

A photograph of construction workers in safety gear. In the foreground, a man in a blue cap and orange safety vest is looking down. To his right, a woman in a black beanie and jacket is shaking hands with a man in a green cap and orange safety vest. The background shows a building and trees. A blue semi-transparent rectangle is overlaid on the center of the image, containing the word "Resiliency" in white text.

Resiliency

Introduction



226,000

commuters crossed
the East River using
temporary transit
services after the storm

When Hurricane Sandy roared into New York on October 29, 2012, it drove the waters around our city right up to, and then over, our doorsteps. Forty-three people died in the deluge and untold numbers were injured. Along the shoreline the storm surge engulfed buildings and destroyed communities. It flooded roads, subway stations, and electrical facilities, paralyzing transportation networks.

After the storm receded, New York was a changed city. Homes and businesses were wiped out. The transportation system was in disrepair. And New Yorkers felt more vulnerable to the effects of global climate change.

As the city recovered, it became clear that addressing immediate damage from the storm was not sufficient. It was critical that the city develop longer term strategies for future storms, building on lessons learned during Sandy, and redouble the effort to address climate change that began with PlaNYC.

Starting in December 2012, Mayor Bloomberg brought together city agencies to develop A Stronger, More Resilient New York, a \$30 billion program to protect and strengthen the city. The program includes almost twenty transportation initiatives to fortify New York's transportation network, and outlines a strategy for rapid response to future emergencies.

This chapter illustrates NYCDOT's response to Sandy, and lists the transportation initiatives that will help protect and strengthen the city going forward.



Chapter 15

Impact of Sandy and the City's Response

During Sandy, many highways, roads, railroads, and airports flooded. At the same time, all six East River subway tunnels connecting Brooklyn and Manhattan were knocked out of service by flooding. The Steinway Tunnel that carries the 7 train between Queens and Manhattan, the G train tunnel under Newtown Creek, the Long Island Railroad and Amtrak tunnels under the East River and the PATH and Amtrak tunnels under the Hudson River were all effected. Major damage occurred to the South Ferry subway station in Lower Manhattan, as well as to the subway viaduct connecting Howard Beach, Broad Channel, and the Rockaways. Service also was disrupted on the Staten Island Ferry, the East River Ferry, and private ferries. Exacerbating flooding was the loss of electrical power, which made it difficult to pump out tunnels, clean up damaged subway stations, and begin restoring service. The difficulty in “dewatering” the tunnels further increased the damage from Sandy, as sensitive mechanical, electrical, and electronic equipment soaked in corrosive salt water. In addition to subway tunnels, flooding closed three vehicular tunnels into and out of Manhattan, interrupting the commutes of 217,000 vehicles, and over 500 miles of roads suffered significant damage.

Under Mayor Bloomberg’s leadership, relief and recovery efforts kicked in immediately. NYCDOT worked to open bridges and tunnels, repair streets and streetlights, and reopen the Staten Island Ferry. NYCDOT bridge engineers inspected, cleared and reopened the four East River bridges by 10 a.m. the day after the storm. DOT reopened long sections of the FDR within 24 hours, restoring this vital north-south link. Staten Island Ferry service resumed within 72 hours of the storm thanks to over 100 DOT staff who worked throughout the storm to protect boats and facilities.

Over the course of the recovery, DOT replaced over 3,800

traffic signals and over 400 street lights and removed 156,949 cubic yards of debris. With assistance from Army Corps of Engineers and DEP, DOT reopened all City-managed tunnels, with some 15 million gallons of water pumped from the Battery Park Underpass alone.

Although major bridges reopened as soon as winds dissipated and portions of the transportation network not directly flooded experienced little damage, the subway and over 500 miles of roads suffered significant damage. The subway system remained out of service in the days after the storm, even as crews worked around the clock to restore service. This led to substantial gridlock on roads and bridges into Manhattan as people tried to return to work by car. The commuting challenges led officials to implement temporary measures to manage travel and congestion.

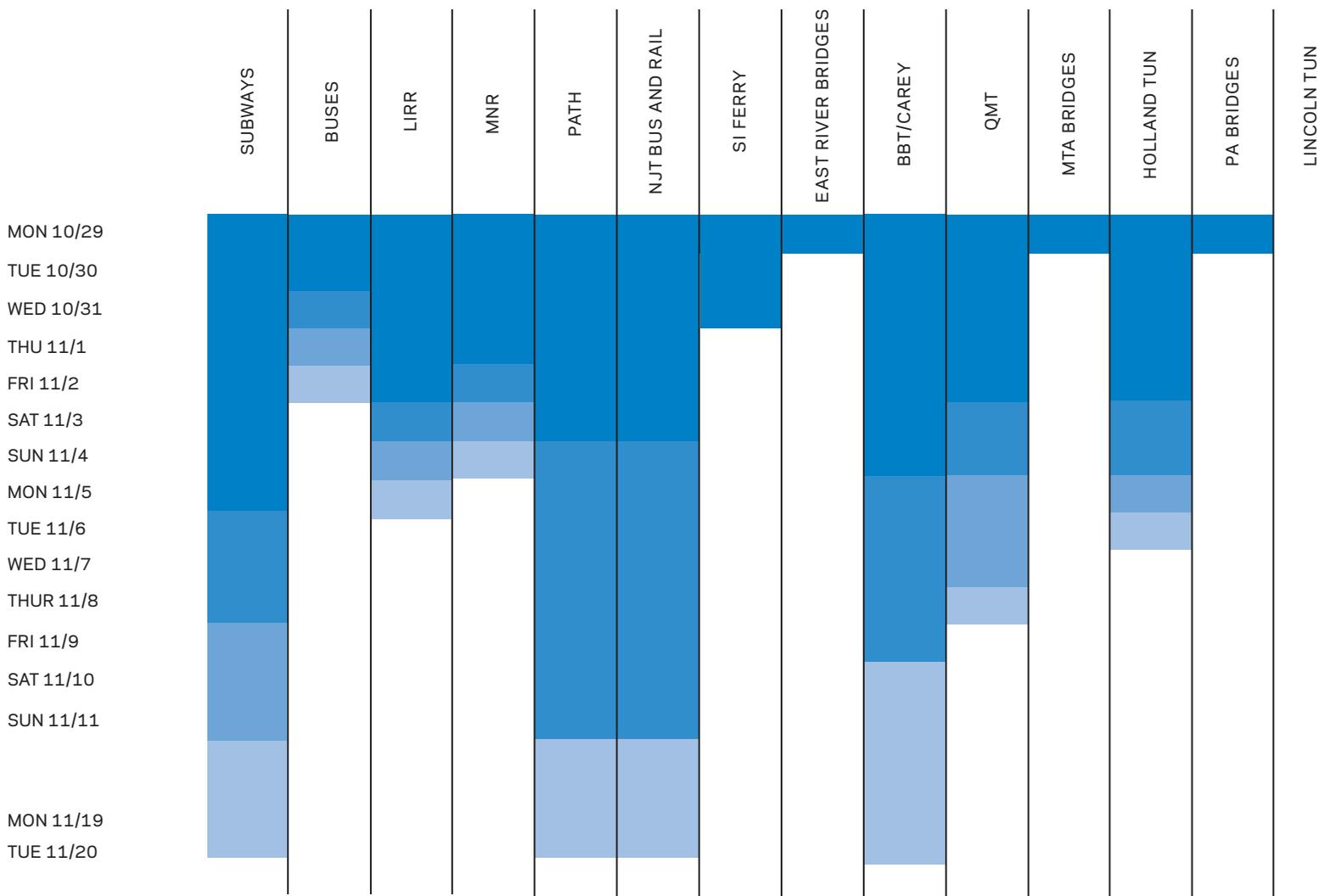
These measures included restrictions on single-occupant vehicles using bridges and tunnels across the Hudson and East Rivers, increased East River ferry service, and the successful “bus bridges” —an above-ground replacement for the subways that sent hundreds of buses back and forth on the bridges between Brooklyn and Manhattan. These measures enabled over 226,000 commuters to cross the East River—almost triple the number able to cross before they were in place.

One week after Sandy struck, many subway lines had been fully or partially restored, but some elements of the system remained closed much longer, with repairs projected to take months and even years.

Overall, Sandy caused over \$19 billion in damage in New York City, including \$800 million to infrastructure managed by DOT. Over \$700 million in damages to streets, signals, bridges, and facilities, including the DOT’s headquarters in Lower Manhattan, and over \$30 million in damage to the Staten Island Ferry and its facilities.

NYCDOT bridge engineers inspected, cleared and reopened the four East River bridges by 10 a.m. the day after Hurricane Sandy.

TRANSPORTATION OUTAGES AFTER THE STORM: BRIDGES PROVED THE REGIONS MOST RESILIENT





30
M.P.H.

12'-8"
CLEARANCE

The Life Group

DOT'S ROLE IN MAYOR BLOOMBERG'S PLAN FOR A STRONGER AND MORE RESILIENT NEW YORK



DOT trucks removing debris in the Rockaways

1. Integrate climate resiliency features into future capital projects:

Using storm water management to increase resiliency, where appropriate tools implemented will include bioswales, raising street grades, and bulkheads.

2. Elevate traffic signals and provide backup electrical power:

Over the next three years, controllers will be raised at approximately 500 vulnerable intersections. In addition, power inverters will be installed in 500 NYPD vehicles to provide backup power should grid power be lost.

3. Protect NYCDOT tunnels in Lower Manhattan from flooding:

Flood protection measure such as installing floodgates and raising tunnel entrances and ventilation structures for the Battery Park and the West Street Underpasses will be considered for implementation.

4. Install watertight barriers to protect movable bridge machinery:

NYCDOT will install watertight barriers to protect the bridges' mechanical equipment from flood damage and to ensure that the 25 of the City's bridges function properly.

5. Protect Staten Island Ferry and private ferry terminals from climate change-related threats:

Using Federal Transit Administration Emergency Relief funds NYCDOT and NYCEDC will construct improvements to floating infrastructure, loading gangways, pilings and piers at Whitehall and Saint George Ferry terminals and other ferry landings. In addition, waterproofing and relocating certain equipment will be initiated.

6. Plan for temporary transit services in the event of subway system suspensions:

NYCDOT working with transportation partners will develop and enforce temporary transportation services such a bus bridges, bus lanes and ferry service based on identifying potential threats. Increased access to LIRR and Metro-North will be investigated.

7. Identify critical transportation network elements and improve transportation responses to major events through regular resiliency planning exercises:

NYCDOT working with transportation agencies will identify the services and elements that need to be available during different events. Identifying crucial elements allows agencies to prioritize investment and improve operational responses.

8. Develop standard plans for implementing High-Occupancy Vehicle (HOV) requirements:

In order to address potential gridlock following both manmade and natural events when the subway system is down, NYCDOT, NYPD, NYC OEM are working together to formalize any exemptions to HOV requirements, including under which conditions the requirements would be implemented

9. Plan for and install new pedestrian and bicycle facilities to improve connectivity to key transportation hubs:

After Hurricane Sandy, NYC DOT removed 156,949 cubic yards of debris.



Bus transporting passengers to the Staten Island Ferry after the storm

NYCDOT and NYPD will deploy temporary pedestrian and bike capacity during an emergency situation and will procure and store the materials needed. NYCDOT will work with CitiBike to explore expansion into areas that are vulnerable to weather related transportation interruptions.

10. Construct new ferry landings to support private ferry service:

NYCEDC will work to expand the network of interim ferry landings and will work with NYCDOT to deploy four new permanent ferry landings which will be designed to be mobile so in an extreme situation they can be relocated to provide transit service where needed.

11. Deploy the Staten Island Ferry's Austen Class vessels on the East River and during transportation disruptions:

NYCDOT will develop operational plans for different scenarios in order to supplement East River Ferry service, the Austen class vessels will be used due to their large capacity.

SIGNALS AND STREET LIGHTS REPAIRED POST-SANDY

	TRAFFIC SIGNALS FIXED	STREET LIGHTS FIXED
STATEN ISLAND	38	90
BROOKLYN	1,645	205
QUEENS	1,339	123
BRONX	77	—
MANHATTAN	727	—
CITYWIDE	3826	418

12. Expand the city's Select Bus Service network and bus priority on arterial highways:

Over the next five years, NYCDOT will work with the MTA to implement four additional bus routes. An additional 12 routes will be launched and include 15 miles of bus priority projects on limited access highways.

Chapter 16

Restoring Mobility after the Storm

On a normal day, the subway carries about 80 percent of the people crossing the East River into Manhattan. Following Sandy, however, with subway service across the river entirely shut down for a number of days, many people tried to commute by car. As a result, gridlock took over many parts of the city including the East River crossings and major

highways and through routes. During, this period, average highway speeds dropped by as much as 71 percent relative to speeds on normal weekdays. It quickly became clear that the transportation network simply was not designed to handle the spike in drivers attempting to enter the central business district south of 60th Street.



Bus Bridge replaces “R” train between Brooklyn and Manhattan

In the days following Hurricane Sandy, transportation and power outages affected 8.5 million public transit riders, 4.2 million drivers, and 1 million air passengers.

BUS BRIDGES

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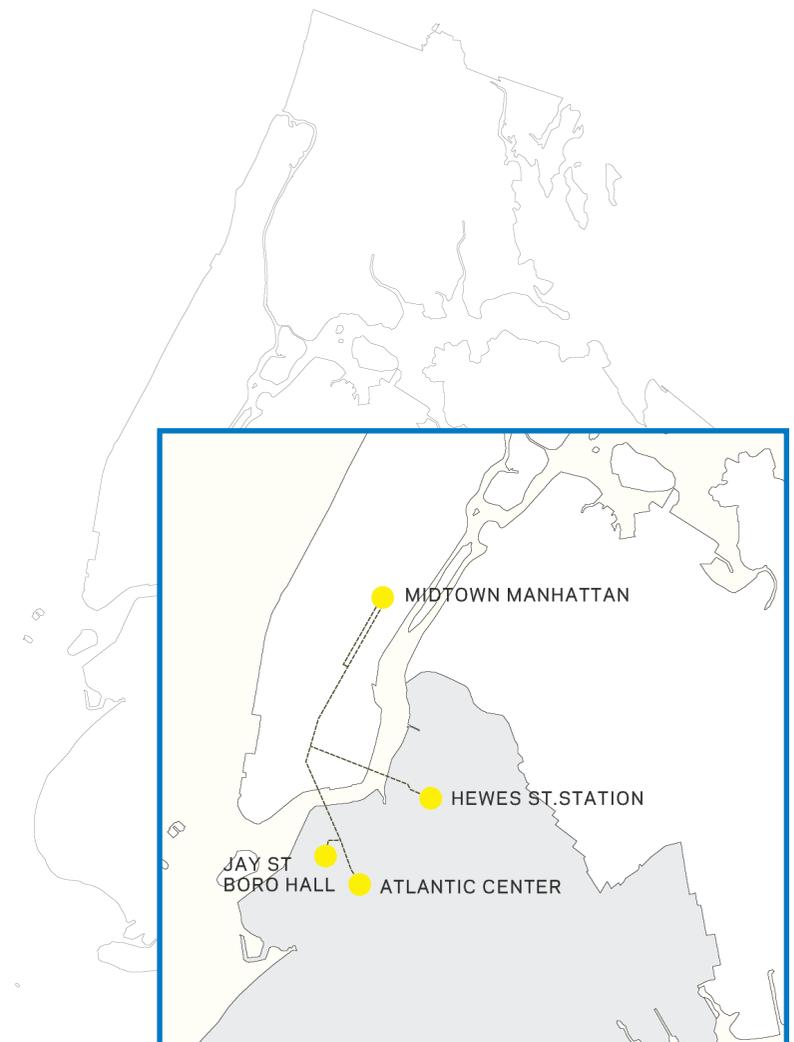
In response, the NYCDOT worked with the Metropolitan Transportation Authority (MTA) and NYPD to institute a series of measures to limit the number of cars coming into Manhattan. First, cars entering Manhattan's central business district were required to have three or more occupants, including those crossing the East River Bridges. Second, the NYPD, NYCDOT, implemented three new temporary, high-capacity, point-to-point bus routes (which quickly became known as "bus bridges"), Bus bridges connected Downtown Brooklyn and Williamsburg with Midtown Manhattan, using 300 buses that the MTA diverted from other routes. As part of this, the lower level of the Manhattan Bridge was turned into a bus only route. Third, the East River Ferry service pattern was modified to increase capacity and provide faster service along routes with the highest demand, taking advantage of the

infrastructure already in place and the vessels on hand.

While no bus service can match the capacity of multiple subway trunk lines, the post-Sandy bus bridges served much of the demand. The morning of Friday November 2nd, 74,000 people crossed the Manhattan Bridge by bus, foot, bike and private vehicle—over three times the 22,000 figure on Wednesday October 31st, when neither the bus bridge nor HOV3+ rules were in effect. On a typical weekday morning, the Manhattan Bridge serves 87,000 Manhattan-bound commuters, 87% of whom are subway passengers. The combination of the bus bridge and HOV3+ rules, in conjunction with increased pedestrian and bike traffic, boosted the Manhattan Bridge's non-subway capacity by over 670%.

These measures accomplished their desired goal, moving over 226,000 commuters across the East River—almost triple the number able to cross before these measures were in place. The bus bridge is a template in case of subway outages in the future.

TEMPORARY BUS BRIDGES AFTER THE STORM





72%

hours after the storm,
Staten Island Ferry
service resumed



Flooding at South Ferry subway station after the storm

NEW AND EXPANDED FERRY SERVICE

Ferries have played crucial roles in emergencies, climate events and times of crisis in New York City. In a waterfront city, ferries can be quickly deployed to evacuate people and can provide redundant transportation service when subways aren't functioning and bridges and tunnels are closed. The importance of ferries was reinforced after Sandy.

NYCDOT operates the Staten Island Ferry, a crucial link between Staten Island and Manhattan. Thanks to the hard work of NYCDOT staff during the storm service resumed just 72 hours after the

storm despite damage to the Whitehall and St George ferry terminals. After the return of service on 11/1, ridership on the East River Ferry surged to 2.5 times the level of a typical weekday morning.

Other ferry services are managed by the city's Economic Development Corporation, but DOT plays an important role in siting ferry docks and improving access to the service. EDC and DOT implemented temporary ferries to provide transportation services for areas hardest hit by the storm, including services to Great Kills and the Rockaways.

Great Kills Ferry

One of the services was a temporary ferry from Great Kills, Staten Island to Manhattan. It launched on November 25th 2013 using Federal Emergency Management Agency funds and ran for eight weeks.

While the temporary service offered a new transportation option for the weeks immediately following the storm, ridership never reached anticipated levels, and waned significantly in its final weeks. On average, only 114 riders used the service in each direction each day, or roughly 19 passengers per boat.

Rockaway Ferry

Helping to assist thousands impacted by Hurricane Sandy in the Rockaways, Mayor Bloomberg, New York City Economic Development Corporation and Seastreak provided a temporary ferry service between the Rockaways and Manhattan starting on November 12, 2013. Originally slated to run through July, the service was extended through Labor Day and then again until January 2014. The service provided alternative transportation due to the closure of the A train to the Rockaways and R train tunnel between Manhattan and Brooklyn. Both lines experience damage after the storm.

On Friday November 2, the number of people riding over the East River Bridges by bike more than doubled from 3,500 to 7,800.

Protecting the fleet

The heroic service of DOT's Ferry Division during Hurricane Sandy prevented damage to six ferryboats during the storm. As winds reached over 80mph and a record breaking tidal surge took over New York harbor, 90 ship-board crew and 60 additional staff on the ferry docks stopped the boats from striking the ferry slips and each other. The ferryboat crews adjusted mooring lines as the tide rose. Captains worked boat engines the entire night making sure the ferries stayed in position between the piers and did not come in contact with the piers or the associated pilings. At one point, an Austen class boat's stern line came lose, and the boat made contact with the Senator John J. Marchi, which was moored nearby. DOT Ferry staff placed make-shift fenders in between the two vessels

to minimize the potential for damage as the vessels came together. As the storm progressed and the storm surge escalated, water engulfed both the Whitehall and St George Ferry Terminals. DOT staff had to move to the upper floors to stay safe.

The professionalism and dedication and long hours put in by DOT's captains, crews and shore staff ensured that almost \$200 million worth of custom-built ferryboats were kept safe and secure during the hurricane. After the storm, ferry staff worked around the clock to repair electrical systems and remove debris to the St. George and Whitehall terminals*. Despite \$30 million in damage to ferry terminals, the Staten Island Ferry was up and running 72 hours after the storm.



Commissioner Sadik-Khan on first Staten Island Ferry to run 72 hours post-Sandy

Bicycles

The city's substantial improvement to the bike network provided much needed transportation capacity in the days after the storm. On a typical weekday, 3,500 people enter Manhattan by bike using one of the

four East River Bridges. On Friday November 2nd, the total swelled to 7,800. Unfortunately, the storm did damage CitiBike equipment that was in storage in the Brooklyn Navy Yard prior to the program's start.



Bicycling rates swelled after the storm

NYCDOT used Twitter, The Daily Pothole, and Facebook to communicate with New Yorkers after the storm.

USING SOCIAL MEDIA IN EMERGENCY SITUATIONS

In the days after Superstorm Sandy, NYCDOT used social media to communicate with the public about the recovery.

The Daily Pothole tumblr, which documents NYCDOT street maintenance crews, was temporarily transformed into a Sandy recovery page, documenting clean-up efforts in affected areas. DOT's roadway repair, street lighting, and emergency response crews focused on clearing the streets of debris and fixing traffic signals and stop signs to help communities get moving again.

The number of Daily Pothole subscribers increased by 50% after the storm, to nearly 15,000, as New Yorkers found the frequent updates to contain useful information about the status of recovery efforts. NYCDOT's twitter and Facebook following also increased after the storm.

The post Sandy experience with the Daily Pothole shows how government and its citizenry can benefit from flexible communication strategies like tumblr during emergencies.



Staten Island Ferry shared a link.
November 24, 2012

Temporary commuter ferry service from Great Kills begins Monday, November 26! Learn more and check the schedule: <http://www.nyc.gov/html/dot/html/ferrybus/greatkills.shtml>

NYC DOT - Ferries - Great Kills Ferry, Staten Island
www.nyc.gov

Mayor Michael R. Bloomberg and Commissioner Janette Sadik-Khan have announced a request for bids for a new, temporary ferry service from Great Kills, Staten Island to Manhattan. The new service is designed to bring immediate relief to, and ease the commutes of, neighborhoods that

NYCDOT Posted information about the Great Kills Ferry on Facebook

The Daily POTHOLE
SANDY RECOVERY





Looking Ahead

For years environmental experts have been projecting the possible catastrophic effects of increasingly volatile and extreme weather conditions on New York, but it wasn't until Hurricane Sandy hit that the region experienced the magnitude of these impacts first hand.

The storm generated a sense of urgency around long-term resiliency and sustainability. The city pledged to redouble environmental efforts outlined in PlaNYC to reduce greenhouse gases that contribute to climate change. It also set in motion plans, procedures, and projects to adapt infrastructure and improve government response to future events.

In the immediate aftermath of the storm, NYCDOT worked closely with other agencies to restore basic operations and assess the extent of the damage to the City's transportation assets. The city's use of bus bridges, for example, proved that transit and roadway networks can be adapted quickly to emergency situations. The experience gave transportation officials a template for future events and helped them refine a list of objectives to keep people moving in emergency situations. These included immediately restricting single-occupant traffic as soon as long-term subway outages are confirmed, creating temporary bus routes to replace inoperative links of the transit network and adding capacity on existing bus routes with disaster-induced demand spikes, and exploiting redundant capacity in modes like ferries to scale up temporary service in disconnected areas. The spike in bicycle riding after the storm also prompted NYCDOT to evaluate additional bike facilities over the East River Bridges.

As vehicular tunnels and subway lines returned to service

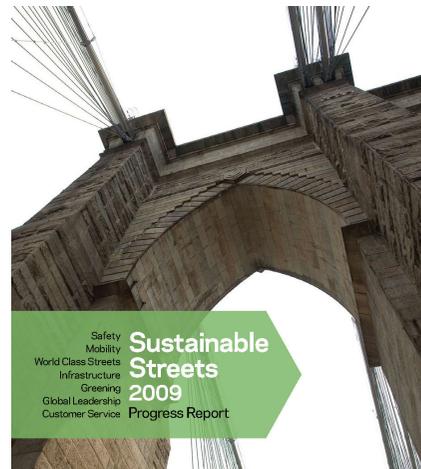
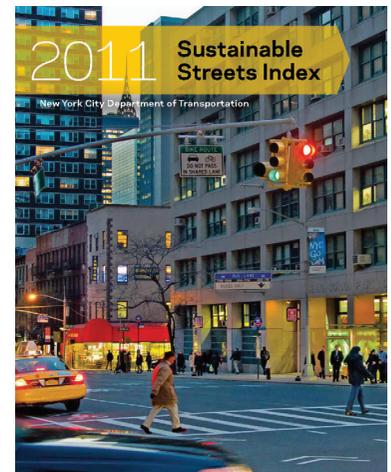
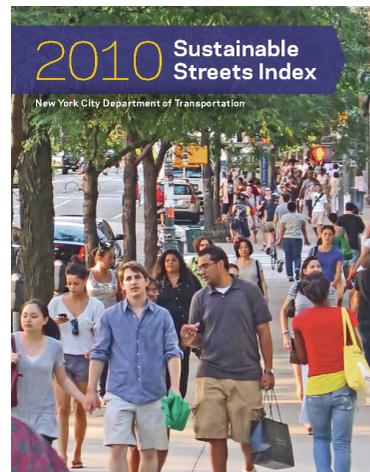
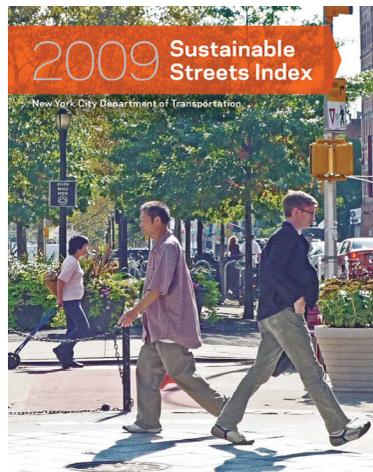
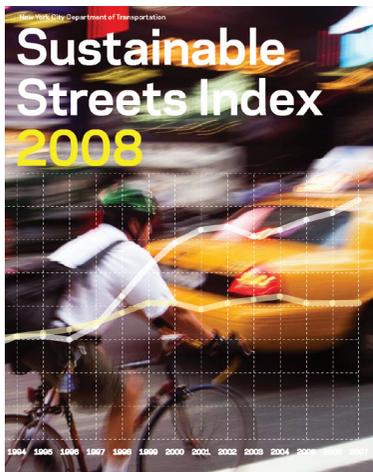
in the weeks following the storm, New York City's transportation network started to return to normal operations. However, many streets in the most vulnerable coastal areas remained severely damaged by the force of the storm. Creeping corrosion necessitated repairs long after the actual floodwaters had subsided. In many locations, merely restoring agency assets (roadways, bridges, ferries, traffic controls) to its pre-Sandy condition is not enough. The transportation system needs to be made more resilient in the face of storm surge, more intense precipitation, warmer temperatures, and stronger winds.

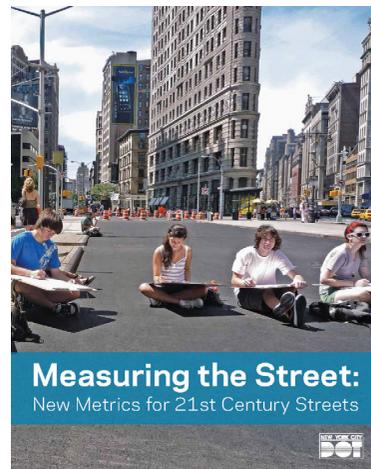
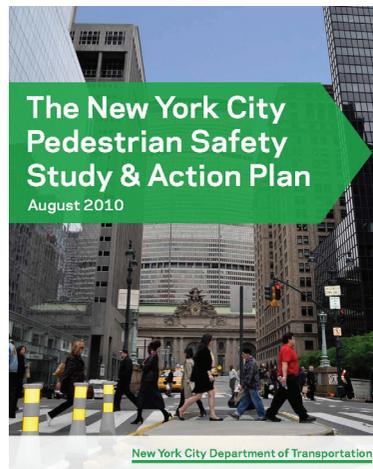
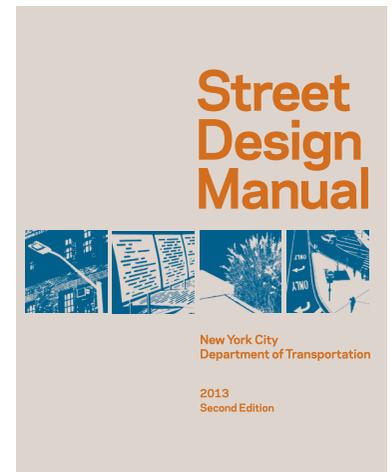
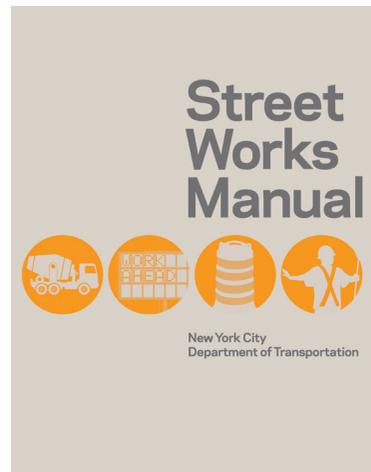
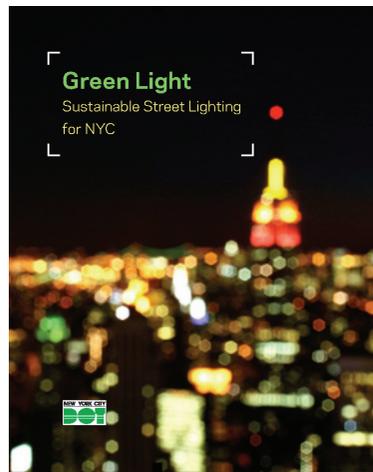
Through the Mayor's Special Initiative for Rebuilding and Resilience (SIRR), NYCDOT and its partner agencies identified innovative ways to rebuild smarter and stronger. *A Stronger, More Resilient New York* outlined 18 transportation initiatives central to the City's resiliency goals. In many areas, the challenge is not merely the protection of a physical asset, but ensuring that transportation network has the redundancy and flexibility to handle unforeseen outages. Continued expansion of bus rapid transit, for instance, not only benefits regular commuters, it also broadens the transit network in ways that can better serve demands when a subway line is out of service. The report also called for larger transit expansion projects for added redundancy, including Amtrak's Gateway project into Penn Station.

All of these initiatives, most especially coastal protection, will require ongoing collaboration among city and state agencies. And they will require sustained, long-term investment during a time of uncertain and shrinking funding for transportation infrastructure.

NYCDOT Publications

Since 2007, NYCDOT has published more material stating agency goals, describing programs and documenting transportation trends and project outcomes than ever before. These are some of DOT's major publications. They and others are available at nyc.gov/dot.







Acknowledgments

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