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**THE US HOUSE OF REPRESENTATIVES**
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***Tuesday, May 21, 2019***

## I. INTRODUCTION

Good morning. My name is Susanne DesRoches and I am the Deputy Director for Infrastructure and Energy for the New York City Mayor's Office of Resiliency. On behalf of the Mayor and the City of New York, I would like to thank Chair Sherrill and Ranking Member Norman for the opportunity to speak today about the City's challenges, accomplishments, and opportunities to build a more resilient transportation network that will benefit New Yorkers and the nation's economy as a whole.

Nearly seven years ago, Hurricane Sandy hit New York City with unprecedented force, tragically killing 44 New Yorkers,[1] and causing over $19 billion in damages and lost economic activity. Neighborhoods were devastated: 88,700 buildings were flooded; 23,400 businesses were impacted; and our region's infrastructure was seriously disrupted.[2] Over 2,000,000 residents were without power for weeks and fuel shortages persisted for over a month.[3] Cross river subway and rail tunnels vital to the movement of people and goods were closed for days. Our airports were closed to passenger and freight traffic, and our ports sustained substantial damage to physical infrastructure as well as goods stored at their facilities. In short, Sandy highlighted New York City's vulnerability to climate change and rising seas and underscores the urgency of the actions we've taken since then to build a stronger, more resilient city. Sandy also vividly emphasized how vital our regional transportation network is to the functioning of a healthy regional and national economy.

In this testimony, I will provide a broad summary of national transportation challenges associated with climate change and discuss New York City's specific vulnerabilities. I will also outline the actions that New York City is taking to improve the resiliency of our transportation

1 https://www1.nyc.gov/site/cdbgdr/about/About%20Hurricane%20Sandy.page
2 http://www.nyc.gov/html/sirr/downloads/pdf/final_report/Ch_1_SandyImpacts_FINAL_singles.pdf
3 ibid

systems and offer suggestions on how Congress and our federal partners can continue to support cities as we prepare for the challenges of climate change.

**A. Findings of the Fourth National Climate Assessment**

The Fourth National Climate Assessment was released on November 23, 2018.[4] National Climate Assessments are mandated by the Global Change Research Act of 1990,[5] and assess the impacts of climate change on the United States. I am a co-author of the transportation chapter of this report, along with professionals from the transportation industry, the US Department of Transportation, and academic and engineering experts.

In this assessment, we found that the impacts of climate change—such as heavy precipitation, coastal flooding—threaten the existence of "a reliable, safe, and efficient U.S. transportation system." The impacts of climate change are already being felt; and will continue to be felt throughout our country and economy.

For instance, by 2100, certain states along the eastern seaboard will experience over 625 million vehicle hours of delay annually due to high tide flooding if roadway networks are not prepared for the impacts of sea level rise.[6] Climate impacts will affect all of our transportation, freight, and transit networks, including air, rail, road, and marine. Climate change impacts on transportation infrastructure will also disproportionately burden vulnerable populations.

Importantly, the assessment found that cities and states are taking action mainly through conducting vulnerability assessments specific to transportation infrastructure. These assessments assist decision makers in identifying and prioritizing ways to mitigate risk through resiliency projects and operational strategies. The National Climate Assessment shows that these vulnerabilities are not limited to one geographic region. The Assessment found many examples of climate vulnerability, including:

- Critical roadways, rail lines, ports, and pipelines bringing fuel and goods to market in transportation hubs such as Mobile, AL, Long Beach, CA, and Houston and Galveston, TX will be at risk with 30 inches of sea level rise.
- 13 of the nation's 47 largest airports have at least one runway with an elevation within the reach of moderate to high storm surge today.
- The Upper Mississippi and Missouri river basins have seen two 300-500 year floods within the past 20 years, posing hazards to bridge structures and the navigability of rivers.

New York City understands that we are not alone as we face climate-related challenges, and we rely on documents such as the National Climate Assessment to reassess our strategies for mitigating our risk and to learn from our peers.

[4] https://nca2018.globalchange.gov/
[5] https://www.globalchange.gov/about/legal-mandate
[6] https://nca2018.globalchange.gov/chapter/12/#fig-12-3

## II. NEW YORK CITY WILL EXPERIENCE TRANSPORTATION NETWORK DISRUPTIONS DUE TO THE EFFECTS OF CLIMATE CHANGE

For more than a decade, New York City has been at the forefront of climate science-informed policy, leveraging the expertise of the New York City Panel on Climate Change (NPCC), an independent panel of academic and NASA scientists formed by the City of New York in 2008, and whose members are appointed by the Mayor. This body provides scientific projections for the region and assists the City's policymakers in understanding and planning for the climate change risks of today and the threats of the future.

The Panel's fourth and latest assessment, released in March 2019, makes it clear that the city will face new and worsening challenges from a range of climate hazards. These include increasing frequency of heat waves that will impact vulnerable populations and up to six or more feet of sea level rise by the end of the century, which will reshape our shoreline and subject transportation corridors to daily flooding.[7] Extreme rainstorms will become more common, necessitating improvements to drainage infrastructure commensurate to these changes. A summary of New York City's climate change projections is provided in Exhibit 1.

The City of New York maintains 6,000 miles of roadways and 794 bridges and tunnels which provide key access corridors for vehicles, transit, and freight.[8] Since 2006, we have installed over 1,200 miles of bike lanes,[9] and are expanding the Western Hemisphere's largest bike-sharing system from 12,000 to 40,000 bikes.[10] Many transportation networks within the city, however, are not operated by City agencies. The Metropolitan Transportation Authority (MTA) is a New York State agency responsible for the operation of subways and buses within New York City and two regional rail networks. The Port Authority of New York and New Jersey (PANYNJ) operates the region's major airports and ports, bridges and tunnels between New York City and New Jersey, as well as the PATH light rail system. NJ Transit operates regional rail to and from New Jersey, and Amtrak maintains and operates rail infrastructure connecting New York City, New Jersey, Connecticut, and long distance rail (see exhibit 1 for an overview of transportation networks in the City). Exhibit 2 provides an overview of transportation networks within New York City. Given that the effects of climate change do not recognize the fact that many different stakeholders operate different parts of the transportation network, it is in the de Blasio Administration's interest to ensure a multi stakeholder response.

No part of New York City's transportation network was spared from the effects of Hurricane Sandy. Starting the day before Sandy hit, most public transportation agencies initiated an orderly shutdown of their systems to protect critical infrastructure and vehicles and to ensure public safety. Due to concerns about high winds and flooding, the Port Authority, MTA, and the City closed major bridges and tunnel crossings, with the exception of the Lincoln Tunnel, the entrances to which were deemed to be high enough above the Hudson River to be at low risk of flooding. Meanwhile, airlines flew their planes out of harm's way, sheltering them at airports out of Sandy's path.

[7] https://nyaspubs.onlinelibrary.wiley.com/doi/10.1111/nyas.14008
[8] https://www1.nyc.gov/html/dot/html/about/about.shtml
[9] https://www1.nyc.gov/html/dot/downloads/pdf/cycling-in-the-city.pdf
[10] https://www1.nyc.gov/office-of-the-mayor/news/576-18/mayor-de-blasio-dramatic-expansion-citi-bike#/0

Once Sandy arrived, its storm surge severely impacted many elements of the transportation system, including subway, railroad, and vehicular tunnels. Vehicular tunnels that were closed due to severe storm damage included the City's Battery Park Underpass and West Street Underpass, the MTA's Queens Midtown and Hugh L. Carey (formerly Brooklyn- Battery) Tunnels, and the Port Authority's Holland Tunnel. Also inundated were all six of the subway tunnels connecting Brooklyn to Manhattan, the Steinway Tunnel that carries the 7 train from Queens to Manhattan, and the G train tunnel between Queens and Brooklyn. The Port Authority's PATH tunnels under the Hudson River also were flooded, with water entering via entrances on both the New York and New Jersey sides, as were Amtrak and the MTA's railroad tunnels under the East River and the Hudson River. Many subway stations and rail yards were flooded, and floodwaters damaged rail viaducts in Queens. Maritime transportation was disrupted due to damage to landings and docks. The Port Authority's airports flooded from storm surge, but waters did not reach critical terminal infrastructure.

After Sandy passed through New York City, days-long power outages severely affected the ability to dewater tunnels and restore service to the transportation systems. Given that many tunnels were inundated with salt water for days, lingering damage caused electrical malfunctions for months and years after the storm. As commuters attempted to return to work three days after the storm, the subway and other transportation systems were still out of service. This caused significant congestion on surface roadways. For example, when Hurricane Sandy disabled subway connections across the East River, over 40,000 additional daily bus trips and another 40,000 private vehicle trips were made over New York City's cross-river bridge network in the weeks after the storm, stressing the ability for the roadway network to absorb excess capacity.[11] Commuters experienced this congestion and also faced severe fuel shortages that would last for weeks. These factors limited the ability for the regional transportation network to support recovery actions and transportation in the wake of the disaster.

Facing these challenges, City officials partnered with the MTA and Port Authority to place bus bridges into service where subway service was not available, impose carpool requirements on bridge crossings, and put in place temporary ferry routes. This emergency operational plan helped New York get moving again even with severely limited transportation options.

Service gradually returned to normal with the City, transportation agencies, and utilities working around the clock to remove debris, dewater tunnels, and restore electric service. Ferries and marine transportation took between two days and a week to restore, while airports were open three days after the storm. Most subway service was restored a week after Sandy, and vehicular tunnels were in service 10 days after the storm. Two weeks after the storm, most, but not all, transportation systems were up and running again. All told, Sandy resulted in almost $16 billion in documented costs to regional transportation agencies.[12]

Hurricanes are not the only extreme weather event to have already caused significant impacts to New York City. Extreme rainfall is also a risk, as evidenced on August 8, 2007 when nearly 4" of rain fell within two hours during morning rush hour. The intensity of the rain was too great for the existing drainage, and flash flooding occurred across the metropolitan region, ultimately

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[11] https://www1.nyc.gov/site/sirr/report/report.page
[12] https://www.fhwa.dot.gov/environment/sustainability/resilience/publications/hurricane_sandy/index.cfm

disrupting the trips of 2.5 million transit customers. Major disruptions were felt on 19 segments of the subway system, service on the lines of both Metro North and Long Island Railroad was suspended, and there were significant disruptions to bus services citywide as highways, roads, and underpasses flooded.[13] These two hours of rain caused so much damage that the President declared a national emergency in Brooklyn and Queens where the damage was most severe, qualifying these boroughs for federal disaster assistance.

The greatest future risk to the city's transportation network is storm surge—a risk that, as Sandy illustrated, is significant even today primarily because so many critical pieces of transit infrastructure are located within the 100-year floodplain, the area that has a one percent or greater chance of flooding in any given year. This is true of many other coastal communities across the United States, as found in the National Climate Assessment. The 100-year floodplain in New York City already includes approximately 12 percent of the roadway network, all of the major tunnel portals other than the Lincoln Tunnel, portions of both airports, a variety of commuter rail assets, our heliports, and a number of subway entrances and vent structures, principally in Lower Manhattan. Going forward, the risks associated with storm surge will grow more severe, as rising sea levels increase the impact of those surges and turn minor surges into major events. A map of New York City's anticipated floodplain in 2050 is provided in Exhibit 3. By 2100, 20 percent of Lower Manhattan's streets could be subject to daily tidal inundation.[14]

Extreme rainfall events are also increasing, and will continue to cause costly disruptions to our transportation system. Other risks that will affect our transportation network include high winds and heat waves. An assessment of all these risks and regional vulnerabilities is included in Exhibit 2.

## III. NEW YORK CITY HAS IMPROVED THE RESILIENCY OF OUR TRANSPORTATION NETWORK

The region is dependent upon the functionality of its transportation systems. After Sandy, the City of New York and its partners took significant actions to repair damaged transportation infrastructure and improve the resiliency of the network. For example, the MTA worked to "Fix and Fortify" its system of subways, buses, regional rail lines, bridges, and tunnels, while the Port Authority embarked on an ambitious resiliency capital program, upgrading temporary measures into permanent protections using forward-looking climate data.

### A. The de Blasio Administration is investing in resilient roadway and ferry networks

In the days after Sandy, underground and aboveground rail transportation networks, as well as roadway tunnels, were disabled. This changed traffic patterns on New York City streets and sidewalks, many of which lacked signalization due to power outages, and led the City to impose mandatory high occupancy vehicle restrictions on East River Bridges, which reduced strain on the transportation network and boosted its efficiency. In the months and years after Sandy, City of New York's transportation department needed to reconstruct 60 lane miles and resurface 500

[13] http://web.mta.info/mta/pdf/storm_report_2007.pdf
[14] https://www.nycedc.com/project/lower-manhattan-coastal-resiliency

lane miles of roadway,[15] as well as perform significant repairs on two tunnels in lower Manhattan. The City continues to invest in its resiliency strategy, including raising traffic signal controllers in flood prone areas, protecting vulnerable moveable bridge machinery, raising streets and street ends in neighborhoods with chronic flooding problems, and siting more than 4,500 street-side rain gardens and green space to date.[16]

Ours is a city of islands, and ferries are an important part of our transportation system. Ferries serve residents of our some of our most vulnerable neighborhoods such as the Rockaways in Queens, Soundview in the Bronx, and several parts of south Brooklyn, and provide important redundancy in the event of severe weather events. In addition, over 22 million people rely on the Staten Island Ferry every year,[17] which provides a critical transportation link to the only borough without a direct rail connection to other boroughs. The Staten Island Ferry Terminals were badly damaged in Sandy, and the ferry system received $191 million from the Federal Transit Administration's Hurricane Sandy Competitive Resilience Program to purchase new vessels capable of operating during large scale evacuations and to complete storm hardening projects at both the St. George and the Whitehall ferry terminals.[18]

**B. The City convenes critical stakeholders to leverage a citywide adaptation knowledge base**

As noted above, the City has fairly limited control over other parts of the regional transportation network, given the complex web of operators and jurisdictions inherent in a connected region encompassing three states and dozens of counties and municipalities.

To coordinate resiliency actions between these important yet distinct agencies, the City first convened the New York City Climate Change Adaptation Task Force in 2008. The City acknowledges that the functionality of the regional transportation effort depends upon the cooperation of transportation agencies and operators of services upon which the transportation industry depends, including liquid fuels, electric power, communications, and water/wastewater providers. Both before and after Hurricane Sandy, the City worked with task force members to understand local climate change projections, and used those projections to assess and prioritizes climate risks to infrastructure assets. This knowledge base was critical to Sandy recovery, and today allows the City to identify potential failure points in advance of major events, and determine what actions or coordination among stakeholders can mitigate certain risks. It also has inspired internal policy at agencies. For example, the Port Authority's Climate Resilience Design Guidelines incorporate climate change projections into an engineering standard used in the design of the transportation authority's capital projects.[19] The task force continues to meet regularly and share information and best practices, as required by Local Law 42 of 2012.[20]

[15] https://www1.nyc.gov/site/sirr/report/report.page
[16] https://www1.nyc.gov/html/dep/pdf/green_infrastructure/gi-annual-report-2018.pdf
[17] https://www1.nyc.gov/html/dot/html/about/about.shtml
[18] https://www1.nyc.gov/html/dot/html/pr2014/pr14-usdot.shtml
[19] https://www.panynj.gov/business-opportunities/pdf/discipline-guidelines/climate-resilience.pdf
[20] https://legistar.council.nyc.gov/LegislationDetail.aspx?ID=1107144&GUID=FB5DD6B3-D9D2-4C02-AD0F-61FF1A91BA88&Options=ID%7CText%7C&Search=834-A

## C. The City is using forward-looking data in the design of City capital construction projects

In the face of climate change and extreme weather, New York City has taken bold action to overhaul how we plan and design our built environment. Every City facility including police stations, schools, senior centers, and public housing built today needs to be ready to serve New Yorkers for decades to come. To ensure that our capital assets are resilient to extreme weather and a changing climate, the de Blasio Administration has developed guidelines to include forward-looking climate change data in the design of all city government capital projects. In March of this year, we released version 3.0 of our Climate Resiliency Design Guidelines after several years of testing and analysis (see Exhibit 4).

The Guidelines provide designers and engineers with step-by-step instructions and tools to incorporate sea level rise, heat, and rainfall projections into the design and construction of capital projects. Examples of design guidelines for heat and sea level rise are included in Exhibit 5. The City engaged the scientific, engineering, and architectural communities to ensure that this innovative product is ready for use. Each time the City invests public dollars in the buildings and infrastructure that New Yorkers rely on, we have an opportunity to invest that money in facilities that are going to be resilient to a changing climate. As an example, climate informed design standards could allow inland roads to absorb more rainwater and elevate coastal streets above the elevation of high tides and sea level rise to the extent possible. Resilient ferry terminals are able to withstand waves and winds, ensuring that soon after a storm ends the life of the city can continue again. With the Guidelines, we are ready to take the necessary steps to go beyond existing design standards and begin building today for the climate we will have tomorrow.

## D. The City is leading on regional emergency management and hazard mitigation

Planning for disaster is a crucial part of our resiliency plan, and the City coordinates closely with the region’s major transportation providers. The New York City Emergency Management agency recently released its latest Hazard Mitigation Plan (HMP), which continues to make the City eligible for post-disaster mitigation funding from FEMA, including Hazard Mitigation Grant Program (HMGP) and the new Pre-Disaster Mitigation (PDM) funding. Beyond the regulatory requirement to complete an HMP, the City intends for the plan to serve as a risk communication tool to the general public, with information on risks and ongoing/completed mitigation actions across a range of natural and climate hazards. The HMP was completed in conjunction with the region’s two largest transportation providers, the PANYNJ and the MTA.

Emergency Management chairs the New York City Urban Area Working Group, made up of New York City, Nassau and Suffolk counties in Long Island, Westchester County, Yonkers, and the Port Authority of New York and New Jersey. The Working Group is instrumental in linking and coordinating regional activities, including joint training and exercises, public education and outreach, and the development of response protocols. The agency is also active in the nationwide group, Big City Emergency Managers, a network of 16 large cities, including New York City, Seattle, Los Angeles, Houston, Miami, Chicago and others, that meet semi-annually to discuss issues of mutual concern.

**E. The City is partnering with FEMA on forward-looking flood mapping products**

Planners and developers across city government and private sector entities require sophisticated tools to plan for current and projected flooding risks and other climate change impacts. In 2016, as part of the resolution of the City's appeal of the Preliminary Flood Insurance Rate Maps, FEMA and the City agreed to develop innovative future flood hazard product(s) to better enable ongoing resilient planning, design, and land use strategies in New York City. The new future flood hazard product(s) will inform adaptation strategies for reducing flood risk to property and the environment <u>today</u> and in the <u>future</u>, as well as design standards and regulation for construction and development, notably building codes, zoning ordinances and land use regulation. In this regard, the future flood hazard product(s) will allow city planners, engineers, architects and contractors to ensure that their buildings and infrastructure are designed to withstand future climate stresses.

## IV. SUGGESTIONS FOR HOW CONGRESS CAN SUPPORT CITIES

Congress can play an important role to ensuring the long term resiliency of our nation's transportation network. I will now outline three specific recommendations to enhance and protect transportation infrastructure and plan for the impacts of climate change.

**1. Use forward looking climate data to inform policy and program design**

We cannot continue to look to past weather conditions to plan for the future. Building code and engineering standards as written today assume that the past 30, 50, or 100 years of weather gives us insight into what the next century of weather will look like. Historic data alone is no longer a reliable proxy for future conditions. We have climate change projections of ever-increasing confidence available today, and those projections offer new practical applications. New York City recognizes the imperative of using forward-looking weather projections to supplement historic weather data, and that's why we've issued the Climate Resiliency Design Guidelines to change how the City designs and builds its infrastructure and buildings. The Guidelines identify the changes to existing design standards that we need to take in New York City, such as: identifying where design flood elevations need to be higher; assessing how much larger stormwater retention systems need to be to manage extreme rain; and identifying which materials and mechanical systems need to be upgraded to better withstand extreme heat.

The City is not alone in this effort. The MTA and PANYNJ have implemented similar resilient design guidelines to ensure that their transportation infrastructure is able to withstand the stresses of climate change and shocks of extreme weather. This is increasingly true of other cities and agencies across the country. The City of New York's efforts used existing Federal guidance on preventive maintenance and resilient design, including:

- Federal Highway Administration Order 5520 (2014) "*Transportation System Preparedness and Resilience to Climate Change and Extreme Weather Events,*" which advises on the use of risk-informed decision making and adaptive learning.
- Executive Order 13690 from 2015 established guidance on how the use of forward-looking sea level rise data in federal capital investments to improve the nation's resiliency Though rescinded in 2017, this EO established an important standard for using

forward-looking data that provided an important foundation for the development of the City's resilient design policy.

We encourage Congress to pass legislation that requires the use of forward-looking climate change data. One near-term example would be for Congress to re-establish EO 13690 and make it law. Using forward-looking data increases the resilience of our built environment, ensuring that assets built today serve Americans for decades to come, do not require additional maintenance costs, and are able to withstand the extremes of climate change. All Federal investments in our country's transportation infrastructure should be designed to a resilient standard using forward-looking climate data.

**2. Enable federal disaster aid programs to help cities make resiliency investments before disasters strike**

We urge the federal government to take an increasingly proactive role to ensure that transportation infrastructure be prepared ahead of natural disasters. In January 2019, the National Institute of Building Sciences published its *Natural Hazard Mitigation Saves: 2018 Interim Report*, and found a national benefit of $11 dollars for every $1 invested. Every dollar we invest in stronger, more resilient transportation infrastructure offers significant returns to not just our city and region, but to the country. The City commends Congress' passing of the Disaster Recovery Reform Act of 2018, particularly Section 1234 on National Public Infrastructure Pre-Disaster Hazard Mitigation, which creates an annual fund with a 6 percent set aside from disaster expenses in the previous year "to allow for a greater investment in mitigation before a disaster." We urge Congress to expand this program, increasing the amount of money set aside for pre-disaster mitigation project scoping so as to better capitalize on the benefits of proactive hazard mitigation.

It is important to acknowledge that extreme weather events are only one of the threats to our infrastructure. The chronic stresses to the built environment caused by higher temperatures, rising seas, and the increasing intensity of rain pose an equally great challenge and cost to the City as one-time natural disasters. However, these are not addressed or funded in the same way. Pre-disaster funding also needs to be provided to specifically address chronic stressors of factors like temperature extremes in addition to the major shocks of events like hurricanes.

We recommend that Congress and our federal partners fund and collaborate on studies that continue to refine and characterize specific climate risks for cities, in order to appropriately target mitigation activities and operational response planning, specifically funding conceptual planning studies to scope large-scale, cost-effective mitigation projects and the operational response activities associated with these projects.

Finally, we are also looking to Congress to help rationalize the distinct ways federal agencies calculate benefit-cost ratios, since each agency has its own methodology. These methodologies should be streamlined and standardized to support faster recovery and mitigation investments. Furthermore, benefit-cost ratios are biased by higher property values, placing lower-income communities at a disadvantage when comparing mitigation projects. We urge Congress to address these issues.

### 3. Fund investments in resilient transportation infrastructure

We urge Congress to increase federal funding for transportation to address existing infrastructure challenges that will be worsened by climate change. There is evidence of ongoing underinvestment in parts of the US transportation system, and it is vitally important for Congress to directed funding towards new construction and asset management to provide the robust, resilient systems that support the nation's economy. Specifically, we urge Congress to increase funding for the public transit, bicycle, and pedestrian infrastructure and services that move tens of millions of Americans daily. These add vital resiliency to the nation's mobility systems.

We urge Congress to make the visionary transportation infrastructure investments that shape our nation and bolster our economy, like those made by this body for generations, such as the Federal Highway Act of 1956 and the Rail Passenger Service Act of 1970. These kinds of investments are the backbone of our national economy and have substantially contributed to American prosperity and global competitiveness. The need for new investment in our transportation system is great, and the call to make those investments resilient is loud and clear.

In the New York City region, one critical infrastructure project is the long overdue rail tunnel between New York and New Jersey, referred to as the Gateway Tunnel, which would vastly strengthen this crucial and vulnerable transportation line serving not just the city but the entire Northeast Corridor. The Portal Bridge and two-track North River Tunnel have been in service for 108 years and need significant improvements in order to remain in service. Sandy pushed billions of gallons of saltwater into the tunnels, degrading existing signals, benchwalls, and electrical equipment and significantly reducing the reliability of the tunnels. In order to repair the existing tunnels, they must be taken out of service for an extended period of time. Without significant repairs, the tunnels could fail, which the Regional Plan Association estimates would cost the economy $16 billion and reduce home values by $22 billion region-wide.

Taking one tunnel out of service would reduce the existing 24-train per hour capacity by up to 75 percent, given the need to run bidirectional trains on a single track. Building the Gateway Tunnel will relieve this pressure and allow Amtrak to repair the existing North River tunnels. Once repaired, a four-track northeast corridor would greatly improve the capacity, resiliency, and redundancy of the transportation network in the Northeast.[21]

All of this infrastructure, whether new or renovated, must be designed to withstand the decades of climate change that are projected, so that necessary improvements that we make to our transportation systems today continue to benefit Americans even as sea levels rise and extreme weather becomes more severe.

## V. CONCLUSION

Enhancing and protecting transportation infrastructure is necessary to the future of New York City and the surrounding region. This Congress has the opportunity to rethink how the federal

[21] https://www.fra.dot.gov/Elib/Document/16762

government supports the transportation infrastructure needs of cities and communities across the country, and to ensure that resilient investments made today provide value to New Yorkers and all Americans for generations to come.

Thank you for the opportunity to testify today and I am happy to answer any questions.

**Exhibit 1.** New York City's climate projections.

For more than a decade, New York City has been at the forefront of science-informed climate policy, leveraging the expertise of the New York City Panel on Climate Change (NPCC), an independent panel of academic and private-sector experts formed by the City of New York and whose members are appointed by the Mayor. This body, which is unprecedented among American cities, provides downscaled scientific projections for the region and assists New York City's policymakers in understanding and planning for the climate change risks of today and the threats of the future. Source: OneNYC 2050.[22]

NPCC projections on climate hazards and extreme events through the end of the century.

Source: NPCC

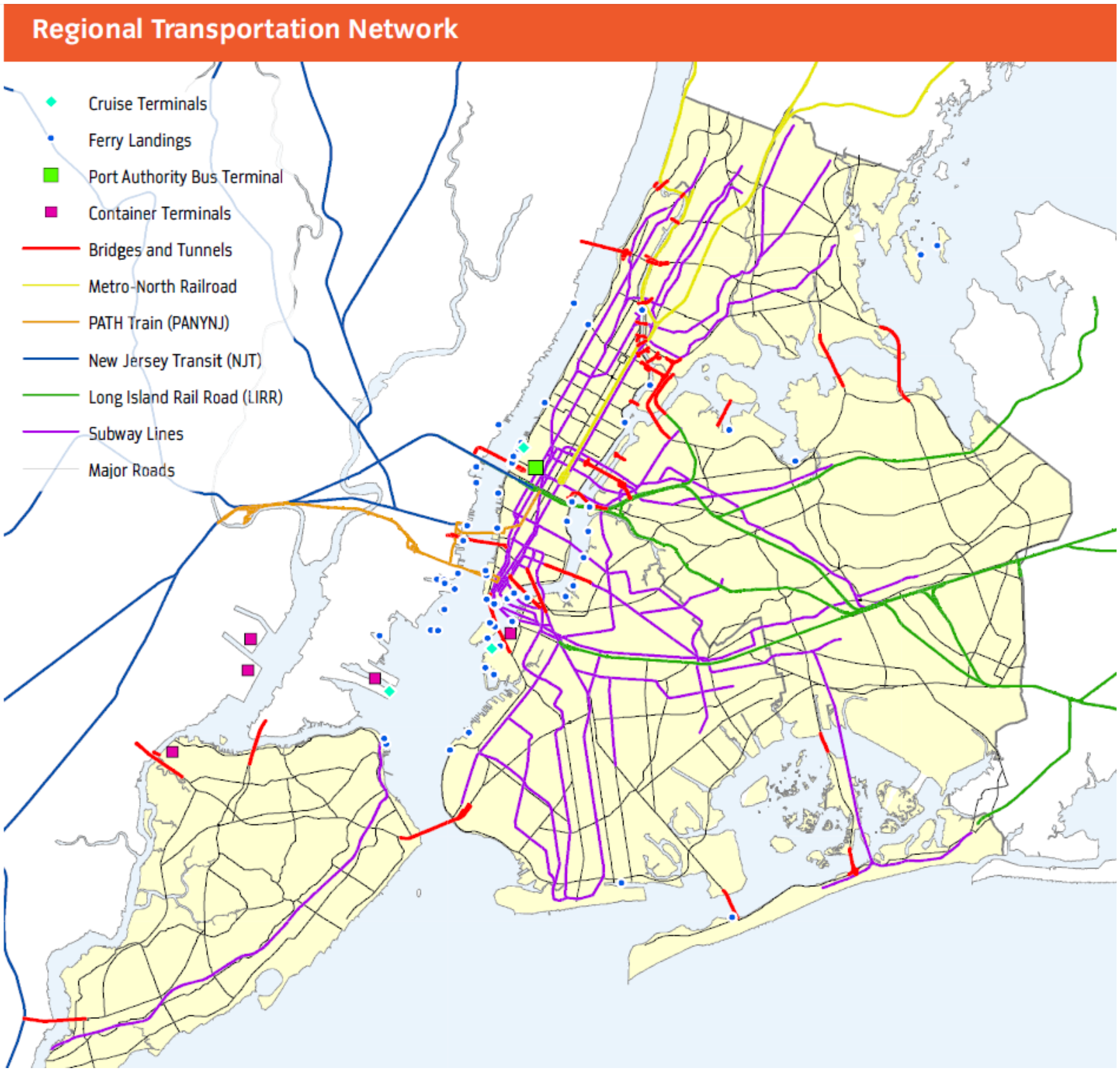
| CHRONIC HAZARDS | BASELINE 1971–2000 | 2050 MIDDLE RANGE | 2050 HIGH END | 2100 MIDDLE RANGE | 2100 HIGH END |
|---|---|---|---|---|---|
| AVERAGE TEMPERATURE | 54°F | +4.1 TO 5.7°F | +6.6°F | +5.8 TO 10.4°F | +12.1°F |
| PRECIPITATION | 50.1 IN. | +4 TO 11% | +13% | -1 TO +19% | +25% |
| | **BASELINE 2000–2004** | **2050 MIDDLE RANGE** | **2050 HIGH END** | **2100 MIDDLE RANGE** | **2100 HIGH END** |
| SEA LEVEL RISE | 0 | +11 TO 21 IN. | +30 IN. | +22 TO 50 IN. | +75 IN. |

| EXTREME EVENTS | | BASELINE 1971–2000 | 2050 MIDDLE RANGE | 2050 HIGH END | 2100 MIDDLE RANGE | 2100 HIGH END |
|---|---|---|---|---|---|---|
| HEAT WAVES & COLD EVENTS | NUMBER OF DAYS PER YEAR WITH MAXIMUM TEMPERATURE AT OR ABOVE 90 °F | 18 | 39 TO 52 | 57 | - | - |
| | NUMBER OF HEAT WAVES PER YEAR | 2 | 5 TO 7 | 7 | - | - |
| | AVERAGE DURATION IN DAYS | 4 | 5 TO 6 | 6 | - | - |
| | NUMBER OF DAYS PER YEAR WITH MINIMUM TEMPERATURE AT OR BELOW 32 °F | 71 | 42 TO 48 | 52 | - | - |
| INTENSE PRECIPITATION | NUMBER OF DAYS PER YEAR WITH RAINFALL EXCEEDING 2 INCHES | 3 | 4 | 5 | - | - |
| | | **BASELINE 2000–2004** | **2050 MIDDLE RANGE** | **2050 HIGH END** | **2100 MIDDLE RANGE** | **2100 HIGH END** |
| COASTAL FLOODS AT THE BATTERY | FUTURE ANNUAL FREQUENCY OF TODAY'S 100-YEAR FLOOD | 1% | 1.6 TO 2.4% | 3.6% | - | - |
| | FLOOD HEIGHTS (FEET) ASSOCIATED WITH 100-YEAR FLOOD | 11.3 | 12.2 TO 13.1 | 13.8 | - | - |

Middle range is 25th-75th percentile. High end is 90th percentile.

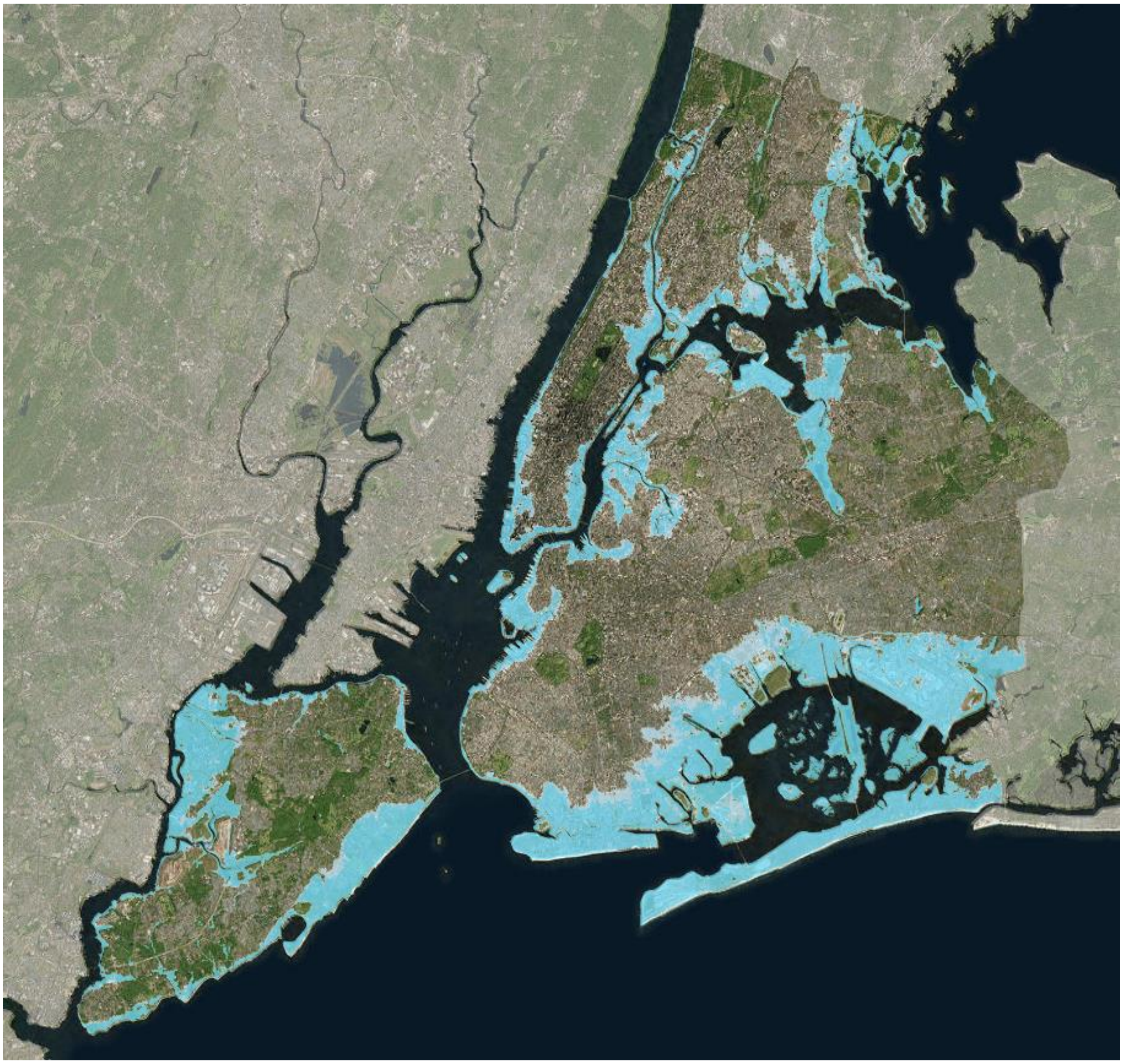
[22] https://onenyc.cityofnewyork.us/wp-content/uploads/2019/05/OneNYC-2050-A-Livable-Climate.pdf

**Exhibit 2.** NYC Transportation Network (does not include all elements of the network, including local roads, bus routes, Amtrak, and freight networks). Source: SIRR 2013.[23]




[23] https://www1.nyc.gov/assets/sirr/downloads/pdf/Ch_10_Transportation_FINAL_singles.pdf

**Exhibit 3.** Anticipated 100 year (1% or greater annual chance of flooding) flood map of New York City in 2050. Source: NYC Flood Hazard Mapper.[24]



[24] https://www1.nyc.gov/site/planning/data-maps/flood-hazard-mapper.page

**Exhibit 4.** NYC Climate Resiliency Design Guidelines. Available at:
https://www1.nyc.gov/assets/orr/pdf/NYC_Climate_Resiliency_Design_Guidelines_v3-0.pdf

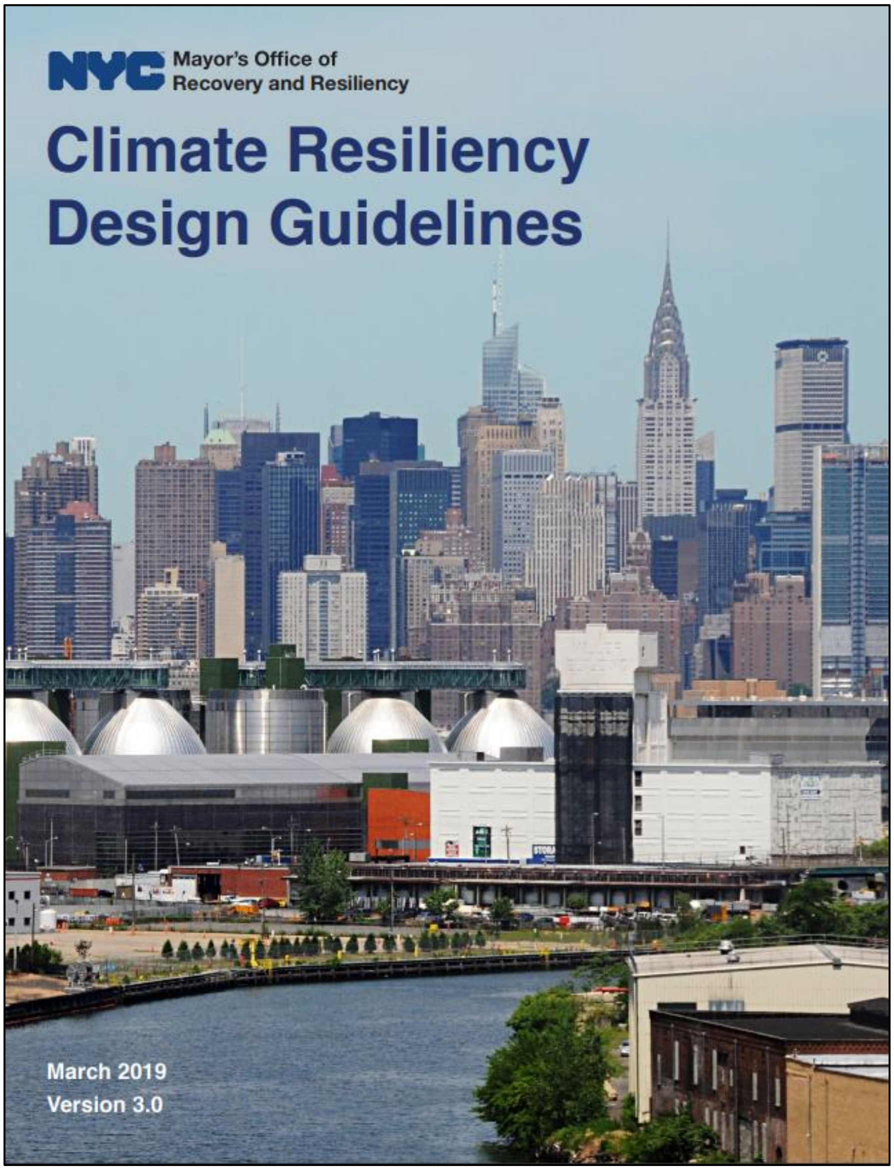


**Exhibit 5.** Forward looking design guidance for extreme heat and sea level rise. Source: NYC Climate Resiliency Design Guidelines.[25]

**Exhibit 5a**. Extreme Heat. The table below provides design criteria for future average temperatures, incidents of extreme heat events projected to different time periods across the 21st century, and guidance on future 1% Dry Bulb temperature and Cooling Degree Days for the NYC area. These design criteria can be applied when designing heating and cooling systems and building envelopes.

**Table 2 – Current and projected extreme heat events and design criteria[27]**

| | *Extreme heat events* | | | *Design criteria* | |
|---|---|---|---|---|---|
| **End of useful life** | **# of heat waves per year** | **# days at or above 90°F** | **Annual average temperature** | **1% Dry Bulb temperature** | **Cooling Degree Days** *(base = 65°F)* |
| **Current** (1971-2000) | **2** | **18** | **54°F** | **91°F** | **1,149** |
| **2020s** (through to 2039) | **4** | **33** | **57.2°F** | -- | -- |
| **2050s** (2040-2069) | **7** | **57** | **60.6°F** | **98°F** | **2,149** |
| **2080s** (2070-2099) | **9** | **87** | **64.3°F** | -- | -- |

*Note: Due to HVAC system typical useful life of around 25 years, only design criteria projections for the 2050s are shown. Projections for the 2020s are not shown because it is anticipated that enough of a safety margin is employed already in current systems to withstand the temperature rise expected through the 2020s. The NPCC is developing projections of 1% Wet Bulb temperatures, which are expected to increase. This design criteria will be added in a later version of the Guidelines.*

[25] https://www1.nyc.gov/assets/orr/pdf/NYC_Climate_Resiliency_Design_Guidelines_v3-0.pdf

**Exhibit 5b**. Sea level rise. Table and schematic below show the process for selecting a sea level rise adjusted Design Flood Elevation that is consistent with the useful life of the asset.

**Table 3 - Determine the sea level rise-adjusted design flood elevation (DFE)[55]**

| End of Useful Life | Base Flood Elevation (BFE)[56] in NAVD 88 | + Freeboard[57] | + Sea Level Rise Adjustment[58] | = Design Flood Elevation (DFE) in NAVD 88 |
|---|---|---|---|---|
| **Critical* Facilities** | | | | |
| **2020s** (through to 2039) | FEMA 1% (PFIRM) | 24" | 6" | = FEMA 1% + 30" |
| **2050s** (2040-2069) | FEMA 1% (PFIRM) | 24" | 16" | = FEMA 1% + 40" |
| **2080s** (2070-2099) | FEMA 1% (PFIRM) | 24" | 28" | = FEMA 1% + 52" |
| **2100+** | FEMA 1% (PFIRM) | 24" | 36" | = FEMA 1% + 60" |
| **Non-critical Facilities** | | | | |
| **2020s** (through to 2039) | FEMA 1% (PFIRM) | 12" | 6" | = FEMA 1% + 18" |
| **2050s** (2040-2069) | FEMA 1% (PFIRM) | 12" | 16" | = FEMA 1% + 28" |
| **2080s** (2070-2099) | FEMA 1% (PFIRM) | 12" | 28" | = FEMA 1% + 40" |
| **2100+** | FEMA 1% (PFIRM) | 12" | 36" | = FEMA 1% + 48" |

*Additional analysis should be conducted to incorporate wave action and wave run-up in DFE calculations especially in areas that are located within the FEMA's 1% annual chance Limit of Moderate Wave Action (LiMWA) zone. Wave run-up is the maximum vertical extent of wave uprush above surge.*

***Facilities defined as critical**

*The criticality definitions below are for use in the application of the Guidelines only. All items identified as critical in NYC Building Code Appendix G are critical in these Guidelines; however, this list includes additional facilities that are not listed in Appendix G.[59] If a facility is not listed here, it is considered non-critical for the purposes of these Guidelines.*

- Hospitals and health care facilities;
- Fire, rescue, ambulance, and police stations, as well as emergency vehicle garages;
- Jails, correctional facilities and detention facilities;
- Facilities used in emergency response, including emergency shelters, emergency preparedness, communication, operation centers, communication towers, electrical substations, back-up generators, fuel or water storage tanks, power generating stations and other public utility facilities;
- Critical aviation facilities such as control towers, air traffic control centers and hangars for aircraft used in emergency response;
- Major food distribution centers (with an annual expected volume of greater than 170,000,000 pounds);[60]
- Buildings and other structures that manufacture, process, handle, store, dispose, or use toxic or explosive substances where the quantity of the material exceeds a threshold quantity established by the authority having jurisdiction and is sufficient to pose a threat to the public if released;[61]
- Infrastructure in transportation, telecommunications, or power networks including bridges, tunnels (vehicular and rail), traffic signals, (and other right of way elements including street lights and utilities), power transmission facilities, substations, circuit breaker houses, city gate stations, arterial roadways, telecommunications central offices, switching facilities, etc.;
- Ventilation buildings and fan plants;
- Operations centers;
- Pumping stations (sanitary and stormwater);
- Train and transit maintenance yards and shops;
- Wastewater treatment plants;
- Water supply infrastructure;
- Combined-sewer overflow (CSO) retention tanks;
- Fueling stations;
- Waste transfer stations; and
- Facilities where residents have limited mobility or ability, including care facilities and nursing homes.

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## EXPERIENCE

**NEW YORK CITY**
**MAYOR'S OFFICE OF SUSTAINABILITY**, **MAYOR'S OFFICE OF RESILIENCY**, New York, NY

**Deputy Director, Infrastructure + Energy** Nov 2017 – Present
**Deputy Director, Infrastructure Policy** Sept 2015 – Nov 2017

Leads the City's efforts to adapt infrastructure systems across the region to the risks of climate change, focusing on the infrastructure resiliency recommendations in the City's strategic plan, OneNYC. Responsible for efforts overseeing analysis and advocacy on a wide range of energy regulatory and legislative matters before the state and federal government. Oversees a team responsible for implementing a cohesive program of resiliency initiatives across several key areas, including energy, telecommunications, water/sewer/waste, and transportation in collaboration with the New York City Panel on Climate Change. Leads the Climate Change Adaptation Task Force comprised of 50 city, state and private infrastructure operators to develop and coordinate resiliency investments to adapt assets to withstand the risks of climate change.

**THE PORT AUTHORITY OF NEW YORK & NEW JERSEY**, New York, NY

**Chief, Resilience and Sustainability, Engineering Department** Sept 2013 – Sept 2015

Promoted to a newly created position charged with incorporating climate resiliency and sustainability into all agency projects and sponsoring supporting programs at an executive level. Engineering department's program lead for resiliency efforts, climate change initiatives, post-Sandy recovery projects, and sustainable design with a team of four staff members. Led an internal team developing agency guidance for integrating climate change resilience into current design standards.

**Sustainable Design and Climate Adaptation Manager** Jan 2009 – April 2013

Hired as the agency's first design manager to integrate sustainability into agency projects and successfully advocate for change in an entrenched organization. Collaborated with project management, staff engineers, architects and construction managers responsible for design and construction, across the $27 billion ten-year capital plan projects. Provided direct technical guidance for large-scale projects including the World Trade Center, Bayonne Bridge, Goethals's Bridge, Newark Airport Terminal A and the LaGuardia Redevelopment Program.

**COLUMBIA UNIVERSITY**, New York, NY Sept 2011 – Present

**Lecturer, Sustainability Management**

**THE NATIONAL ACADEMIES OF SCIENCE**, Washington D.C.

**Panel Member, Transportation Research Board, Airport Cooperation Research Program** Jan 2012 – 2018
**Panel Member, Transportation Research Board, Resiliency** Jan 2018 – Present

Member of Resiliency Section that promotes discussion among principals, disseminate research findings, and identify priority research topics in the area of transportation systems and services before, during and after periods of increased stress, service disruptions, and human need. Invited to participate as an industry expert for three national ongoing studies: Airport Climate Adaptation Synthesis, Climate Change Adaptation Planning Risk Assessment for Airports and Addressing Significant Weather Impacts on Airports.

**NEW YORK UNIVERSITY**, New York, NY Sept – Dec 2016

**Adjunct Assistant Professor of Urban Planning, NYU Wagner Graduate School of Public Service**

**URBAN GREEN - BUILDING RESILIENCY TASK FORCE,** New York, NY Dec 2012 – May 2013

**Public Sector Task Force Member**

Task force developed recommendations for building code enhancements aimed at increasing resiliency of the built environment for all anticipated climate risks. Recognized for extraordinary contributions to the effort.

**MAYOR'S OFFICE, LONG TERM PLANNING & SUSTAINABILITY**, New York, NY Feb – May 2008

**Study Researcher, Columbia University**

**ESI DESIGN**, New York, NY Sept 2005 – May 2007

**Project Manager and Senior Designer**

**PRATT INSTITUTE**, New York, NY Sept 2002 – May 2004

**Visiting Professor, Department Industrial Design**

*Experience from 1997 – 2005 as a Design Director at Hixon Design Consultants, at McClanahan Book Company and Golden Books Family Entertainment is available upon request.*

## EDUCATION & CERTIFICATIONS

**COLUMBIA UNIVERSITY SCHOOL OF INTERNATIONAL & PUBLIC AFFAIRS**, New York, NY
Masters Degree, Public Administration in Environmental Science and Policy

**PRATT INSTITUTE**, Brooklyn, NY
B.S. Industrial Design

**U.S. Green Building Council**, LEED Accredited Professional, Building Construction and Design 2008

## PUBLICATIONS

Jacobs, J.M., M. Culp, L. Cattaneo, P. Chinowsky, A. Choate, S. DesRoches, S. Douglass, and R. Miller, 2018: Transportation. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 479–511. doi: 10.7930/NCA4.2018.CH12

DesRoches, S., Murrell, S., "*Transportation Infrastructure Resiliency Guidelines for the Port Authority of New York & New Jersey*," ASCE 2nd Integrated Transportation & Development Congress, Orlando, FL, June 2014.

DesRoches, Susanne, Brian McLaughlin, and Scott Murrell. "*Anticipating Climate Change*." Civil Engineering Magazine. 1 Apr. 2011: 50-55. Print.

Cremin, P., DesRoches, S., "*Sustainable Infrastructure Guideline Development at the Port Authority of NY & NJ*," ASCE 1st Integrated Transportation & Development Congress, Chicago, IL, March 2011.

DesRoches, S., McLaughlin, B., Murrell, S., "*Assessment of Climate Change Impacts to Port Authority of NY & NJ Facilities*," ASCE 1st Integrated Transportation & Development Congress, Chicago, IL, March 2011.

Cremin, P., DesRoches, S., "*Sustainable Infrastructure Initiatives Take Off*." CE News. 01 November 2010: 18-23. Print.

*A complete list of speaking engagements is available upon request.*