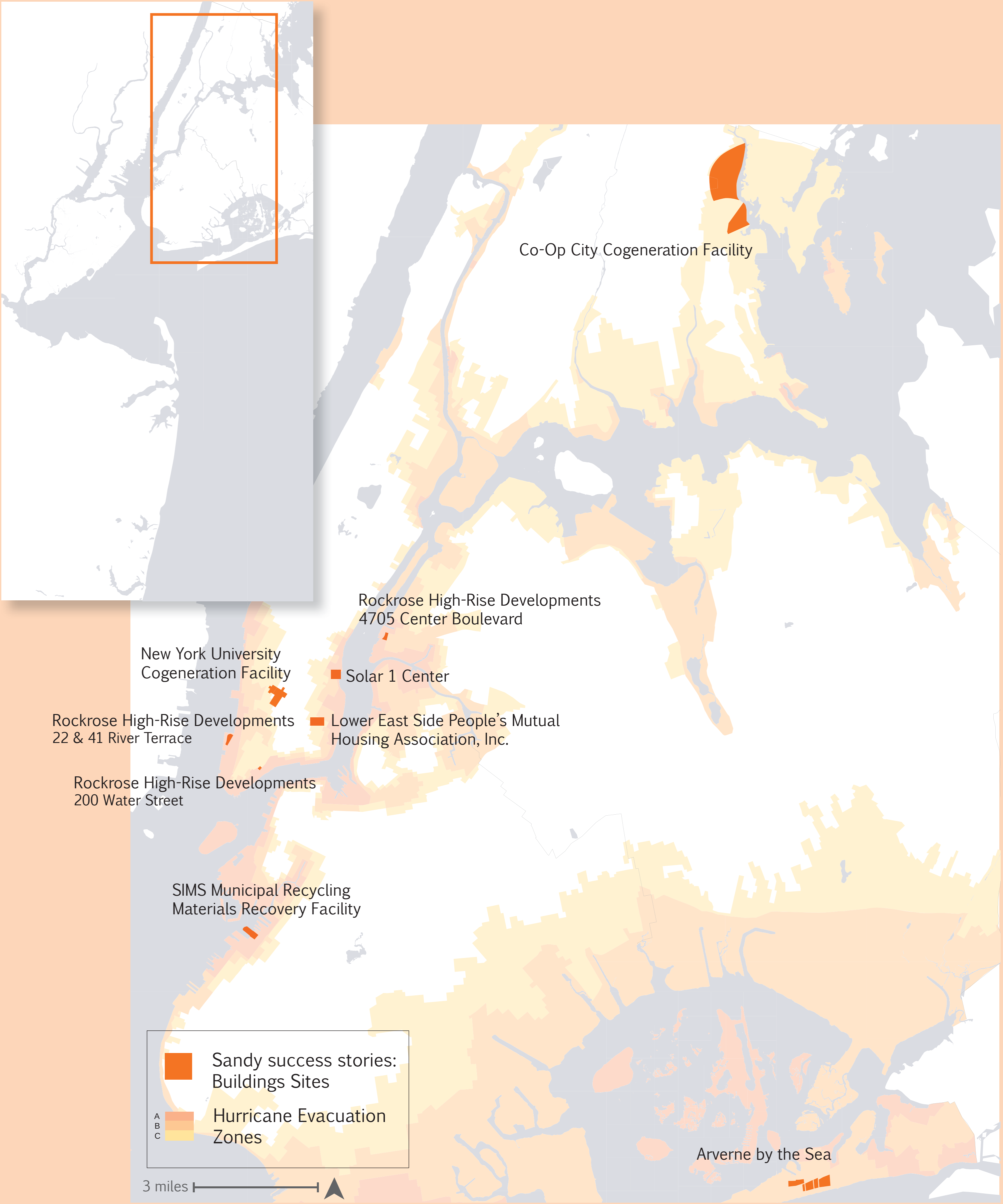
### Lessons Learned

The beachfront areas with the seawall and mature dune configuration generally did better than those areas that only had one or none of these components. Properties set back from the shoreline and those built upon pilings avoided serious damage to their homes. Those property owners who encouraged dune growth saw less damage and can relatively easily rebuild their sections of the dunes.

Residents of Bay Head intend to extend the existing seawall. The new portion of the seawall will incorporate a milder slope to better attenuate wave action. The seawall's design will also consist of careful interlocking rock placement to further bolster the new formation without the need for concrete infill, helping to achieve the milder slope while keeping costs down. The resulting dead space between the rocks will dissipate wave energy as it hits the porous structure, thereby better protecting the shoreline. With sea level rise in mind, the new seawall design will rise one foot higher than the existing wall to provide longer-term mitigation. Based on lessons learned from Sandy, experts are recommending that residents also build and maintain dunes along the entire beachfront area in front of the wall, covering the wall structure with sand to strengthen storm surge protection and reduce beach erosion.

Strategic site planning and building design decisions allowed many waterfront developments to weather the storm without significant damage. These developments included a variety of solutions that enhanced resiliency, including site grading, strong foundations, water tight sealing, elevated equipment, energy efficiency measures, and on-site energy production, including cogeneration and solar.

# III. BUILDING SITES



# ARVERNE BY THE SEA

## THE ROCKAWAYS, NY

***"The varying scales of defense from the water to the property lines played a crucial role in mitigating the surge in this area of the Rockaways."*** **– Gerald Romski, Benjamin Development Company**


### Summary

Arverne by the Sea is a large master-planned mixed-use community along Rockaway Beach in Queens. While the first phase of the development was built on the existing street grid and tied into the existing infrastructure, later phases were built at higher elevations and integrated storm and flood management systems. Following Superstorm Sandy, the newer development areas fared much better than the older one due to the multi-level approach to storm and flood protection.


### Background

Arverne by the Sea is a development of six residential neighborhoods on the Rockaway Peninsula in Queens, bordered by Beach 80th Street to the west, Beach 62th Street to the east, Rockaway Freeway to the north, and Shore Front Parkway and the new Beachfront Road to the south. In total, it comprises 2,300 two-family houses and condominiums, over 100,000 square feet of retail space, and community amenities, including a new YMCA, parks and playgrounds. In 2004, the development team, a partnership between the Benjamin Companies and the Beechwood Organization, began construction on the first two developments, Ocean Breeze and Palmer's Landing. Both of these neighbourhoods are located north of Rockaway Beach Boulevard. Construction on the remaining four neighborhoods (the Sands, the Breakers, the Tides, and the Dunes) began in 2007, following the construction of new roads, new storm and sewer management systems, a new beach front preserve, the importing of fill, and the re-grading of the site.

### Design Details

Many of the design decisions that impacted performance at Arverne during and after Superstorm Sandy were based on findings and recommendations that came out of the development's environmental review process, also known as City Environmental Quality Review (CEQR). Analysis undertaken during that process led to approval for the developers to use existing storm and sewer infrastructure for two of the proposed neighborhoods (Ocean's Breeze and Palmer's Landing). As a result, the developers built these two neighborhoods on the existing street grid and tied them into existing infrastructure systems.

However, the NYC Department of Environmental Protection (NYC DEP) did not feel the city's existing infrastructure could handle the load for the remaining portions of the development, and the developer was required to build new storm and wastewater infrastructure before constructing the other four new Arverne neighborhoods. For these neighborhoods, all located south of Rockaway Beach Boulevard and across Shore Parkway and the new Beachfront Road from the beach, the NYC Department of Housing Preservation and Development (NYC HPD) also required the developers to analyze the impact of rising sea level and integrate strategies to protect the development from related storm impacts.

Following the environmental review process, the development team began construction of the two neighborhoods that would connect to the city's existing infrastructure, while simultaneously constructing the new infrastructure sys-


*Arverne by the Sea community site plan consisting of six development sites*

tems to support the other four neighborhoods. Although the construction of new infrastructure required significantly more time as well as additional investment, it did provide the opportunity to integrate various flood and storm protection measures relevant to oceanfront communities into the plans.

The development team, with experience of designing new buildings to handle hurricane conditions in Miami, designed the development around multiple levels of protection. The first level of protection is the beach, which is relatively wide in front of Arverne by the Sea. The next level of defense would come from the adjacent wooden boardwalk, which would absorb some of the power of a storm surge. Behind the boardwalk between Beach 73rd and Beach 62nd Streets, the development team constructed a new beachfront preserve that includes sand dunes with grasses holding the dunes in place and a mix of shrubs and trees that can break up the surges that move beyond the boardwalk.

To the north of the preserve, the Arverne development team introduced a new road, Beach Front Road, as part of its stormwater system. The road is designed to drain floodwaters into a new stormwater outflow before the water flows to Arverne's residential properties. The next line of protection is the development's higher elevation. The developers imported over 1,000,000 cubic yards of fill to cover the new underground infrastructure and elevate the development from flooding, and then strategically graded the fill as part of its stormwater management system. This system includes underground chambers to receive water from the wide street mains connected to large sewer mains.

Finally, the developers designed each Arverne building to be resilient to flooding and storms. Each property has its own stormwater detention and retention system, consisting of two large drains in the front and back of each house connected to the same large sewer mains installed by the developer. The homes were constructed on concrete-slab foundations grounded by wood pilings. They do not have basements, as basements are prone to flooding. The developers included cement-composite shingles to cover the steel-framed structures and equipped each house with hurricane-grade windows. Lastly, the developer installed new power lines underground with submersible transformers to avoid electrical outages due to extreme wind and damage caused by flooding.

### Impact of Sandy

During and following the storm, the two older neighborhoods of Arverne by the Sea incurred some damage. The buildings in Palmer's Landing and Ocean's Breeze had two feet and three feet of flooding, respectively. While some of this damage was due to the fact that these developments are located closer to the bay side of the peninsula, where much of the flood damage occurred, the developers believe that this damage could have been minimized had these building been elevated and tied into a new stormwater management system.

The newer beachfront properties at Arverne came through the storm with damage limited to some shingle loss and minor street flooding. While the boardwalk was destroyed and both the preserve and Beach Front Road were covered in sand, these protective barriers in combination with the newer development's higher elevation and new stormwater management system prevented the flooding seen in the older communities. Additionally, while Arverne by the Sea did lose power as a result of Sandy, electricity was restored more quickly than in other Rockaways communities due to the underground power lines and the fact that water did not reach the electrical meters.

### Lessons Learned

Arverne by the Sea incorporated a range of protective measures in mitigating storm and flood damage. Incorporation of heightened elevation and advanced storm water management systems proved to be a leading factor in protecting the newer developments of Arverne by the Sea. The developers believe that if they had designed the newer Arverne neighborhoods just six inches lower, the level of damage could have been significant. Additionally, they believe that the varying scales of defense from the water to the property lines played a crucial role in mitigating the surge in this area of the Rockaways.


*Aerial view of Arverne by the Sea displaying the multiple levels of protection from the beach to the developments' doorstep*


*Destroyed boardwalk near Arverne by the Sea*


22 and 41 River Terrace


200 Water Street


4705 Center Boulevard

# IV. BUILDING SITES

# ROCKROSE HIGH-RISE RESIDENTIAL DEVELOPMENTS

## MANHATTAN and QUEENS, NY

***"The location of mechanical equipment above the first floor was critical; it helped avoid costly damage to equipment and allowed for building operations to resume quickly."* – Paul Januszewski, Rockrose Development Corporation**


### Summary

Rockrose Development Corporation owns and manages dozens of residential, commercial, and mixed-use buildings in Manhattan and Queens. At least four of its residential buildings are located in flood-prone areas that FEMA's Flood Insurance Rate Map identifies as Zone A, including in Lower Manhattan and Long Island City. However, with a combination of luck and strategic design decisions, these buildings experienced minimal damage during Superstorm Sandy.


### Background

Rockrose Development Corporation owns four residential buildings in flood-prone areas of New York City: 4705 Center Boulevard, Long Island City, 22 and 41 River Terrace, Battery Park City, and 200 Water Street, between John and Fulton Streets, Manhattan. The flood protections in place vary from development to development, based on their locations, histories, and current uses.

*4705 Center Boulevard* is located along the East River in Long Island City, Queens. The development of the site is part of a cooperative undertaking of the State of New York and the Port Authority of New York and New Jersey to remediate and redevelop 74 acres of former industrial property into a new waterfront community, called Queens West. The Queens West Development Corporation (QWDC), a subsidiary of the Empire State Development Corporation, is responsible for the redevelopment project, and to date has designed and constructed public streets and utilities for the site as well as ten acres of public parkland and recreation areas between the East River and the new community. Selected developers have constructed nine residential buildings, including 4705 Center Boulevard (opened in 2007), along with 120,000 feet of retail and a public school. The current construction phase of the redevelopment includes two additional residential buildings, one new acre of parkland, a second public school, and a library.

*22 and 41 River Terrace* are located in Battery Park City, a 92-acre community along the Hudson River in Lower Manhattan, built on top of the fill. Battery Park City is managed by the Hugh L. Carey Battery Park City Authority, a New York State public benefit corporation charged with the planning, creation, coordination and maintenance of the mixed-use neighborhood. Parcels of land are leased to developers who build in accordance with the Authority's guidelines, including green provisions to maximize energy efficiency and minimize water usage.

*200 Water Street* is a 32-story building located adjacent to South Street Seaport in Manhattan's Financial District. It was designed by the famed Emory Roth & Sons and is best known for its iconic 50 foot high digital clock created by Rudolph de Harak. In 1971 it opened as an office building and in 1997 Rockrose purchased it and converted it to high-end residential use.

### Design Details

*4705 Center Boulevard*

Given the industrial history of the Long Island City waterfront, the new Queens West neighborhood, including the 4705 Center Boulevard site, required significant brownfield remediation before con-

*41 River Terrace*

*4705 Center Boulevard*

struction. Contaminated soil was carted away and enough clean fill was put in its place to elevate the building site four feet above the mean high water line. Because of the former contamination and fill, 4705 Center Boulevard was built without a basement and therefore all of the building's mechanical equipment is located on the first floor.

The QWDC and its landscape architects designed the waterfront park adjacent to the building to optimize views, maximize community amenities, and provide passive areas for relaxation. Originally, in 2001, the master plan for the development called for a narrower park that would run adjacent to a new road that would divide the development's buildings from the waterfront. Rockrose proposed that QWDC increase the width of the park by both eliminating the road and moving the buildings further back from the water in order to provide a more enjoyable atmosphere for future residents and improve the value of the development. This change was incorporated into the final design of the park, which now has a width of 125 yards and includes landscaped areas for lounging, sports facilities, picnic areas, a public waterfront esplanade, grassy passive recreation areas, wetlands plantings, and a community garden. The park also includes a landscaped berm, or hill, to separate the public waterfront park from the residential development. This berm peaks at nine feet above the bulkhead, for a total height of thirteen feet above the mean high water line.

*22 and 41 River Terrace*

22 and 41 River Terrace and the rest of Battery Park City have been built on top of fill from the original World Trade Center site and from dredging of the harbor. With this fill, the entirety of Battery Park City rests at a higher elevation than the surrounding areas. Additionally, there is a waterfront esplanade along the entire length of the community and a series of passive and recreational park areas between the river and the development's buildings. Nelson A. Rockefeller Park is adjacent to 22 and 41 River Terrace and includes Battery Park City's most expansive lawn area and several gardens.

*200 Water Street*

Unlike the other three buildings, 200 Water Street was not built upon elevated fill and did not benefit from landscaped buffer between the site and the waterfront. However, the building has one key resilient feature: its mechanical equipment was located above the first floor of the building by accident of history. Designed with a small basement, the building was expected to connect to the Con Edison steam system for heat, hot water, and air conditioning services. When Rockrose purchased the building, the company


*Rip rap along the water's edge at Gantry Plaza State Park*

decided it would make more economic sense to disconnect from the steam system and instead install boilers and chillers in the building. Since the basement was too small to house this equipment, Rockrose placed this equipment on a mezzanine above the first floor.

### Impact of Sandy

Due to a variety of factors, 4705 Center Boulevard, Queens West and the two Battery Park City buildings experienced virtually no damage from Superstorm Sandy. Rockrose believes this was due in part to the sites' elevation, protective landscaping, and their lack of basements, which together protected against both surge and flood-related damage.

While residents at 4705 Center Boulevard did not experience any disruption in building services, those in Battery Park City did experience a few minor inconveniences. Although Battery Park City did have power after the storm, the surrounding neighborhoods did not making it difficult for workers and residents to get supplies. Additionally, 41 Terrace, which is located just 40 feet from the water, did experience approximately seven inches of flooding when water began to seep through the concrete foundation. However, since the building had power, building staff were able to pump the water out quickly, minimizing any damage.

200 Water Street did sustain significant water damage from the storm and, due to its location, was without power for weeks. The cost of running generators and repairing elevator equipment and other damage to the lobby area was approximately $2.5 million. This cost would have been three times as much had there been mechanical equipment in the basement. Unlike many of its neighbors, 200 Water Street avoided the need to purchase expensive replacement equipment and was able to reopen less than four weeks after the storm.

### Lessons Learned

As demonstrated by all four buildings, the location of mechanical equipment above the first floor was a critical factor that helped avoid costly damage to equipment and allowed for building operations to resume quickly. Based on this lesson, Rockrose plans to elevate its mechanical and electrical equipment wherever possible in new projects located in flood-prone areas, and simultaneously make equipment rooms as flood proof as possible.

On a neighborhood scale, 4705 Center Boulevard and 22 and 41 River Terrace demonstrate the critical role that waterfront parkland, site elevation, and strategic landscaping can play to protect waterfront developments from storm surges, flooding, and debris.

# LOWER EAST SIDE PEOPLE'S MUTUAL HOUSING ASSOCIATION, INC.

## MANHATTAN, NY

***"Sandy was an important warning sign for the affordable housing field. We must make a commitment to strategic reinvestment in long-term sustainability and resilience for affordable housing and the organizations that steward it."*** **– Enterprise Community Partners**

### Summary

The Lower East Side People's Mutual Housing Association (LESPMHA) has a typical affordable housing portfolio: a combination of older, inefficient buildings and newer, energy-efficient buildings. Often stressed under normal circumstances, older, inefficient buildings are especially vulnerable in times of crisis. LESPMHA's newer, energy-efficient buildings provide an example of how these vital community resources can be built to be stronger and more resilient in the face of climate change and devastating weather conditions. At the same time, LESPMHA's story illustrates the critical value of organization-level preparedness to manage and mitigate the impact from natural disasters.

### Background

The Lower East Side People's Mutual Housing Association, Inc. was founded in 1987 to provide long-term affordable housing to the residents of New York City and to preserve the Lower East Side as an economically and ethnically-integrated community. Since 1990, LESPMHA has renovated, owned, and managed twenty seven previously vacant buildings, constructed two new buildings (60 and 46 apartments), and provided building management and maintenance services to other private for-profit and not-for profit housing providers. LESPMHA currently manages 650 units of affordable housing, many of which are affordable to very low-income residents.

### Design Details

LESPMHA was an early partner in Enterprise's Green Communities Initiative, and its newer buildings are among the most energy-efficient buildings in Enterprise's portfolio. Many energy efficiency strategies have also improved the resiliency of these new buildings. For example, locating a boiler on the roof, rather than in the basement, makes buildings less vulnerable to flooding. Having an extremely well insulated and air-tight building will allow it to retain comfortable temperatures for residents in extreme heat or cold without resorting to the use of energy-dependent mechanical climate controls for heating or cooling.

Additionally, in both the newly constructed and the older, renovated buildings, LESPMHA identified flooding of the building as a vulnerability and therefore had procedures in place to prepare the buildings for storms and to respond directly after a flood, a utility outage, or both. These procedures went into effect prior to the storm. Staff took precautions by shutting down all major mechanical appliances susceptible to electrical surges and ensured that elevators cabs were positioned above the ground floor. With great foresight, LESPMHA also developed and implemented an extensive communication strategy involving the organization's management staff, maintenance staff, and residents so that when electrical service and telecommunication networks went down, LESPMHA was able to effectively communicate with its maintenance staff and residents to ensure timely and effective recovery.

### Impact of Sandy

The Lower East Side experienced significant flooding during Superstorm Sandy, as water rose above basement floors throughout the neighborhood. LESPM-


*Flooded boiler*


*Flooded boiler*

HA's newer buildings that had boiler rooms located on the roofs sustained minimal damage. Even with power out in the neighborhood, residents were able to stay warm thanks to the good insulation and air sealing of the buildings. No other building services were affected by the storm.

In the older affordable housing developments managed by LESPMHA, ten basements flooded. In five buildings, comprising 76 low-income apartments, mechanical systems were severely damaged – including hot water heaters, booster pumps, compactors, elevators and electrical wirings. However, the operational response of the buildings' staff helped get these buildings operational quickly and prevented mold growth.

LESPMHA, like many community-based affordable housing operators in New York, is a lean organization, with its staffing and financial capacity optimized for day-to-day operations, and stretched thin in times of crisis. Despite these challenges, LESPMHA staff was able to draw on experience gained from managing their newer buildings in order to respond quickly and effectively to the needs of the damaged buildings. They were also able to use their knowledge of building science to minimize flood damage.

Since LESPMHA had prepared for flooding as a possibility, once it actually happened staff moved into response mode right away, following established procedures regarding communications and swiftly restorating basic building services. Staff mobilized early to bail floodwater from basements manually or with generators and entered basements with flashlights to get part numbers and procure replacements so that they could have them on hand for repairs, thus minimizing the down time. As soon as power was restored to the neighborhood, the group began and completed work to restore building systems. Because of LESPMHA's focused early response, boilers could be put back in service with repairs rather than full replacement, saving capital and allowing staff to hold off on equipment replacement until the end of the system's life or a planned energy efficiency upgrade. Having to undertake repairs rather than buy and install replacements saved not only time and money; it also shortened the discomfort for residents.

Staff applied basic building science to help in the recovery, using the stack effect to help dry the basements that were severely flooded. Building staff opened fresh air pathways to circulate the moisture out of the basement, up the stairwell through roof bulkheads and out of the building. Due to this quick response, LESPMHA was able to quickly dry all the basements and substantially mitigate the possibility of mold forming there. The key to avoiding mold was the speed of clean-up and the ability to use nature to help dry the flooded basements.

### Lessons Learned

Enterprise continues to work with LESPMHA on its medium- and long-


*227 East Third Street*

term repair and resilience needs. Moving forward, the two organizations are developing a capital plan for retrofits to the affected buildings (including moving key building systems out of basements vulnerable to flooding) and assembling capital sources to fund these retrofits. LESPMHA will also apply through Enterprise's Resiliency Request for Proposals to be part of a peer-group learning network of affordable housing owner/operators, ensuring that other organizations benefit from their experiences and lessons learned.

# SIMS MUNICIPAL RECYCLING MATERIALS RECOVERY FACILITY

## BROOKLYN, NY

***"We always planned to take into account sea level rise and storm surges into the design in order to safeguard our investment over the long-term. It just makes good business sense."* – Tom Outerbridge, Sims Metal Management**

### Summary

The construction site of the future Sims Municipal Recycling Materials Recovery Facility (MRF) in Sunset Park, Brooklyn incurred minimal damage from Sandy due to the development team's decision to significantly increase the elevation of critical portions of the site. While site plans include various measures to make the MRF more environmentally friendly, the decision to increase the elevation was a business one: Sims Municipal Recycling (Sims), a division of global recycler Sims Metal Management, wanted to protect its long-term investment from rising sea levels and intensifying storms. Sims also proved that being prepared for extreme events like Sandy does not have to be expensive. The company's use of fill made of recycled material allowed the site to be elevated effectively and relatively cheaply.

### Background

The Sims MRF will serve as the principal processing facility for all of New York City's curbside metal, glass, and plastic recyclables as part of a long-term contract (up to 40 years) with the NYC Department of Sanitation (DSNY). The site is located on the waterfront on a former police impoundment parking lot in Sunset Park, Brooklyn. With this location, the Sims MRF will leverage barge and rail transport, which will help to minimize the amount of truck traffic through the city's neighborhoods, thereby reducing related truck pollution. In addition to supporting the city's improved waste management and air quality goals, Sims aims to create a state-of-the-art high-performance, sustainable facility, which includes measures to protect its $44 million investment from rising sea levels and future storm intensification. This protection was important to the development team, given the fact that the original pier, surrounded by the Gowanus Bay on three sides and constructed on historic fill, did not have adequate elevation to protect it from flooding in the event of sea level rise and intensified storm surges.

### Design Details

Early on in the life of the project, Sims committed to follow high-performance green design guidelines in developing the site. As part of this commitment to sustainability, the project team and its architect, Selldorf Architects, integrated renewable energy generation, on-site stormwater treatment capability, and native landscaping into the site master plan. Along with these features, the design focused on elevation and grading, varying waterfront edges to make the site more resilient to rising sea levels and future storm intensification.

In designing these features, the development team agreed that it could not base its plan on existing flood zone maps on the basis that they would soon (within 40 years) be out-of-date due to predicted rising sea levels. Accordingly, the design called for raising the elevation of those portions of the site allocated to buildings and recycling equipment by approximately four feet above the standard high-tide mark.

Sims took advantage of the fact that they were elevating portions of the site to create a grading scheme that resulted in a gravity-based stormwater management system. The grading plan had to account for rail and street connections and access to the site. To meet fill and grading requirements, Sims used an infill mixture consisting of crushed glass from the City recycling program and crushed stone or "mole rock" from tunneling operations associated with the Second Avenue Subway and East Side Access Tunneling Projects.

The landscaping plan was designed to support stormwater management and make the site more attractive for the surrounding community. Given the waterfront location of the site, the development team selected salt-tolerant vegetation, capable of surviving salt air and the occasional dousing of salt water and requiring little to no maintenance over time.

To support a marine-based operation with the necessary water depth for barge and tug operations, it was necessary to build a wharf and dredge the area along the south side of the pier. As part of the permitting process for approval to dredge, the New York City Economic Development Corporation (NYCEDC) developed a mitigation plan to replace the intertidal habitat existing in the rip rap that would be removed. With approval from the NYS Department of Environmental Conservation, NYC EDC constructed three artificial reefs out of stone from the Arthur Kill Channel deepening project off of the west side of the pier. In addition to fulfilling permit requirements, the reefs would provide for some wave attenuation to protect the pier.

At the time of Superstorm Sandy, construction was approximately 50 percent complete (Sims' plans called for the facility to open during Summer 2013). All of the site work (grading, dynamic compaction, etc.) in the area of the buildings was finished, as well as dock construction and dredging. The large recycling buildings were erected, closed in, and ready for interior fit outs and exterior trim work. Most of the remaining work involved recycling equipment installation, underground utility work, paving, erection of an administration building and education center, and landscaping.

### Impact of Sandy

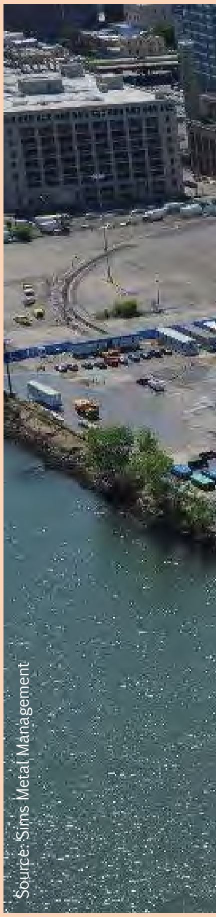
The areas of the pier where the buildings were under construction had an elevation of 11 feet above Mean High Water (MHW) level, the standard unit of measurement for waterfront elevation, and did not incur any flooding. In contrast, the lower lying areas of the pier were flooded by as much as 2.5 feet of water. In anticipation of the storm, all major processing and construction equipment had been stored on the higher ground, preventing costly damage and project delays.

There was some minor damage to building siding and trim work, as well as to temporary construction and electrical equipment. However, the impact was not significant enough to meet the project's insurance deductible, and after two days of clean-up, construction was able to resume.

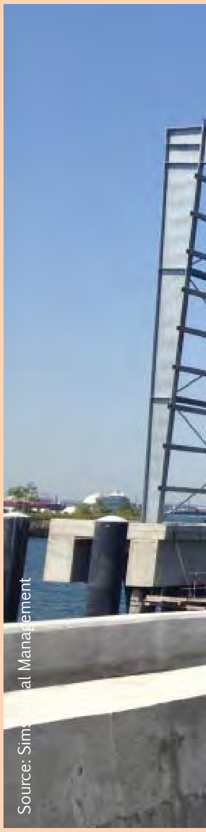
### Lessons Learned

The storm confirmed the importance of elevating critical and expensive infrastructure. Since the storm, Sims has altered the plans for certain elements of the remaining construction to include additional elevation. The three electrical substations on site will now be elevated up to a total elevation of 13 feet MHW. The guard booth at the site's entryway was also elevated an additional two feet above the original plan.

Sims is currently evaluating design plans for its other waterfront locations around the region, including a new building planned for its facility located on Newtown Creek in Long Island City, Queens.




*Artificial reefs at west s*



*Barge unloading dock*

side of the pier

during construction

# NEW YORK UNIVERSITY COGENERATION FACILITY

## MANHATTAN, NY

***"We are assessing building resiliency of all our campus buildings to an event such as Sandy. As far as cogen goes – everything worked according to design."*** **– John Bradley, New York University**

### Summary

In 2011, New York University (NYU) replaced its oil-fired cogeneration (cogen) plant with a natural gas-fired one that expanded its output capacity from seven to 13.4 megawatts (MW). The replacement also resulted in a decrease of greenhouse gas emissions by 23 percent and a reduction in air pollution by 65 percent at the plant. The new cogen plant's ability to operate on "island mode" enables NYU to continue to generate and distribute power, heat, and hot water even when the city's power grid is down, which proved to be extremely advantageous during Superstorm Sandy.

### Background

As part of Mayor Bloomberg's University Challenge, a call to New York City colleges and universities to voluntarily reduce their greenhouse gas emissions by thirty percent by 2017, NYU launched its Climate Action Plan (CAP), to reduce the university's carbon footprint and improve its sustainability. A new $125 million cogen system was one of the CAP's key projects. Cogen systems, also known as Combined Heat and Power (CHP), produce electricity and capture and use the heat by-product to generate steam. The steam is then used for additional electricity production and heat and hot water services. The plant is located below a 13,000 square foot public plaza on Mercer Street. It provides electricity to 22 NYU buildings and produces heat and hot water as well as chilled water and air conditioning for 37 buildings. It is on of the largest private cogen plants in NYC. NYU estimates it will save $5-8 million in energy-related costs per year.

### Design Details

The NYU cogen plant was designed to be extremely energy-efficient in order to reduce both energy costs and the university's carbon footprint. It was also designed to ensure the safety and comfort of NYU's students and faculty and to protect on-going research when the central power grid is down.

The switch from oil to natural gas alone significantly reduces emissions of greenhouse gases and criteria pollutants. However, the key to the plant's efficiency comes from the use of highly efficient turbines and the use of waste heat and steam from electricity production to create additional electricity and provide heat, hot water, chilled water, and air-conditioning for the campus.

To do so, natural gas first fuels twin high-tech gas turbines, which work very much like jet engines. As the turbines turn, their rotation is used to generate 11 MW of electricity. Hot exhaust from the turbine is directed to heat recovery steam generators which make steam. This steam is then piped to a steam-turbine electrical generator which produces an additional 2.4 MW of electricity. The steam is then used to make hot water for the campus in two high-temperature hot-water heat exchangers and is used to operate a chiller that provides cool water and cold water for air conditioning.

While cogen plant is connected to the Con Edison electrical grid, NYU ensured that the plant could still operate when the Con Edison grid is not in service. Most cogen plants automatically switch off when power no longer flows from the grid; however, the NYU system was design to go into “island mode” in such instances, meaning the plant automatically disconnects from the grid, allowing operations to continue.

NYU’s new cogeneration plant

- includes two 5.5 MW gas turbines and a 2.4MW steam turbine;
- provides electricity to 22 buildings up from 7 with the old fuel oil cogen;
- provides heat to 37 buildings; reduces greenhouse gas emissions by 23%;
- reduces EPA Criteria Air Pollutants by 68%;
- produces twice the electrical power of the old facility – at 13.4 megawatts – and avoids the combustion of 500,000 gallons of fuel oil annually;
- and is digitally controlled for better monitoring and maximum efficiency.

### Impact of Sandy

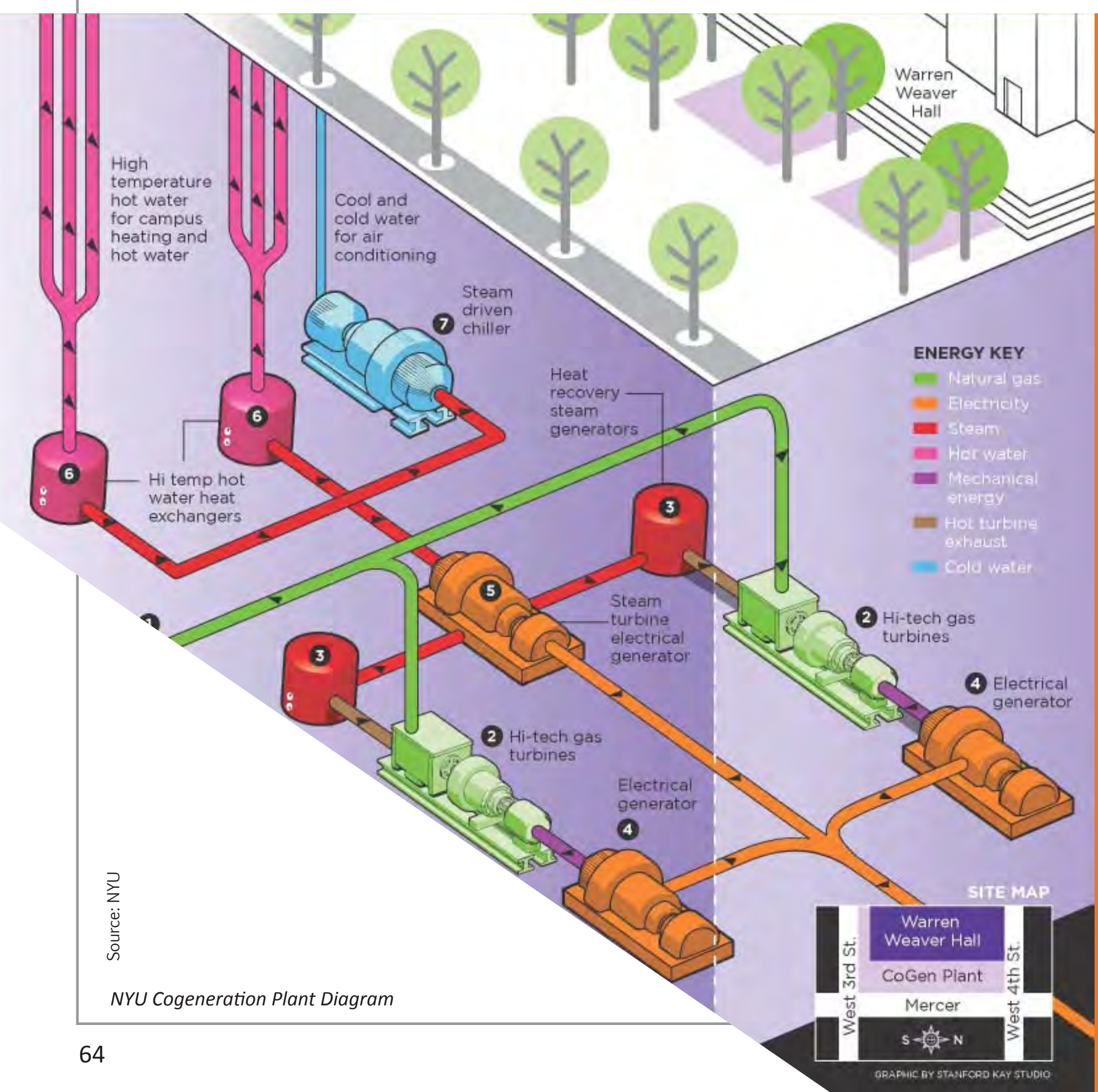
During and after Superstorm Sandy, when Con Edison’s electrical grid shut down in Manhattan below Midtown, NYU’s cogen plant was able to continue to provide the connected campus buildings with electricity, heat, and hot water. Once the plant’s controls sensed that power was not flowing from the Con Edison grid, the plant automatically and instantaneously isolated from it and proceeded to operate independently.

The 22 buildings connected to NYU’s cogen plant for electricity continued to have power, heat and hot water. However, the remaining 15 buildings that usually receive heat and hot water from the plant but do not receive electricity from it did not have heat or hot water once the Con Edison grid shut down, since there was no electricity to power the pumps that circulate water in these buildings.

Once Con Edison was able to restore power to the grid, NYU’s cogen plant was able to reconnect with it. To ensure this was done safely, Con Edison staff notified the NYU cogen plant’s operator so that the breakers from the plant’s control room could be closed. Through a monitoring system, NYU’s operator was able to observe the frequency and voltage of electricity coming from Con Edison; and once it was operating in sync with the cogen plant, the operator manually closed the breakers one at a time.

### Lessons Learned

NYU is assessing the resiliency of all of its buildings following the storm to ensure they can perform well during future events such as Superstorm Sandy. NYU is satisfied with the performance of its new cogen facility and believes that good communication between Con Edison and NYU was critical to the smooth transition into and out of island mode, allowing for uninterrupted energy services to the NYU campus.




Source: NYU

*NYU Cogeneration Plant Diagram*


*Cogen-powered NYU buildings light up Greenwich Village*

# CO-OP CITY COGENERATION FACILITY

## MANHATTAN, NY

***"We decided to invest in an onsite cogeneration plant because we wanted to save money…We have certainly saved money, but we are also really happy to provide our residents with the added benefit of independence from the power grid."* – Herb Freedman, Marion Real Estate, Inc., on behalf of Riverbay Corporation**

### Summary

The Co-op City development in the northeast corner of the Bronx has a cogeneration (cogen) plant that has the capacity to produce as much as 40 megawatts (MW) of power at any given time. This enables the plant to produce enough power to fully cover Co-op City's electricity demand as well as produce enough steam to avoid the reliance on additional boilers, except for a few months during winter. During and after Superstorm Sandy, when the surrounding neighborhoods were without power, Co-op City continued to provide power as well as heat and hot water to its residents.

### Background

Co-op City is the largest single residential development in the United States, home to roughly 50,000 people. Completed in 1973, Co-op City contains more than 15,000 housing units in 35 high-rise buildings and seven townhouse clusters, eight parking garages, three shopping centers, a high school, two middle schools, and three grade schools. The area is managed by RiverBay Corporation, a non-profit management company.[1]

In 2003, Co-op City began a $240 million renovation project that included several greening strategies, such as switching to energy-efficient lighting, installing water-conserving technologies, replacing windows, and replacing its power plant with a cogen facility. The $68 million cogen plant was completed in 2009.

### Design Details

The new plant, also known as Combined Heat and Power (CHP) at Co-op City, was built with two intentions: to upgrade the aging heating and cooling plant and to save costs through the combined production of heat and power. After the 2003 East Coast blackout, RiverBay Corporation decided to ensure that the cogen plant can operate independently from Con Edison's grid.

To reduce energy costs and greenhouse gas emissions, the cogen plant runs on natural gas, which powers the turbines that produce electricity and steam. The steam is then used to generate additional electricity and produce hot water, heating, and cooling. The plant has the capacity to generate 40 MW of power at any given time with its three turbines. Two of the turbines alone can produce enough electricity for Co-op City; the third is used as a backup if any of the two others are shut down and to be able to generate additional electricity in the summer to sell to the grid. RiverBay Corporation estimates that Co-op City is saving $15-16 million in energy costs a year as a result of the upgrade of its former power plant to a cogen system, resulting in the ability to recover its full construction costs in less than five years.

In addition to energy savings, the system is designed to be able to run independently from the Con Edison grid, when necessary. To do so, the plant is able to switch its steam turbines from a mode synchronized with the electricity coming from the Con Edison's system to "island mode" under which the system is disconnected from the four Con Edison feeders and runs independently.


*Co-op City aerial view*

## Impact of Sandy

According to Con Edison, roughly 50,000 Bronx residents lost power during Superstorm Sandy, including those living in the neighborhoods surrounding Co-op City. Residents in Co-op City, however did not lose power nor did they lose heat or hot water.

Three out of the four electricity feeders that connect the cogen plant to the central grid failed during the storm. The one remaining feeder would not have been able to provide sufficient power for all of Co-op City. Since Co-op City was able to produce its own electricity, this was not a problem. With one feeder in operation, there was no potential for the electricity to "back-flow" from the plant and damage the Con Edison system. Therefore, Co-op City's Power Plant Department did not have to switch the cogen plant to island mode.

If the last feeder did fail, the plant would have been able to disconnect and continue to provide power. A direct phone line between Con Edison's District Operator and Co-op City's Power Plant Department ensured efficient communication throughout the surrounding area's blackout.

## Lessons Learned

The ability to both generate power and provide thermal services allowed "business-as-usual" operations for residents and staff at Co-op City. Had it not been for the cogen plant, Co-op City would have experienced power losses during the storm. Prior to Superstorm Sandy, the cogen plant had been a worthwhile investment for the River Bay Corporation; however, the experience during the storm now makes the investment look even better.

| | |
|---|---|
| Capacity: | 40 MW |
| Equipment: | Two dual fuel Siemens SGT-400 Gas Turbines (12.9 MW) |
| | Two once through steam generators |
| | Dual fuel 150,000 pph auxiliary boiler |
| | Steam turbine (15 MW) |
| Annual Savings: | 160,000,000 kWh |
| | 8,000,0 Therms |
| | $16 million (payback 4-5 years) |
| Efficiency: | 90% LHV |


*Co-op City's central plant and supporting structure*


*Gas turbines and heat recovery steam generator*


Solar 1

# SOLAR 1 CENTER
## MANHATTAN, NY

***"Thank you so much for sharing your solar energy with us to charge our phones, you guys were heaven sent in our time of need. Along with phone and computer charging, we also charged up a nebulizer for a young man with asthma."* – Wanda Vasquez, a neighbor who posted on the Solar 1 Facebook Page**

### Summary
The Solar 1 Center is a green energy, arts, and education center along the East River in Manhattan. The design of its small waterfront structure included resilient measures that ultimately preserved the building during Superstorm Sandy and allowed it to provide much-needed power to its neighboring community.

### Background
Designed in 2000 by architects Kiss + Cathcart, the Solar 1 Center was originally intended as a small solar-powered display for an Earth Day celebration in Battery Park. That building was dismantled and stored in a warehouse until the Community Environmental Center (CEC) received approval from the Department of Buildings to install the Solar 1 hut on a leased blacktop area alongside the East River. Contractors began constructing the 500 square-foot building in late 2002 – potentially the smallest building in Manhattan and the only stand-alone solar-powered building in the city.

### Design Details
Solar 1's roof holds a 3.5 kilowatt (kW) solar array to power its operation, including lights and computers. Since the building was originally designed to be temporary and the permitting and interconnection processes to connect a solar electric (also known as photovoltaic, or PV) system to the grid was more complicated in 2002, Solar 1 never interconnected the system to Con Edison's infrastructure. However, the building does have one direct line to the Con Edison grid to power its heating and air conditioning equipment.

Solar 1 included other strategic design measures into its building. To anchor the small building against winds off the East River, a deep foundation was put in place. The building was also constructed with Structural Insulated Panels (SIP), which were assembled with thick seals to create a water and air-tight structure, improving its efficiency and resiliency. Because of Solar 1's location and space constraints, all electrical equipment, including the inverter and batteries for the solar system, was stored in the building's loft space.

### Impact of Sandy
Solar 1 staff estimate that the storm surged 10-13 feet above the adjacent bulkhead. The surge destroyed the wooden ramp on the north side of the building and the stage on the south side. The building itself, however, remained intact due to its strong foundation and tight construction. The building only saw two feet of flooding, which most likely came up from a hatch underneath the building.

The solar panels on the building's roof, the elevated back-up battery system, and the inverter located in the loft space were all undamaged. Since the PV system was never connected to the Con Edison grid and the system itself was undamaged, Solar 1 had power one day after the storm while the surrounding communities did not have power for a week. Solar 1 was able to provide power for its own lights, a small radio, and a charging station for the local community


*Solar 1*

in Stuyvesant Town, Waterside, and Peter Cooper Village. Long extension cords were also used to power chainsaws to remove nearby fallen trees.

## Lessons Learned

Solar 1's sustainable construction and its ability to provide power off the grid made it especially resilient to Superstorm Sandy. The tight construction supported by the SIP system prevented the building from flooding. And while all of Manhattan below 23rd Street was without power, including those buildings with PV systems interconnected to the grid, Solar 1 was able to run its operation and help the surrounding community.

Solar 1 is currently planning the construction of Solar 2, a larger environmental learning center that will include exhibition space, classrooms, and a café. The Solar 2 project will be the first energy-positive building in New York City. It will display the most advanced sustainable design, renewable energy, and energy efficiency technology and methods available, along with engaging, interactive exhibits and innovative environmental programming.

Solar 2's state-of-the-art sustainable technologies are expected to include a 92 kW solar array; a geothermal heating and cooling system; high-efficiency lighting and HVAC systems; blackwater, graywater, and rainwater reclamation and reuse systems; a green roof and vegetated green screen; a wetlands area; a potential nearby electric vehicle (EV) charging station; and access for bicycles, kayaks, and other small boats.

Storm mitigation features in the current design for Solar 2 include a two-foot platform on which the building will sit and placement of windows towards the top of the first floor. The façade's brick material as well as the green screen are intended to protect the structure from floating debris during a surge. However, the recent FEMA designation of the Solar 2 site as a V Zone will require modifications to the design of the building. These may include increased height, breakaway walls and increased resistance to wave action.

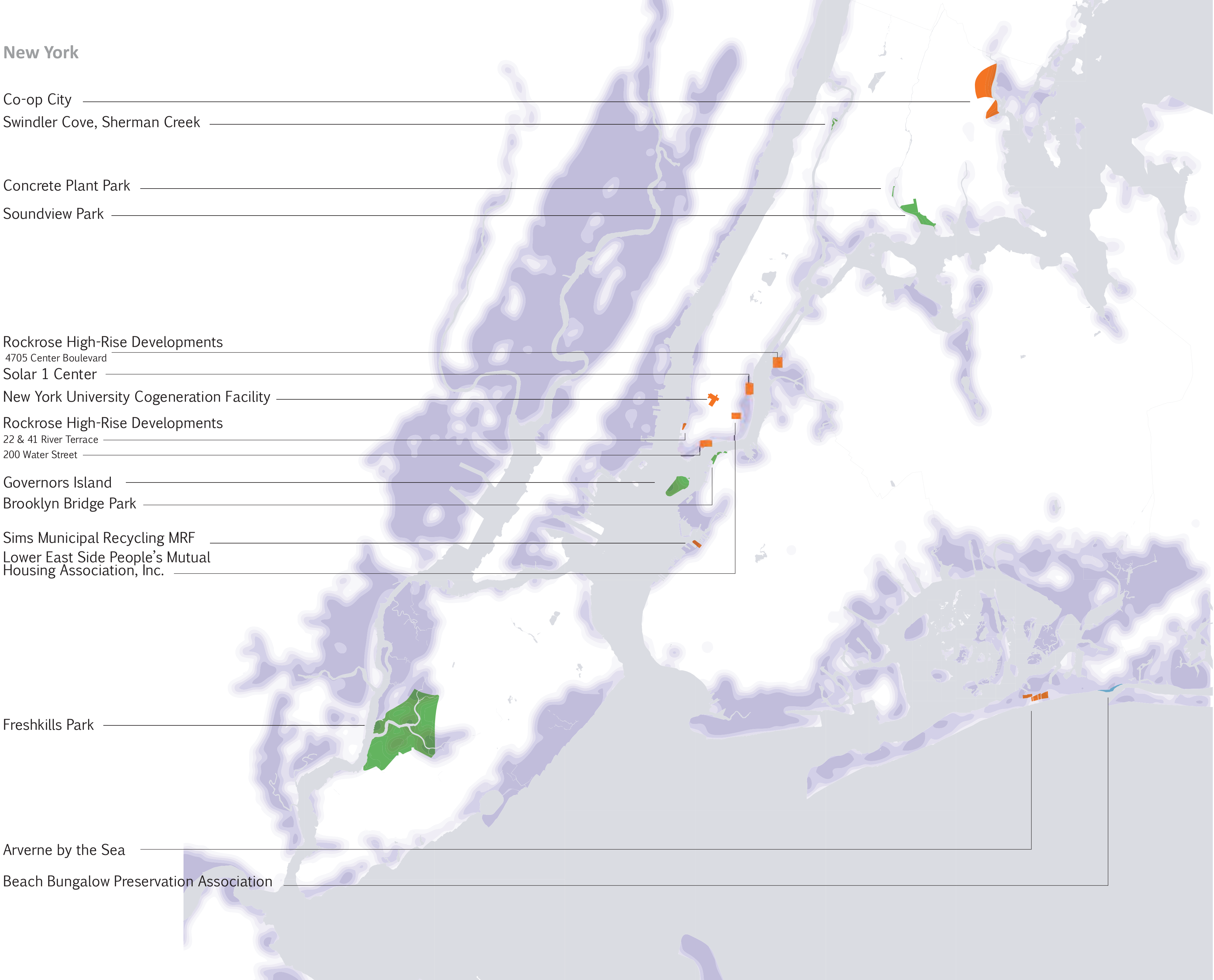
In terms of power for the building, the battery back-up system will be elevated on the west side of the structure with a three-hour system to backup files on the computers and shut the building down during a storm emergency. This battery system will incorporate advanced technology, which requires less space yet provides an increased level of back-up power compared to the system in place at the existing Solar 1 building. All cooking facilities in the Solar 2 building will operate off of electric power so that the building can also function as an emergency shelter when power and gas service in the area are shut down.

Currently, Solar 1 plans to interconnect the planned PV system to the grid using new, state-of-the-art inverter technology that will allow the system to "island" or disconnect from the system whenever the central grid loses power.


*Solar 2*


*Neighbors charging phones at Solar 1 while during power outage*

## New York

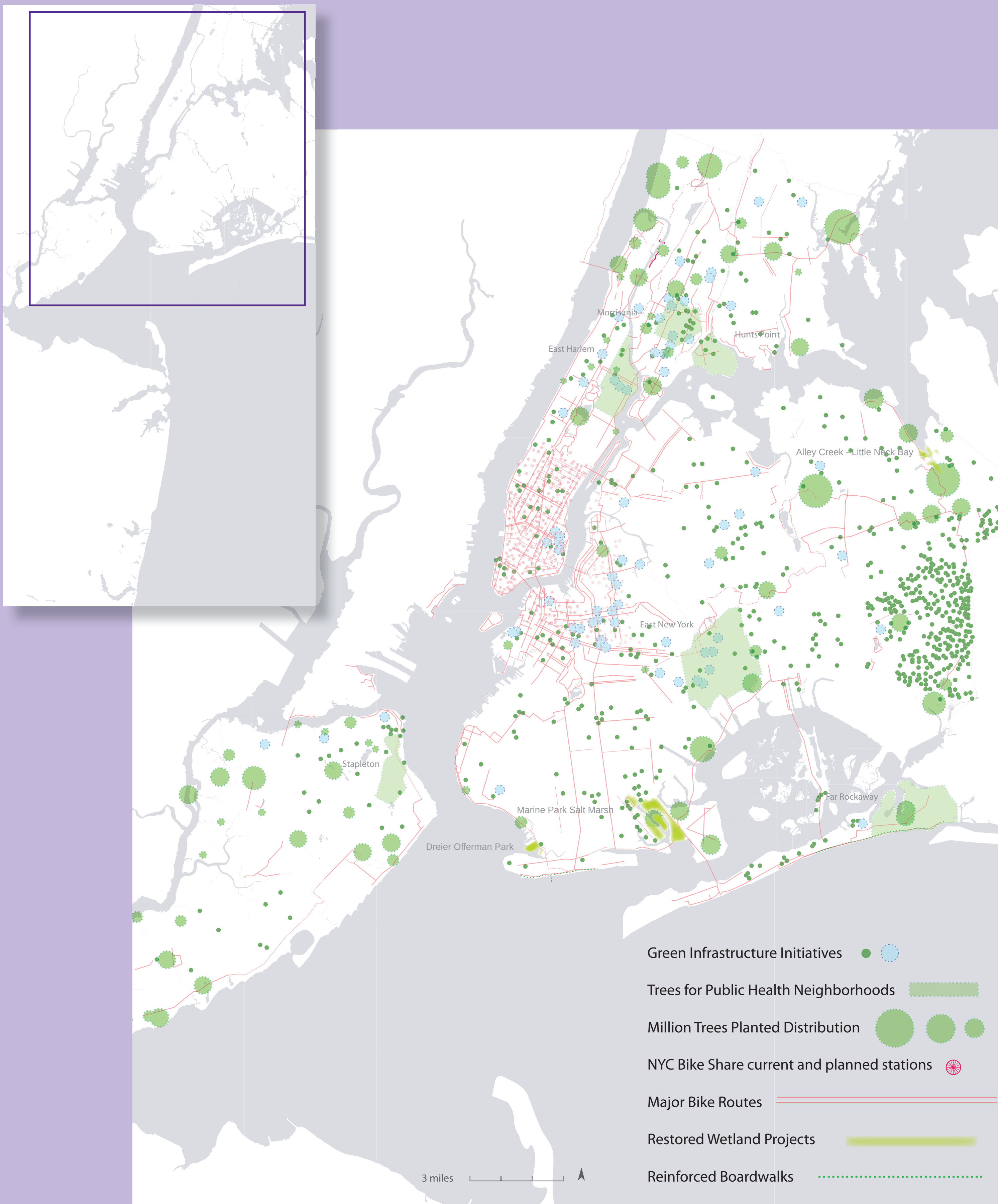


Co-op City
Swindler Cove, Sherman Creek
Concrete Plant Park
Soundview Park
Rockrose High-Rise Developments
4705 Center Boulevard
Solar 1 Center
New York University Cogeneration Facility
Rockrose High-Rise Developments
22 & 41 River Terrace
200 Water Street
Governors Island
Brooklyn Bridge Park
Sims Municipal Recycling MRF
Lower East Side People's Mutual Housing Association, Inc.
Freshkills Park
Arverne by the Sea
Beach Bungalow Preservation Association


New Jersey
Waterfront Parks
Beaches
Building Sites
Flooded 10/29/2012
Eastern Long Island
Westhampton Beach
Bay Head Beach
3 miles

New York City has implemented a variety of initiatives to improve water quality, restore natural habitats, mitigate urban heat island effect, clean the air, and reduce energy consumption. These sustainability investments increased the city's resilience to the impacts of intense storms, reducing the need for costly repairs and replacements. Beyond their own resiliency, many of these measures provided protection for surrounding communities by preventing flooding, blocking wind, and helping to drain upland areas more quickly.

# V. CITYWIDE



Morrisania
East Harlem
Hunts Point
Alley Creek - Little Neck Bay
East New York
Stapleton
Far Rockaway
Marine Park Salt Marsh
Dreier Offerman Park
Green Infrastructure Initiatives
Trees for Public Health Neighborhoods
Million Trees Planted Distribution
NYC Bike Share current and planned stations
Major Bike Routes
Restored Wetland Projects
Reinforced Boardwalks
3 miles

# V. CITYWIDE

# WETLAND RESTORATION

***"While the City originally intended its wetland restoration projects to improve water quality and habitats, it now has a new appreciation for how the restoration of historic wetland areas can also help make the City more resilient."*** **– Bram Gunther, Natural Areas Conservancy and NYC Department of Parks & Recreation**


## Summary

Across the region, areas flooded by Superstorm Sandy tended to be those that historically had been wetlands. Therefore, the greatest benefit of wetland restoration projects in New York City may very well have been the prevention or displacement of more vulnerable uses from their low-lying, flood-prone sites. However, based on observations from staff at the NYC Departments of Environmental Protection and Parks & Recreation after Superstorm Sandy, some of these restored wetlands may have also provided sand-erosion control, debris management, and flood protection.

The extent to which wetlands helped reduce wave energy and protect local neighborhoods is still unclear. However, experts acknowledge that wetlands in general, especially expansive ones, can dissipate wave energy, reducing damage to waterfront communities. Given the relatively narrow form of New York City's wetlands and the high-tide conditions existing when the storm surge hit parts of the City, much of the wetlands was submerged and the absorption of wave energy was likely minimal.


## Background

Over the past two decades, the City of New York has spearheaded wetland restoration projects throughout the five boroughs. Wetlands are vegetated land areas that are regularly saturated with water, hosting a mix of plant species that are adapted to their unique aquatic and soil conditions. Found in saltwater, freshwater, and a mixture of the two, the category includes swamps, marshes, bogs and other similar ecosystems. This case study focuses on three different wetland restoration projects in New York City: Little Neck Bay/Alley Creek in Queens and Gerritsen Creek and Dreier Offerman Park in Brooklyn.

*Little Neck Bay's Alley Creek*

Little Neck Bay is a body of water that separates Queens from Nassau County along the north shore of Long Island. It is adjacent to the Long Island Sound and is tidally connected to the East River. Throughout the twentieth century, portions of the Bay's wetland areas were filled to support housing development, degrading water quality and contributing to habitat loss. Pollution from surrounding septic tanks, the city's combined sewer outflows, and stormwater runoff from upland areas further impacted Little Neck Bay's ecosystem. Beginning in 1997, the Port Authority of New York and New Jersey restored 13 acres of salt marsh on the Bay to mitigate wetland disturbances from a capital project at nearby LaGuardia Airport. Building upon this restoration and to improve the water quality of Alley Creek and Little Neck Bay, the New York City Department of Environmental Protection (DEP) also invested $142 million to construct a five-million gallon Combined Sewer Overflow (CSO) retention tank. These investments were recommendations included in the June 2009 Waterbody/Watershed Facility Plan (WWFP), which was the first step toward development of a Long-Term Control Plan (LTCP) to achieve Clean Water Act goals for improvement of water quality. DEP later undertook a $20 million restoration project in Alley Creek at the southwestern end of Little Neck Bay as part of its effort to improve water quality and ecological habitat in the area. By 2010, DEP had restored eight acres of tidal wetlands and eight acres of adjacent coastal grassland and shrub land habitat.


January 11, 2013: Beach sand moved upslop along gabion


Gerritsen Creek, Brooklyn before Sandy

*Gerritsen Creek*
Gerritsen Creek is a freshwater creek south of Marine Park in Brooklyn that occupies the westernmost inlet of Jamaica Bay. It provides a natural habitat for a diverse group of animals and myriad plant life. In the 1950s, the Department of Sanitation (DSNY) used this area as a landfill, filling the marshes at Gerritsen Creek with household garbage and construction debris. As a consequence, the area became increasingly contaminated, and Phragmites, an invasive reed grass that thrives on contaminated soils, grew aggressively.

As the hydraulic sand in the fill settled and the tides distributed the sediments, salt marshes started to re-emerge along the shoreline. In 2010, the City of New York, in partnership with the US Army Corps of Engineers (USACE), initiated a project to restore the Creek's ecology. Completed in 2012, the project restored 20 acres of salt marsh, 22 acres of upland coastal grassland, and six acres of coastal forest restoration.

*Dreier Offerman Park*
Dreier Offerman Park is located in the Bensonhurst neighborhood of Brooklyn, just north of Coney Island. The largest tract of this parkland was acquired in the 1960s and consisted of land created by miscellaneous fill, including earth from the Verrazano-Narrows Bridge excavation that had been placed in what had been open water. Due to funding constraints, DPR never completed the intended park renovation. In 2011, DPR embarked on the Dreier Offerman shoreline restoration project to improve habitat for birds and fish in the area. The restoration project was under construction during Sandy.

## Design Details

The City embarked on these restoration projects to improve the water quality of its bays, creeks, and other waterways and to provide habitat for a variety of wildlife. However, due to the varying existing conditions and specific project objectives, each project had slightly different design details.

*Little Neck Bay's Alley Creek*
With the Alley Creek restoration, DEP aimed to improve water quality in the area and attract new animal species. To achieve these objectives, DEP first constructed a new five-million gallon tank that will hold the stormwater and sanitary water mix collected by the city's combined sewer system to prevent it from spilling into Alley Creek and Little Neck Bay during rain events. Once complete, the agency was able to begin restoration of the wetlands. First, to reestablish the historic tidal flows, NYC DEP began excavating construction-derived fill material and replaced it with sand to support marsh vegetation. Using existing adjacent wetlands to determine the proper elevation, the design called for an elevation low enough to allow the tide waters to flow, but high enough to support the growth of wetland plants. To increase the effective wetland restoration acreage, DEP designed the wetland to have a moderately steep slope (3:1), shallow enough to dissipate wave energy and minimize erosion, but steep enough to contain flow during higher tide events. To help achieve improvements in water quality, the City chose indigenous plants that could help absorb and filter storm water runoff from adjacent neighborhoods and roads. The landscaping plans also focused on plants that had once been part of the area's natural ecology, including salt marsh cord-grass plugs in the low-lying areas and meadow grass, native trees and shrubs, and wildflowers in the upland.

With the discovery of a small freshwater spring during the restoration at Alley Creek, DEP altered the original design to also include a freshwater wetland system and further increase the biodiversity of the vegetation. The park's design also included the replacement of the boardwalk along the existing trail within the Alley Park Environmental Center. With

improved views of the wetland setting and associated wildlife, the new boardwalk includes a reconstructed observation deck and walkway located along the west bank of Alley Creek, approximately 500 feet south of Northern Boulevard.

*Gerritsen Creek*

Gerritsen Creek's restoration project focused on the revitalization of its aquatic and coastal grassland habitats. This included the restoration of its originally rich plant life, which was impaired from years of contamination and the growth of Phragmites, which crowded the soil and blocked sunlight from reaching other plants. The City, again in partnership with US ACE, cleared the Phragmites and other debris from the area, excavated the fill, and shaped the area to both allow water to flow through the site and support salt marsh plants. The slope between the wetland and upland areas was moderately steep to provide both protection from wave action and flood protection for the surrounding areas.

DPR added a one-mile long footpath made of crushed-stone surface with a timbered edge that follows the edge of the upland area. Additionally, as part of the Million Trees NYC initiative, DPR planted an upland coastal forest to provide an additional buffer between the water and surrounding Brooklyn communities.

*Dreier Offerman Park*

Dreier Offerman Shoreline Restoration project's primary goal was to restore the park's shoreline to improve the habitat for birds and fish. Similar to the other wetland projects, DPR excavated landfill and replaced it with clean sand to form a beach and to serve as planting media for the salt marsh. For this wetland, DPR designed a steep bank that was supported by gabion baskets (baskets of stones held together by wires) for the stabilization of earth movement and erosion.

### Impact of Sandy

These three wetland restoration projects fared well during Superstorm Sandy. This was particularly the case for the low-lying areas where the storm surge coincided with high tide, when these areas were underwater. Upland and the higher sections of transitional areas had to withstand comparatively harsher storm conditions.[6]

*Little Neck Bay's Alley Creek*

The moderately steep slope at Alley Creek provided stability to the bank, minimizing damage to the wetlands. The wetland area also captured and absorbed floodwaters, helping to prevent any flooding from the Bay out to neighboring roadways and communities. The physical configuration of the site and the physical stability of the side slopes allowed the wetland area to act like a tub to contain the rising flood tide and hold it within the confines of the wetland system.

*Gerritsen Creek*

In most locations, the top of the saltmarsh slope was higher than the storm surge. As a result, debris floated off of the marshes and the waves deposited it a few feet below the top of the slope. After two seasons, the Gerritsen Creek marsh had grown sufficiently dense enough to remain undisturbed from the storm surge and actually lifted any unwanted debris up out of the marsh and on to upland areas. Debris lifted by the rising tide did scour plants on transition slopes in some locations, but not enough to denude the slopes nor make them vulnerable to erosion from the flow of water into the creek from upland areas. While about approximately 600 feet of the timber path edging was lifted out of the ground by the rising tide, no soil erosion was observed in the wetland, upland or transition areas.

*Dreier Offerman Park*

At the time Superstorm Sandy hit, the Dreier Offerman restoration project was under construction. During the storm, neither the newly-placed sand on the beach nor the partially erected gabion basket slope shifted drastically; it moved slightly upslope, suggesting the storm deposited more sand than it eroded at the site. The main impact of Superstorm Sandy appeared to be sand deposition further upslope. This alleviated concerns of potential gullying erosion of the recently placed sand at the site.

### Lessons Learned

Following Superstorm Sandy, several lessons can be drawn in regards to the restoration of wetlands. First, plants have to be chosen for their tolerance for flooding and salt inundation. In areas transitioning to fresh-water systems, plants must be selected that can survive in both fresh- and salt- water environments.

Second, the slope of the transitional area from the water to the uplands is critical to the stability and long-term resilience of the plants and the wetland as a whole. A moderately steep slope (1:3) seems to provide the most benefits in terms of supporting plant life and habitat, preventing erosion, attenuating wave action, and ensuring survival in the face of sea level rise. The slope is steep enough to support the growth of low marsh plants while minimizing the growth of Phragmites, which grow at higher elevations. At the same time, this slope is shallow enough to minimize the reflection of wave energy that erodes the wetland area. Areas with such a slope, such as at Alley Creek and Gerritsen Creek, fared particularly well during the storm.

The City is now assessing the sand movements that occurred during the storm to better understand how other waterfront areas could potentially benefit from natural sand accumulation (as opposed to erosion). This knowledge may help the City avoid the high costs of over-engineering restored shorelines to prevent erosion.

While the City originally intended its wetland restorations projects to improve water quality and habitats, it now has a new appreciation for how the restoration of historic wetland areas can also help make the City more resilient. While the extent of this benefit is still not fully understood, the preservation and restoration of wetlands, at minimum, helps to ensure that more vulnerable uses are not located in these low-lying, flood-prone areas. Moving forward, the City will continue to analyze storm-related benefits of its wetlands and incorporate design measures to maximize their ability to contribute to the City's resiliency.


Before


After

# V. CITYWIDE

# GREEN INFRASTRUCTURE

***"Green infrastructure helped absorb stormwater runoff and reduced the volume of rain that would have flown into the City's combined sewer system, and subsequently, the city's waterways."*** **– Nette Compton, NYC Department of Parks & Recreation**

## Summary

The City of New York is implementing green infrastructure strategies including the creation of small vegetated islands and tree plantings within the public realm. These green infrastructure initiatives enrich and improve the urban environment, increase the overall quality of life, and help make the city more resilient by mitigating climate change impacts. During Superstorm Sandy, the city's green infrastructure helped absorb rainfall, thereby reducing flooding and discharges into the city's combined sewer system and waterways.

## Background

Green infrastructure is generally defined as decentralized efforts to engineer, enhance, or protect multifunctional landscape features. Different kinds of green infrastructure have the potential to manage stormwater, intercept rainfall, block the sun, and cool the city.

The City of New York has been investing in two citywide green infrastructure initiatives in particular: Greenstreets and MillionTreesNYC. The Greenstreets program was launched in 1996 through a partnership between NYC Department of Parks & Recreation (DPR) and NYC Department of Transportation (DOT). Started as an urban beautification initiative, it has converted over 2,500 patches of unused concrete and striped roadway surfaces formed by the city's intersecting streets into small, vegetated triangles, medians, and curbside bump-outs, otherwise known as "pint-sized" parks.

In 2008, the Greenstreets program began incorporating active stormwater management into the sites as a means of reducing the city's combined sewer overflow problem, while also improving the health of plants and reducing the need to water. Subsequently, the City obtained an American Recovery and Reinvestment Act (ARRA) grant in 2009 to build 28 such sites in flood-prone areas.

Beginning in 2010, the City created the Green Infrastructure Unit in DPR to partner with the Department of Environmental Protection (DEP) in the execution of its Green Infrastructure Plan. With DEP funds and collaboration, DPR is building green infrastructure in DEP's priority combined sewer overflow sewersheds, along with other agencies. All of these locations will be maintained by DEP-funded crews, trained in the specifics of managing green infrastructure systems.

DPR launched MillionTreesNYC in partnership with the New York Restoration Project in 2007 after Mayor Bloomberg revealed plans to plant one million trees by 2017 as part of PlaNYC. Acknowledging the environmental benefits of trees, such as cleaning the air, helping to manage stormwater, and reducing the need for air conditioning (thereby reducing energy consumption), MillionTreesNYC called upon New Yorkers to participate in the City's efforts to plant the one million trees. The City itself is planting seventy percent of the trees in parks and public spaces; private organizations, homeowners, and community groups are planting the other thirty percent. This will increase the city's urban forest by twenty percent. As of March 2012, over 660,000 trees had been planted.


*Large garden replaced a dangerous turning slip at Victory & St. Paul, Staten Island*


*Installation with lush plantings replaced a fequently flooded*

## Design Details

The implementation of the Greenstreets program and MillionTreesNYC often overlap. The Greenstreets program on the one hand converts areas of paved roadway into green spaces filled with trees, shrubs, and groundcover. MillionTreesNYC adds trees to these same neighborhoods along sidewalks, parks and private property.

Greenstreets are intended to enrich city streets by adding lushness and color to the concrete and asphalt hardscape. They aim to add natural beauty to otherwise barren spaces, while also helping to clean the air, cool the city, provide food and habitat for migratory birds and pollinators, and manage stormwater. By replacing paved roadbed, the Greenstreets program increases the pervious surface area available to capture stormwater. A one-acre greenstreet can hold approximately 55,000 gallons of stormwater. Where suitable, sites are designed to actively redirect stormwater runoff into the planting bed for on-site storage and irrigation of plants. DPR landscape architects employ gently sloping sidewalks, trench drains, curb cuts, bioswales, deep excavation, and crushed bluestone storage reservoirs to accomplish this goal.

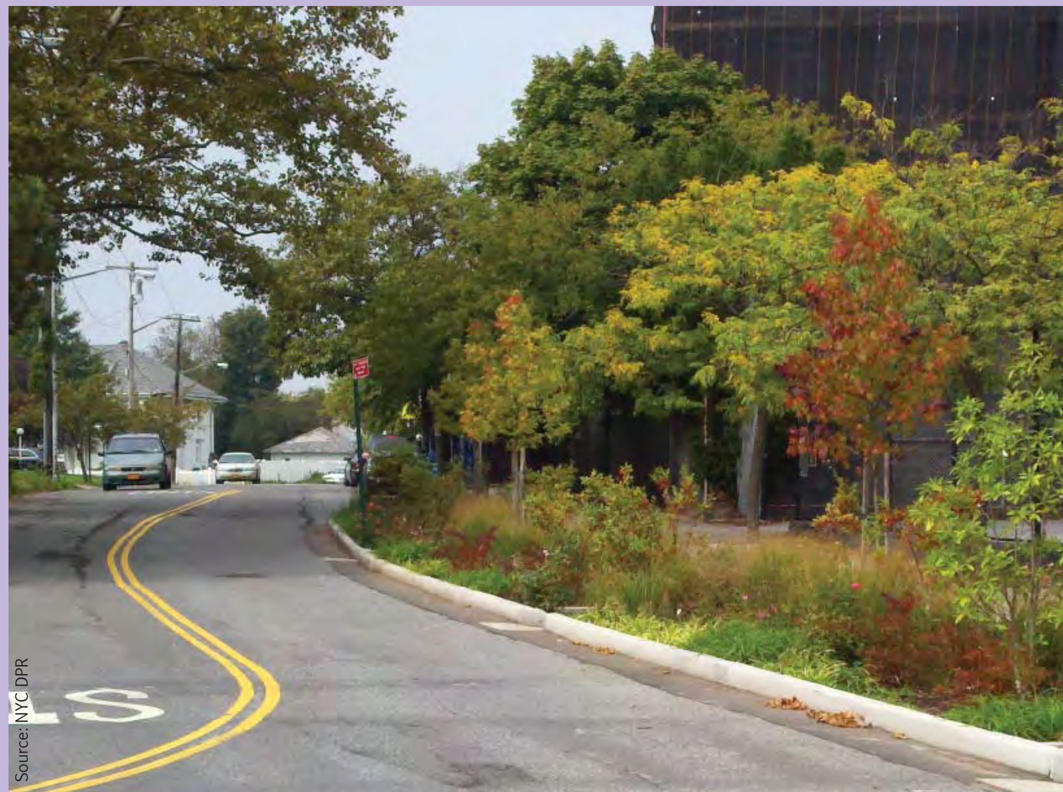
For MillionTreesNYC, the City aims to maximize the environmental benefits of the trees while making them resilient to a variety of urban challenges, including roadway pollution, disease, and intense storm conditions. To increase the resiliency of the City's tree portfolio, DPR and its partners focus on the diversity of planted tree species and to date have planted over 140 different trees. Trees are selected for a specific location based on-site characteristics such as exposure to wind, light, and flood risk. These characteristics are then matched with the biological attributes of the trees, such as the size of trees, root strengths, and salt water tolerance. In addition, MillionTreesNYC ensures that maintenance for the specific tree species is appropriate.

## Impacts of Sandy

Since most Sandy-related damage was due to storm surge and related flooding, the role green infrastructure played in the City was not at first obvious. Most likely however, green infrastructure did help to absorb stormwater runoff and reduced the volume of rain that flowed into the City's combined sewer system, and subsequently, the city's waterways.

The City has some verification of the benefit that green infrastructure played during Sandy. Sensors were installed at one Greenstreet site, Nashville Street in Cambria Heights, Queens. These sensors provided real-time monitoring of the amount of rainfall and runoff entering the site, and how much of it infiltrated, evaporated, or overflowed to nearby catch-basins. The measures showed that the site, which was specifically designed to capture direct precipitation and receive runoff from adjacent street and sidewalk surfaces, retained 100 percent of the total inflow of water it received during the storm, a volume 31 times its catchment area (40,000 gallons). While this performance is the ideal and may not be possible in all locations, it does demonstrate how well-designed green

space at Francis Lewis Blvd, Queens




*Installation along schoolyard to capture stormwater and encourage slower traffic at Westborne & Bay, Queens*

infrastructure can impact the water systems of a neighborhood.

Similar to greenstreets, trees helped absorb stormwater. Their leaves slowed the infiltration of water into sewers. The heavy winds and tidal storm surge however also negatively impacted trees in the city. The City did lose over 11,000 street trees and many more park trees as a result of Sandy. The trees that were found to be most vulnerable to the storm were species the City no longer plants, such as Norway Maples and Silver Maples. In addition, many trees were lost that had limited growing space or rooting volume.

### Lessons Learned

In general, the City's green infrastructure initiatives did add to the City's ability to manage stormwater and, in some cases, prevent erosion. Because these sites are designed with large rooting areas, these trees can develop expansive root systems that help protect them against wind damage, while allowing them to grow quickly and provide more benefits like stormwater capture and shading.

Modeling efforts suggest that the Nashville Greenstreet is able to capture and hold 74 to 86 percent of the rainfall on an annual basis, depending on the distribution, timing, and amount of precipitation. Other greenstreets, designed with similar infiltration capacities and storage capabilities to those of Nashville may be able to perform correspondingly. The monitoring effort suggests that greenstreets can be effective strategies for reducing the impact of extreme precipitation events on combined sewer systems and should be considered a key component of efforts to build up regional resilience to climate risks.

DPR plans to conduct a full survey of tree damage to better understand the long-term impacts of the storm. MillionTreesNYC is committed to increasing the resiliency of the city's trees through strategic species selection and planting locations. Trees will be planted where they have access to the resources they need to create stable roots and where they will be well maintained and monitored. For example, trees that sustained damage due to flooding will be replanted with trees tolerant to flood inundation.

# V. CITYWIDE

# BIKE INFRASTRUCTURE

***"With the subways out of commission due to Hurricane Sandy, countless New Yorkers turned to bicycling to get around town. Many have never looked back."* – Caroline Samponaro, Transportation Alternatives**


### Summary

Superstorm Sandy provided the impetus for a change in behavior by a subset of the commuting population. With subway service suspended and gasoline shortages throughout the five boroughs, many New Yorkers decided to commute to work by bicycle. Bike infrastructure created in recent years, such as the extended network of bike lanes, facilitated this decision to bike. Following the storm, the city's bike commuter population jumped from 10,000 cyclists a day to 30,000. Cycling served a key role in keeping the city moving following the storm and demonstrated its potential for emergency planning.


### Background

Over the past few years, New York City has taken a strong lead in making the city more bike-friendly. New bike lanes have been added, out- and in-door parking spaces for bikes have been provided, and cycling as an alternative form of transport has been promoted. As a consequence, commuter cycling has doubled since 2005 and increased by 26 percent between 2008 and 2009 alone. Over the past decade, while the number of people who ride bikes every day in New York City has more than doubled, the number of annual bicyclist injuries and fatalities has been halved.

### Design Details

Over the past six years, the New York City Department of Transportation (DOT) has strongly encouraged cycling through a variety of initiatives. In order to make riding a bike safer and more convenient across all five boroughs, DOT added 300 miles of bike lanes to the existing street plan. Where possible, it designed protected bike lanes with parking as a buffer between the bike lane and car traffic. It installed outdoor racks on public sidewalks for New Yorkers to park their bikes and introduced a law that requires commercial buildings to provide access and space for parking bikes indoors. The city also plans to introduce a bicycle sharing program that will be the largest in the country when it begins service in May 2013.

### Impact of Sandy

Following Superstorm Sandy, the subway system was shut down, gasoline availability was limited, and car traffic in some parts of the city was severely congested. In response, some 20,000 New Yorkers who usually use other forms of transportation decided to commute to work by bike. Immediately after the storm, bicycles offered one of the more convenient means to get around. The advantages of cycling became apparent in the absence of subway service: it was convenient, affordable, and in most cases fast, especially in a city where most trips are less than five miles.

The shift in behavior was supported by a passionate and committed community. In the aftermath of the storm, New York's bike advocates and professionals helped to make cycling a viable option for as many stranded residents as possible. Bike shop owners opened their stores, even if they had no electricity. They provided information and free bike safety checks. They also helped repair long abandoned bikes that people dug out of


*Commuters cross the Manhattan Bridge after Sandy, November 1, 2012*


*Volunteers use bikes to deliver emergency package*

storage. The local bicycle and pedestrian advocacy organization, Transportation Alternatives, set up commuter stations to pump up tires, answer questions and cheer people on with hot coffee donated by local businesses.

Separately, cyclists also provided aid to those areas most affected by the storm, riding out, for example, to affected areas of the Rockaways with donations and supplies. A partnership effort between Giant USA and two bicycle advocacy groups (Transportation Alternatives and Recycle-A-Bicycle) operating under the name “Ride NYC Forward” donated 100 bikes, helmets, and locks to improve the mobility of residents in the most stricken areas of Rockaways, Red Hook, Manhattan’s Lower East Side, and coastal Staten Island.

### Lessons Learned

The storm revealed the potential of cycling as a mobility multiplier that enhances transportation options. Cycling can also be part of an emergency and disaster preparedness plan. However, in order to be able to rely on cycling when other transportation options fail, cycling infrastructure needs to be in place and people need to feel comfortable using bikes. This means that cycling also needs to be promoted as a transportation option during normal times.

New York City’s efforts to promote the growth of commuter cycling and to improve cycling infrastructure have been key to mainstreaming bicycling as an everyday transportation choice. Making bicycling safer and more convenient has normalized it, allowing people to fall back on it as a commuting option when the city’s transportation system is shut down. These efforts need to continue in order for New Yorkers to be at ease with cycling – both in normal and not so normal times. Only then will the city and its residents realize the full potential of cycling and bike-friendly infrastructure.

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*NYC Bike Embassadors supporting cyclists*


*Cyclists in Boerum Hill, November 1, 2012*

# ALTERNATIVE BOARDWALK MATERIALS

***"About a mile of boardwalk has been reconstructed using pre-stressed concrete planks. The pre-stressed planks survived the hurricane force with minor movement at few locations."* – NYC Department of Parks & Recreation**

### Summary

As an alternative to tropical hardwoods, the City of New York has been piloting different materials for its ten miles of oceanfront boardwalks. The pre-stressed concrete planks installed along sections of boardwalk in the Rockaways and Coney Island proved to be especially resilient to the pounding of waves brought on by Superstorm Sandy.

### Background

In 2007, Mayor Michael R. Bloomberg announced that the City of New York would reduce its use of tropical hardwoods due to their impact on deforestation and climate change. New York City has been one of the nation's largest consumers of tropical hardwoods, utilizing the strong and durable material for its boardwalks, benches, ferry piers, marine transfer stations and the Brooklyn Bridge promenade. Unfortunately, the logging of tropical forests to supply construction material has contributed to global deforestation at a rate of 0.2% a year, and this deforestation accounts for approximately 20% of the world's annual man-made greenhouse gas emissions.

As part his announcement, Mayor Bloomberg required agencies to refrain from designing new boardwalks with tropical hardwoods and mandated studies to identify alternative materials that could be used when these structures have to be replaced. In accordance with the Mayor's plan, New York City Department of Parks & Recreation (DPR) conducted a study to find sustainable and cost-effective alternatives to tropical hardwoods and found pre-stressed concrete planks to be the most cost-effective and environmentally sustainable option. Following the study, DPR introduced pre-stressed concrete planks to sections of both the Rockaways and Coney Island boardwalks.

### Design Details

DPR aimed to pilot the use of an alternative to tropical hardwoods to ensure that the option it chose for its sustainability and cost-effectiveness was also durable, functional, and aesthetically pleasing. The pre-stressed concrete planks in Coney Island and the Rockaways typically measured 8' wide by 19' long. The planks in Coney Island had a tongue and groove design to interconnect the planks, while in the Rockaways the planks were connected by means of specially-designed steel keys or vector connectors embedded in the concrete planks. Elements of steel keys are fabricated with the planks and welded together after installation of the planks.

In response to community feedback, a section of the Coney Island boardwalk was built with combined pre-stressed concrete and a finished recycled plastic lumber (RPL) surface treatment, designed to look like traditional hardwood. However, to date, DPR has found that only the concrete finished surface (without RPL) has been able to meet all the requirements for strength and reliable slip-resistance for emergency and critical maintenance vehicles.

### Impact of Sandy

Superstorm Sandy decimated large portions of the traditional timber boardwalk areas in Coney Island and the Rockaways. The storm surge tore up sections of the boardwalks and in some cases deposited them in the adjacent commu-

Source: NYC DPR

*Destroyed hardwood decking besides pre-stressed concrete planking*

Source: Ariella Maron

*Destroyed boardwalk after Sandy in the Rockaways, C*

nities or washed them away to sea. The pre-stressed plank installations, however, survived the storm force due their physical weight and strong connections to their supporting structures. In a few locations, there was minor movement of the planks, causing some cracking of connected surrounding materials. In one isolated case, a plank was forced away from its base and deposited on the ground next to the boardwalk.  However, almost all the pre-stressed boardwalk survived with minimal damage. DPR expects all the concrete sections to be open to the public by Memorial Day 2013.

### Lessons Learned

DPR has begun repairs to the pre-stressed concrete planks and their supporting infrastructure where necessary. To reduce the future occurrence of cracking, DPR will make some adjustments and improvements in the connections between the planks, as well as connections between the planks and their support structures.

DPR intends to provide access to certain beach areas for the summer 2013 beach season. To meet this short-term objective, the agency is constructing poured-in-place concrete access walkways or islands at high-traffic beach access points. For the longer term, DPR is evaluating options to replace the sections of boardwalk that were completely destroyed during the storm. Where possible, the agency expects it will repair, patch and secure existing damaged wood boardwalk; however, for sections that require complete replacement, DPR does not anticipate using tropical hardwood.

While the use of concrete as a boardwalk material has proven to be a durable alternative to wood, some members of the surrounding communities would still prefer the use of a material that more closely resembles the traditional wood boardwalk. To address their concerns, DPR has designed the concrete installation for the eastern most section of the Coney Island boardwalk to have more of a wooden look. To achieve this, DPR will once again add RPL decking with the pre-stressed concrete planks but, to ensure the installation meets requirements for strength and reliable slip-resistance, the RPL will be incorporated into the concrete in the factory. DPR anticipates that, following trials and testing of a more slip-resistant RPL, this combination of materials may prove to be a reliable future alternative for the entire boardwalk.

Queens


*Rockaway Boardwalk, Queens after Sandy: Concrete pile sub-structure without wooden planking system*


*Destroyed boardwalk after Sandy in the Rockaways, Queens*

# VI. CONCLUSION

This compilation of stories has highlighted solutions that helped to make pockets of the region more resilient to the impact of Superstorm Sandy. The stories broadly fell into four locational categories:  waterfront parks, building sites, beaches, and citywide initiatives. The solutions employed across the range of stories involved a variety of strategies, including land use designations, site-planning decisions, softening of the water's edge, landscaping and building design, energy distribution, stormwater management, and operational planning.

The lessons learned from each "successful" site can and should help inform policy and investment decisions around land use and site planning, building design, and energy and storm protection infrastructure.  However, just as critical are other conclusions arising from the case studies as a group, including  the physical and economic value of implementing an ambitious sustainability agenda and the need for multiple levels of protection to make individuals, their neighborhoods, and the economy healthier and more resilient to the impacts of climate change.

Although more work is needed to synthesize the lessons from other case studies around the region, there are some specific lessons and directions that seem to be emerging from this initial round of Sandy Success Stories. They suggest the need for the city and its partners to continue to pursue a sustainability agenda that promotes:

- the creation and maintenance of quality open space and additional wetlands along the waterfront, for both recreational and ecological purposes
- distributed stormwater management, through green infrastructure such as wetlands, Greenstreets, and tree plantings
- ambitious energy policies that support clean, distributed generation and promote energy efficiency
- sustainable transportation alternatives to allow for mobility when gas supply is limited and/or the subway system is not fully operational
- building designs that are able to withstand storm impacts, heat waves, and utility failures and that allow building operators to continue to provide key services to their tenants in an emergency situation
- more resilient communities, with access to climate risk information and the capacity to develop and implement neighborhood-level disaster response plans.

Sandy signaled that climate change is already occurring and impacting the quality of life in New York's neighborhoods and the health of its economy. In response, we must significantly reduce our environmental footprint while making our city more able to withstand the impacts of climate change. It is our hope that these lessons inform the conversation and contribute to the development of a more resilient foundation, both at policy and community levels, upon which to rebuild and leave our region even stronger.

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**Cover Images**

*Clockwise from top-right corner:* Gerritsen Creek, Brooklyn (Gabby Bennett-Meany); Soundview Park, Bronx (NYC Department of Parks & Recreation); 41 River Terrace, Manhattan (Rockrose Development Corporation); Beach 24th Street Far Rockaway, Queens (Beachside Bungalow Preservation Association); Pier 1 Brooklyn Bridge Park, Brooklyn (Michael Van Valkenburgh Associates); Westhampton Beach, Long Island (US Army Corps of Engineers); Concrete Plant Park, Bronx (NYC Department of Parks & Recreation); Solar 1 Center, Manhattan (Solar 1)