A. Hazard Profile

i. Hazard Description
Aging public infrastructure and utilities are a problem across the United States, especially in older cities like New York. In addition to age-related deterioration, infrastructure and utilities may also face increasing strain from population growth, with more people, there are more cars on the roads, riders on public transit, more demand for water and wastewater treatment, and energy. Endogenous hazards (such as construction or maintenance flaws) and exogenous hazards (natural hazards) may also increase the risk of failure. Effective maintenance and security are critical to reducing potential risks.

Four critical infrastructure sectors established under the authority of Homeland Security Presidential Directive 7 (HSPD-7)—transportation, water systems, energy, and telecommunications—are examined here for their potential for failure in New York City.

Transportation
New York City's transportation system is sprawling and complex, comprised of large, interconnected rails, roadways, bridges, tunnels, and water transportation networks.

Rail Transportation
Freight, commuter, and subway lines are subject to infrastructure failures due to weakening joints, erosion, and unstable rails that can cause train car collisions and derailment. The functioning of rail lines is also vulnerable to disruption due to power failures. Subway breakdowns, while not frequent, can occur as a result of aging machinery.

Rail transportation's underground and above-ground rails are vulnerable to weather-related events. Underground rails are vulnerable to flooding and coastal storm events, whereas above-ground rails are subject to high winds that can cause subway or rail cars to tip or derail. The MTA prepares for these weather events by moving cars to secure locations. Extreme temperatures can also affect railroad tracks, causing the steel to shrink during extreme cold weather and buckle during extreme heat events, which could cause train derailments.

Since rail transportation systems depend on electricity for power, consuming 1.8 billion kilowatt hours of power each year, utility disruptions are also a concern. For example, in October 2013, a power failure caused by the loss of a feeder cable on the New Haven line of the Metro-North Railroad affected commuter service from Grand Central Station in Manhattan to Stamford, Connecticut, for 12 days.
Roadway Transportation

Bridge components are subject to cracking, rusting, ground subsidence, and corrosion caused by exposure to water, wind, vibration, ozone, dust, dirt, acidity of bird droppings, chemicals in salt products, and gasoline. Many of New York City's bridges are over 100 years old and are vulnerable to age related deterioration. For these reasons, New York State law mandates that vehicular bridges be inspected every two years. Bridge maintenance is extremely important to prevent failures. For example, in 1988, NYC DOT inspectors identified areas of rust on the Williamsburg Bridge, which was subsequently closed for two months so repairs could be made.

According to the PlaNYC Progress Report 2013, New York City has continued to make major investments in maintaining its bridges. For example, the Brooklyn Bridge rehabilitation project provides for rehabilitation and repair of ramps and approaches, and the Manhattan Bridge's suspenders, which connect the bridge deck to the main cables, have recently been replaced and upgrades have been made to the necklace lighting and maintenance platforms. The smaller Third Avenue and Willis Avenue bridges spanning the Harlem River were completely replaced in 2005 and 2011, respectively. In addition to needing substantial repairs, these bridges had not met current structural or seismic requirements, making them particularly vulnerable. The Goethals Bridge, a PANYNJ facility that connects New York with New Jersey and is part of the I-278 corridor that runs through all five boroughs, will also be completely replaced. In 2013, the raising of the Bayonne Bridge roadway began as part of a harbor-wide effort to accommodate larger container ships; the project is expected to take four years to complete.

Tunnels are also vulnerable to infrastructure failures. Water can seep into tunnels as a result of groundwater penetration or broken water mains. Open vents and active ventilation systems are vulnerable to rain and coastal flooding. NYC DOT, MTA, and PANYNJ regularly inspect tunnels to identify any structural vulnerability.

While at-grade roadways are generally less vulnerable to failure than bridges and tunnels, subsurface conditions (such as a sinkhole or collapsed sewer) can undermine streets and lead to failure.

Retaining walls, many of which were built in the early 1900s, are also vulnerable to failure. In many cases, these retaining walls are critical to the structural integrity and function of major transportation links. In 2005, the failure of a retaining wall in Washington Heights buried a portion of the Henry Hudson Parkway in rubble, causing major disruptions to traffic.
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Water Transportation
Water transportation systems are also vulnerable to infrastructure failures. The New York Harbor allows for water-borne transportation for commuters, residents, and tourists and allows New York City to remain competitive as one of the largest shipping ports worldwide. Accessibility to the waterfront also provides alternative options for evacuating residents during major emergencies in New York City and for moving people safely when other modes of transportation experience shutdowns, such as during power outages. After the 9/11 attacks, ferries safely evacuated hundreds of thousands of people from Lower Manhattan and were used in the following days for transportation of emergency personnel, vehicles, and equipment to and from Ground Zero.

In addition to regular maintenance of the vessels themselves, there are over 50 piers, slips, docks, and ferry terminals in New York City that must be regularly maintained to ensure the safe docking of ferry boats and unloading of passengers. Major coastal storms and ferry accidents are two types of incidents that can cause damage to these structures and result in large debris in the waterways, posing a navigational hazard. Additionally, many of the piers have mechanically operated ramps that rely on electricity to operate, and shipping container terminals cannot operate without power. Any incident resulting in power outages would have a major impact on passenger ferry and shipping operations.

(For more information on the transportation system, see New York City's Hazard Environment)

Water Systems
Water Supply
New York City receives its water from a complex system of tunnels, dams, reservoirs, and aqueducts. As identified in the New York City's Hazard Environment, three upstate reservoir systems impound water from this system. Water is distributed from these reservoirs to the city through three aqueducts and then delivered to Water Tunnels 1 and 2 that are responsible for bringing water to city residents. Water Tunnel 1, completed in 1917, is 18 miles long, and Tunnel 2, completed in 1936, is 20 miles long. Both tunnels have been in continuous service since they were activated. For Tunnels 1 and 2 to be inspected and rehabilitated if needed, the City has been constructing Tunnel 3. Tunnel 3 has been constructed in stages due to its immensity and is projected to be completed by 2020.

Around 30% of the distribution system was built before 1930. Water main breaks are due to a combination of factors including temperature (being more likely to occur in the colder months) and the material from which the water main is made. In 2012, there were almost 350 breaks in the City's network of approximately 6,800 miles of water mains, down from a high of 632 breaks in 2003. This year, there were fewer than six breaks per 100 miles of pipe, well below the accepted industry standard. Although
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water main breaks may occur, they rarely cause extensive damage to the city's water distribution system.

The City also monitors the aqueducts and tunnels that deliver water from the city's reservoirs. The Delaware Aqueduct, which runs 300 to 2,400 feet below surface, has confirmed leaks in two areas and leaks up to an estimated 36 million gallons per day. While the leaks are concerning, the situation in the tunnel and amount of water loss is stable. In the opinion of the professional engineering firm retained by the New York City Department of Environmental Protection (DEP) to investigate the status of the tunnel, there is very little immediate risk of failure of the tunnel.

DEP operates numerous dams in upstate New York and maintains a dam safety program that seeks to meet or exceed New York State Department of Conservation (NYSDEC) and federal dam safety guidelines.

There are two existing water siphons that provide potable water to Staten Island via Brooklyn. In preparation for the New York Harbor deepening project, both siphons will be replaced by one 72-inch siphon positioned deeper underground. Concerns have arisen that the 50-foot dredging of the Harbor might disrupt one or both of the existing siphons, so this replacement project is designed to ensure uninterrupted water service to Staten Island by adding a redundancy of 5 million gallons per day (MGD) of water supply under normal conditions. In addition to infrastructure improvements to connect the new siphon to existing water systems, a chlorine station will be constructed on the Staten Island side.

According to the PlaNYC Progress Report 2013, since 2002, the City has invested $186 million to investigate the leak in the Branch Tunnel of the Delaware Aqueduct and to develop the City's long-term plan, Water for the Future, to repair the leak and ensure reliable water. In addition, the City has invested more than $507 million to upgrade dams and related upstate assets and plans to commit another $283 million until 2021 to complete the dam reconstruction program.

Wastewater Treatment
As identified in the New York City's Hazard Environment, the city manages and operates 14 wastewater treatment plants that treat 1.3 billion gallons of wastewater daily before releasing it to local waterways. The city's wastewater treatment system is vulnerable to infrastructure failure during weather-related events, partly due to the combined sewer system that collects both stormwater and sanitary waste. For example, during periods of heavy rains or snow, flooding, and coastal storms, the combined volume of sewage and stormwater can exceed the capacity of wastewater treatment facilities. In the event of a power failure, wastewater treatment facilities may lose the ability to treat wastewater. As a result, combined sewer overflows (CSOs) would travel directly into the local waterways. DEP currently invests in "green" infrastructure and Bluebelt projects to
help absorb stormwater before it can enter the sewer system. For more information see New York City's Hazard Environment section.

Energy
Most of New York City gets its energy in the form of electricity, natural gas, and steam. An energy disruption can be defined as a loss of electrical service, gas, or steam supply due to equipment failure, natural hazards, sabotage, or accident.

**Electricity Systems**
The city's electrical distribution system consists of a combination of underground networks and overhead utility lines. As identified in New York City's Hazard Environment section, the Consolidated Edison Company of New York, Inc. (Con Edison) provides services nearly all of New York City, with the exception of the Rockaway Peninsula in Queens, which is serviced by utilities overseen by the Long Island Power Authority (LIPA).

An infrastructure failure in the electrical distribution system would be a power disruption or outage. Power disruptions are most common during extreme heat events in the summer, when residents and businesses have air conditioners turned on and power usage is at its peak, straining the system's capacity. They can also occur during a coastal storm or severe weather, when winds take down trees and overhead power lines or there is flooding of the underground electrical network. Electric generation plants are also vulnerable to flooding because a majority of the plants are located in the 100-year floodplain. In addition, power failures can occur during winter storms when power lines and poles are broken by accumulated ice or downed trees. (For more information, see Extreme Temperatures, Severe Weather, and Winter Storms.)

**Natural Gas:**
A common emergency with the natural gas distribution system is an indoor or outdoor leak, which can be caused by weather, equipment failures, or human error (such when a leak is caused by building contractors). Since natural gas has no odor, transmission line operators add an odorant to the gas. The use of the odorant allows members of the public to smell natural gas and to report that odor to first responders. Another indication of a gas leak is pressure loss. Repairs to leaks will often require closing valves or opening trenches to access underground pipes.

**Steam:**
As identified in the NYC Hazard Environment, approximately 1,700 customers in the city rely on the Con Ediion district steam system, located in Manhattan south of 96th Street. The most concentrated steam distribution centers are in the Financial District and midtown Manhattan. Pipes require periodic repair and maintenance due to the age of the pipes and extreme service conditions, which include high temperatures and high
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pressure conditions. Steam mains are maintained by Con Edison, and leaks are addressed immediately.

Emergencies can develop when potable water or rainwater surrounds steam pipes and the main must be turned off until the water condition is alleviated. Steam pipe explosions are rare, but when they do happen they can be catastrophic and severely impact human life and street infrastructure. Explosions can be a result of a phenomenon called "water hammer," whereby rapid cooling of the main creates excessive condensation that is not removed effectively from the steam pipe. Pooling condensate is picked up by flowing steam and driven—with great force—into pipe fittings.

(For more information on the energy system, see New York City’s Hazard Environment)

Telecommunications
As identified, in New York City’s Hazard Environment, the telecommunications sector is made up of physical properties (such as wireline, wireless, satellite, cable, and broadcasting equipment) as well as services (such as the Internet, information services, and cable television networks). Communication is vitally important and essential to health and public safety.

Telecommunication systems are vulnerable to weather events including flooding, coastal storms, high winds, and extreme heat. Since electricity is used to power telecommunications, the systems are also vulnerable to power failures. Telecommunication failures can also occur as a result of congestion (call volumes and internet usage) overloading the communications system during a crisis or disaster.

An understanding of the risk of infrastructure failures in the telecommunications system requires an understanding of the major components of the system. It consists of critical facilities such as telephone central offices, colocation hotels (buildings where data are transferred from one provider to another), cabling, cell sites, and equipment in individual buildings. All of these components are interconnected and must function along the entire distribution route for communication to be successful. Critical facilities are responsible for transmitting services such as telephone, wireless, internet, and cable. Although critical facilities have back-up batteries and fuel-powered generators, these systems are vulnerable to flooding if located in the building basements. For example, Verizon’s central office had generators and electrical switchgear located at or below grade. During Hurricane Sandy, these systems were inundated with salt water, which caused power failures that led to a loss of phone service over a wide swath of Lower Manhattan.

Critical facilities are also vulnerable to extreme heat events because these facilities are dependent on the city’s power distribution system. These facilities contain computer-controlled digital and fiber optic equipment that are sensitive to dust, temperature, and
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humidity. Although these facilities are equipped with ventilation and cooling systems, a long-lasting heat event may threaten the power grid and shorten the lifespan of electronic telecommunications equipment.

The distribution of telecommunications consists of cabling, which is located both above and below ground. Overhead cabling is subject to failure due to high winds, tornadoes, and ice storms and underground cables could be destroyed by earthquakes and flooding. As identified, in New York City's Hazard Environment, the three main types of cabling in the city's telecommunications system are lead-encased copper, coaxial, and fiber cables. The oldest cabling in the telecommunications system is lead-encased copper, which is in poor condition due to its age. Some of these cables have leaks, compromising the pressurized air system designed to keep water from inundating the copper wiring. A newer material, coaxial cable, is relatively resistant to water but used only for cable television and Internet distribution. Finally, fiber cables are the most reliable cabling type because they are both water-resistant and capable of carrying all types of service.

Due to the density of the city, cell sites in the city are most often placed on the rooftop of buildings. Because these sites depend on power supplied by energy providers and have only a four- to eight-hour backup life, they are at risk from power failures. In addition, cell sites are most often placed on private buildings, making it challenging to restore during power outages because power must first be restored to the individual building.

Although federal, state, and city agencies are involved in the regulation of the telecommunications industry, no single governmental entity has the full responsibility for the entire system nor has the jurisdiction to require that service is available in emergencies. The FCC does promote best practices for mitigation through the Communications Security, Reliability, and Interoperability Council; however, it does not require communication companies to comply with these standards or able to enforce mitigation practices across communication systems.

(For more information on the Telecommunications system, see New York City's Hazard Environment)

ii. Severity

Transportation
The severity of infrastructure failures for New York City's transportation system largely depends on the size and criticality of affected networks, their location, the number of people directly impacted, and the secondary impacts to essential services and the economy. A failure can range from a localized occurrence to a system-wide incident, depending on the type of failure.
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Water Systems
The severity of water distribution and treatment failures can range from a localized event, such as a water main break, to a system-wide incident, such as a dam failure impacting the distribution of water for New York City residents. Severity is largely dependent on the location of the failure, the number of people impacted, the duration of the disruption, and impacts to essential services.

Energy
The severity of energy disruptions depends on the cause, location, duration, and time of year. It can range from localized events to city-wide power outages. Although New York City's power system is much more reliable than the national average, impacts from a failure of the city's grid system can be significant. During the Northeast Blackout of 2003, the New York City Fire Department (FDNY) rescued more than 800 people trapped in elevators and the subway system was halted, stranding 400,000 passengers traveling on 400 subway trains who were eventually evacuated by the MTA. Due to an absence of back-up power for the city's traffic signals, traffic disruptions, city tunnel closures, and congestion occurred.

The severity or extent of power failures also depends on the electrical distribution system. New York City's electrical distribution includes overhead utility lines and underground networks. Overhead utility lines are less reliable and are vulnerable to weather like high winds and ice storms. However, they can typically be restored faster than underground networks because the damage can be easily located, accessed, isolated, and repaired. Overhead utilities are found in more suburban areas of the city including Staten Island, the Rockaway Peninsula, and parts of Queens, Bronx, and Brooklyn. Manhattan is the only borough that relies exclusively on an underground network system.

Underground networks, on the other hand, are not vulnerable to high wind events but are more vulnerable to coastal flooding. This is especially true for underground transformers and cables as well as area substations (responsible for reducing voltage for distribution) located in the flood zone. Furthermore, underground networks take two to three times longer to restore than overhead lines. This is usually due to the time needed for crews to safely access underground manholes or transformers, find the location of the fault, electrically ground equipment for safety, and make repairs to wires and other power equipment. These repairs can be complicated by traffic, pedestrians, and proximity of the public and vehicular obstructions.

Historically, power outages are more likely to occur during extreme heat events in the summer, when peak load is at or above 11,000 megawatts (MW) per day. The record peak load of 13,322 MW was reached July 19, 2013. Outages may also occur as a secondary impact of a coastal storm, high wind event, or ice storm.
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The severity of a power outage can be also be determined by the duration of the outage, and a longer outage can have a severe impact on the social environment. During the Queens blackout in 2006, 174,000 residents were without power for nine days. Four days after Hurricane Sandy hit, ConEd was able to restore power to most customers in Manhattan; however, some customers were without power for two or more weeks. LIPA’s electric service restoration took an average of 14 days, with some customers experiencing much longer outages.

Telecommunications
The severity of a telecommunications failure depends on the cause, location, and duration of the disruption. It can range from a localized disruption in service to a citywide failure. Since telecommunications services are dependent on the city’s power grid, major energy disruptions could also result in citywide disruptions in telecommunications.

iii. Probability

Transportation
Due to the extent of New York City's transportation system combined with future population growth, it is likely that transportation failures will occur in the future. In addition, more frequent occurrences of extreme weather events (earthquakes, periods of extreme temperatures, coastal storms, and flooding) may increase the chance of failures. Operational errors and design flaws—which are not easy to predict—may also increase the risk of failures.

Water Systems
Based on the extent of New York City's water distribution and treatment system combined with future population growth, it is likely that water distribution and treatment failures will occur in the future. In addition, more frequent occurrences of extreme weather events (coastal storms, flooding, and severe weather) increase the threat to water-related infrastructure failures.

Energy
Based on the age and extent of New York City's energy distribution system combined with future population growth, it is likely that energy disruptions will occur in the future. More frequent occurrences of weather-related events (extreme temperatures, severe weather, coastal storms, and flooding) increase the chances of energy failures. In addition, human error or damage during equipment operation, maintenance, or construction—none of which is easy to predict—may increase the risk of failures.

Telecommunications
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If telecommunications companies do not invest in mitigation strategies—such as hardening facilities, switching to fiber cables, and elevating electrical equipment—infrastructure failures will continue to occur in the future. Due to the absence of a single entity overseeing telecommunication systems, mitigation regulations are not required or enforced increasing the likelihood of future communication failures.

iv. Location

Transportation
Locations in the city that are most vulnerable to transportation-related infrastructure failures include bridges, vehicular tunnels, subway and railroad tunnels, and retaining walls adjacent to roadways. These infrastructural systems are dispersed throughout the city. Major bridges that could be vulnerable to infrastructure failures include the George Washington Bridge, Verrazano-Narrows, Robert F. Kennedy (formerly Triborough), Hell Gate, Brooklyn, Manhattan, Williamsburg, and Ed Koch-Queensboro. In addition, the major underwater vehicular tunnels that could be vulnerable to infrastructure failures are the Holland, Lincoln, Queens Mid-town, and Hugh L. Carey (formerly the Brooklyn Battery Tunnel).

Water Systems
The city is also vulnerable to infrastructure failures in the water system, which includes the reservoirs, dams, aqueducts, water tunnels, and distribution mains. The Catskill/Delaware watersheds are located northwest of the city, and the Croton Watershed is north of the city in Westchester and Putnam Counties. Although the reservoirs, aqueducts, and dams are located outside the city's boundaries, there is redundancy built into the system to minimize impacts and occurrences of failures (leaks, cracks, or collapse).

Energy
Energy disruptions can occur anywhere in New York City. Nevertheless, depending on the cause, some areas are more vulnerable to power outages than others. For example, areas along the coast are more susceptible to power outages during a coastal storm. Areas that are serviced by overhead power lines are more vulnerable to outages during an ice storm or high wind event. Figure 1 shows New York City's power network system.
### Telecommunications

Although New York City’s telecommunications systems are generally reliable, a large volume of traffic is routed through a small number of colocation facilities in Lower Manhattan, increasing vulnerability. In addition, 13% of critical telecommunications facilities are located in the 100-year flood zone. Areas in the city that are serviced by overhead utility cables—including parts of the Bronx, Brooklyn, Queens, and Staten Island—are more vulnerable to telecommunication disruptions caused by high winds, ice storms, and tornadoes.

#### v. Historic Occurrences

Table 1 identifies major infrastructure failure occurrences by affected sector.

<table>
<thead>
<tr>
<th>Date</th>
<th>Infrastructure Sector</th>
<th>Location</th>
<th>Description</th>
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</thead>
</table>
| August 24, 1928 | Transportation        | Manhattan | • Subway train derails in Times Square  
                   |           | • 16 fatalities  
                   |           | • 100 injuries                                                                 |
| August 31, 1959 | Energy                | Manhattan | • Power outage for a 500-block radius around Central Park during an extreme heat event  
                   |           | • 500,000 people lose power for nearly 13 hours   |
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<th>Date</th>
<th>Infrastructure Sector</th>
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</table>
| November 9, 1965| Energy                | Citywide | • Several Northeastern states and parts of Canada experience blackouts  
|                 |                       |          | • 800,000 subway riders are stranded  
|                 |                       |          | • Major traffic disruptions  
|                 |                       |          | • Planes unable to land |
| December 29, 1969| Transportation       | Bronx    | • Southbound IRT train derails near 180th Street  
|                 |                       |          | • 48 injuries |
| May 18, 1973    | Transportation       | Manhattan| • Northbound No. 5 Lexington Avenue Express train derails south of Grand Central  
|                 |                       |          | • First eight cars of the 10-car train derail |
| August 28, 1973 | Transportation       | Queens   | • 20-foot chunk of concrete ceiling duct in Steinway Tunnel hits subway cars  
|                 |                       |          | • One fatality  
|                 |                       |          | • 18 injuries  
|                 |                       |          | • Passengers trapped in 115-degree heat and heavy smoke |
| July 13, 1977   | Energy               | Citywide | • A series of lighting strikes initiates a 25-hour blackout  
|                 |                       |          | • Leads to widespread looting  
|                 |                       |          | • Estimated $300 million in damage |
| August 19, 1989 | Energy (Steam)       | Manhattan| • Explosion near Gramercy Park  
|                 |                       |          | • Two steam workers and one resident killed  
|                 |                       |          | • 200 residents evacuated from their building due to the release of asbestos |
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<th>Infrastructure Sector</th>
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</table>
| Dec. 29, 1989 | Energy (Natural Gas)  | Bronx          | • Natural gas main in South Bronx explodes, producing a tower of flames nearly 12 stories high  
• Explosion is caused by a backhoe truck striking a 26-inch underground main outside of a Con Edison distribution plant  
• Two fatalities (one Con Edison utility worker)  
• Forces a shutdown of power and subway service in Bronx and areas of Manhattan |
| August 28, 1991 | Transportation        | Manhattan      | • Southbound No. 4 train derails going over a switch north of Union Square  
• Five fatalities  
• 200 injuries  
• Service disrupted for 6 days  
• Considered the worst subway accident in 63 years |
| February 2, 1993 | Telecommunications    | Manhattan      | • A bomb planted by terrorists explodes in the World Trade Center (WTC) underground garage, killing 6 and injuring over 1,000  
• Breakdown of communications at WTC because of insufficient capacity in FDNY’s radio network |
| June 5, 1995  | Transportation        | Manhattan/Brooklyn | • Manhattan-bound M train on the Williamsburg Bridge is hit from behind by a J train  
• One fatality  
• 50 injuries  
• Spacing of signals and poor performance of train brakes contribute to the crash |
| August 13, 1996 | Transportation        | Brooklyn       | • Brooklyn-bound D train derails while pulling out of DeKalb Avenue station  
• Caused by track work in the area |
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</table>
| August 31, 2000 | Energy (Steam)        | Manhattan | - Steam pipe explosion near Washington Square Park near New York University Bobst Library  
|                 |                       |           | - Explosion scatters debris  
|                 |                       |           | - Releases asbestos in the air |
| June 21, 2000   | Transportation        | Brooklyn  | - Southbound B train derails at Dekalb Avenue  
|                 |                       |           | - First three cars of train derail  
|                 |                       |           | - 70 injuries  
|                 |                       |           | - 70 feet of track need to be replaced |
| September 11, 2001 | Energy/  
|                 | Transportation/Telecommunications | Citywide | - Terrorist attacks on the World Trade Center (WTC) cause major damage to infrastructure and disruptions to critical services  
|                 |                       |           | - Bridges and tunnels close  
|                 |                       |           | - Tracks and stations under the WTC shut down after first attack  
|                 |                       |           | - Trains running to Lower Manhattan lose power and have to be evacuated  
|                 |                       |           | - Two substations lose power  
|                 |                       |           | - Portions of Con Edison's infrastructure in Lower Manhattan are destroyed  
|                 |                       |           | - Disrupted broadcast capabilities because One WTC housed many television and radio broadcast antennas |
| August 15, 2003 | Energy/Transportation/Telecommunications | Citywide | - Power surge causes power outages in some Northeastern states and parts of Canada  
|                 |                       |           | - Subway riders are evacuated from tunnels  
|                 |                       |           | - Airports suffer major disruptions |
| May 13, 2005    | Transportation        | Manhattan | - A 75-foot-high stone retaining wall built in 1908 collapses onto Henry Hudson Parkway  
|                 |                       |           | - Wall in need of reinforcement |
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<tr>
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<th>Infrastructure Sector</th>
<th>Location</th>
<th>Description</th>
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</table>
| July 18, 2006   | Energy                      | Queens     | • Major power outages in Astoria, Long Island City, Sunnyside, and Woodside during extreme heat event
  • 174,000 people lose power
  • Power is disrupted at LaGuardia Airport
  • Subway lines in Queens lose power |
| July 18, 2007   | Energy (steam)              | Manhattan  | • Steam pipe explosion occurs at 41<sup>st</sup> Street and Lexington
  • Shakes nearby office buildings
  • 40-story-high shower of mud and debris
  • One fatality
  • 45 injuries |
| February 13, 2009 | Transportation           | Manhattan | • Coney Island-bound D train derails at 81<sup>st</sup> Street station
  • Two subway cars derail
  • Broken rail may have contributed to the accident |
| August 7, 2009  | Water systems               | Manhattan  | • Water main break floods several building basements
  • Buildings are evacuated
  • Some streets are closed |
| September 29, 2009 | Water systems/Transportation | Manhattan | • Water main break causes street collapse
  • Forces evacuation of residents |
| July 8, 2010    | Energy/Transportation       | Manhattan  | • Power outage in an Amtrak tunnel at Penn Station
  • Causes delays for Amtrak and NJ Transit |
| July 10, 2010   | Water systems/Transportation | Manhattan  | • Water main break near Union Square
  • Causes major street damage and transportation disruptions |
| Aug 7, 2010     | Water Systems/Transportation | Manhattan  | • Water main break occurs on E 59<sup>th</sup> St
  • disrupts service for several hours
  • Causes transportation disruptions |
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<th>Date</th>
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<tbody>
<tr>
<td>July 27 – August 1, 2011</td>
<td>Water Systems/Energy (natural gas)</td>
<td>Bronx</td>
<td>- 108 year-old water main break occurs in the Bronx and floods nearly a foot and a half on Jerome Avenue for several blocks near 177th St</td>
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<td>- Creates a 40 by 46 foot crater on Jerome Ave</td>
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<td>- Damages two nearby gas mains caused by water infiltration</td>
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<td>- Con Ed shuts down service to 500 customers</td>
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<td>- Disrupts vehicular traffic and subway/bus service</td>
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<tr>
<td>Aug. 12, 2011</td>
<td>Water/Energy (natural gas)</td>
<td>Manhattan</td>
<td>- Water main break causes big sinkhole and floods St Nicholas Ave and 152 Street (Washington Heights)</td>
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<tr>
<td></td>
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<td>- Creates a large sinkhole in the street</td>
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<td>- Gas main break is also damaged due to water infiltration</td>
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<td>- Disrupts gas and water service for days</td>
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<td>- Disrupts subway service</td>
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<tr>
<td>July 25, 2012</td>
<td>Energy</td>
<td>Citywide</td>
<td>- Storm knocks out power to approximately 4,800 people</td>
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<tr>
<td>September 18, 2012</td>
<td>Energy</td>
<td>Citywide</td>
<td>- Storm knocks out power to approximately 4,500 people</td>
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<tr>
<td>October 29, 2012</td>
<td>All sectors</td>
<td>Citywide</td>
<td>- Hurricane Sandy knocks out power to millions of New York City residents</td>
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<td>- Tunnels are flooded and subway service suspended</td>
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<td>- Telecommunication networks disrupted</td>
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<td>- Increase in combined sewer overflows to local waterways</td>
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<td>November 8, 2012</td>
<td>Energy</td>
<td>Citywide</td>
<td>- Nor’easter knocks out power to approximately 5,500 customers</td>
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<tr>
<td>July 18, 2013</td>
<td>Transportation</td>
<td>Bronx/Manhattan</td>
<td>- CSX garbage train derails onto Metro North Hudson Line tracks</td>
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<td>- Causes widespread transportation disruptions to and from the city</td>
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18. INFRASTRUCTURE FAILURES
Section III: Non-Natural Hazard Risk Assessment

<table>
<thead>
<tr>
<th>Date</th>
<th>Infrastructure Sector</th>
<th>Location</th>
<th>Description</th>
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</thead>
</table>
| September 25, 2013 | Transportation/Energy | Manhattan | • Feeder cable fails on the Metro North New Haven line  
                  |                       |          | • Disrupts service between Stamford, CT, and Grand Central Terminal in  
                  |                       |          | Manhattan for 12 days                                                      |

Table 1: Infrastructure Failures in New York City 1928 to 2013

B. Vulnerability Assessment

i. Social Environment
Infrastructure failures can impact New York City residents by disrupting essential services. Depending on the severity of the incident, it may also cause fatalities and severe injuries.

Transportation
Transportation infrastructure failures can have primary and secondary impacts on the social environment, depending on the severity of the incident. Bridge and roadway collapses, retaining wall collapses, and tunnel leaks may cause injuries and fatalities. The secondary impacts of these failures include transportation disruptions, which would affect people's access to work, education, goods, and services. Low-wage workers are often hardest hit during mass transit disruptions because a majority of workers rely on public transportation to get to work. Furthermore, hourly workers lack job security, can easily be replaced, and are less likely to recover from the loss of wages during the disruption.

Water
Water infrastructure failures affect the social environment by disrupting water distribution and increasing risks to public health. For example, failures in the water distribution system for drinking water could be severe for city residents, particularly vulnerable populations such as the very young, the elderly, or those with compromised immune systems. Water system or dam failures north of the city could cause a water shortage. Since water is needed for flushing toilets, bathing, and washing hands, water shortages could increase the risk of communicable diseases (see Drought Hazard Analysis). Water infiltration into basements from water main breaks might also cause mold issues.

The public may also be exposed to contaminated water during a flood or coastal storm. Wastewater treatment plants may not be able to handle the influx of sanitary and stormwater, causing pollutants to discharge directly into the local waterways.
Energy

Electricity

Since electricity is essential to daily life, a power outage is not only a nuisance, it can be life-threatening and cause major economic losses.

People who are most at risk during an electricity failure include seniors, the homebound, young children, individuals with disabilities or those who require power-dependent medical equipment, and people who are dependent on medicines that must be refrigerated. Non-functioning elevators or the inability to charge cell phones may make it difficult for some vulnerable populations to access health care services. Older New York City Housing Authority (NYCHA) developments, which typically consist of high-rise buildings, are more sensitive to power outages and power voltage reductions, which would impact low-income populations who typically live in these developments. During Hurricane Sandy, approximately 80,000 NYCHA residents in 423 buildings lost power, heat, and/or hot water. Restoration of these services to all NYCHA buildings took place over a 20 day period after the storm hit and was completed for all developments by November 18.

During outages, people who use backup generators, charcoal grills, gas stoves, ovens, and grills indoors improperly for cooking or heating are at risk of carbon monoxide poisoning. Power outages that occur during winter months may prompt people to use this equipment inappropriately to generate heat. New York City requires carbon monoxide alarms with battery backup in residences. However, immigrant populations with limited English proficiency may not be aware of this safety requirement and may be at greater risk.

Widespread power outages impair the operations of healthcare facilities. During the 2003 Northeast Blackout, 4 out of 75 New York City hospitals lost power despite having back-up power generators. During Sandy, three hospitals lost power due to internal equipment problems and had to evacuate patients during or after the storm. In addition, 61 nursing homes and adult care facilities were located in areas impacted by power outages (some due to internal equipment problems) and/or flooding. Around half of these facilities were able to continue operating at first, but within a week of the storm, 26 had to shut down and five were partially evacuated.

Loss of power at healthcare facilities may compromise medical supplies and medications that need appropriate temperature control, putting patients' lives at risk. Disruptions to steam distribution can also be problematic for hospitals, which rely on steam to sterilize equipment.

Electricity failures are detrimental for vulnerable populations that rely on life-sustaining equipment (LSE) and residents who depend on medicine that must be refrigerated. Con Edison and LIPA/National Grid currently notify these customers of potential or actual
power outages so they can use back-up equipment. Chronically ill or homebound people who live on upper floors of high-rise apartments are also vulnerable to power failures, which disrupt elevator service, making it difficult to evacuate them.

Power disruptions can also have an impact on the public safety. They may lead to civil disturbances (looting and arson), cause traffic and subway accidents, and trap people in elevators and subways. Electricity disruptions can affect water and food supplies. For example, electric pumps are needed to provide water to upper floors in buildings over six stories. In the event of a power outage, tenants in high-rise buildings may lose water and suffer from dehydration. In addition, lack of water for flushing toilets and washing hands increases the risk of the spread of communicable disease.

According to a study by the Department of Health and Mental Hygiene (DOHMH) on the impact of power outages on public health, food-borne illnesses may also result from consuming food spoiled due to lack of refrigeration. In August 2003, the time of the Northeast Blackout, 70% of emergency department visits were for diarrheal syndrome, which was above the normal daily average, and worker absenteeism increased by 29% due to gastrointestinal illness.

DOHMH's study also found that mortality rates increased during energy failure events. In August 2003, an increase in both accidental and natural deaths resulted in 90 excess deaths. Researchers theorize that some of the deaths can be attributed to the added physical demands on vulnerable people due to non-functioning elevators, A/C units, and subways; closed stores and pharmacies; and air pollution. Loss of power also hinders the ability of first responders to charge equipment, utilize computer networks, and operate communication devices. In the event of a power or utility outage during hot or cold weather, many more people may be at risk of illness or death due to lack of air conditioning or heat.

Power disruptions also impact the economy of the city. For example, financial markets and the service industry would all be affected, resulting in lost revenue for the city. Furthermore, electricity failures would cause transportation disruptions, preventing people from going to work and resulting in lost productivity.

Steam
Steam pipe explosions can cause injuries and fatalities as well as impact air quality. Since asbestos was used to insulate steam pipes when they were constructed in the late 1800s, explosions can release asbestos into the air. This happened during the 1989 steam pipe explosion in Gramercy Park, prompting a vacate order for 200 residents who lived near the site of the explosion. This same explosion also killed two Con Edison employees and a neighborhood resident. In 2007, a steam pipe explosion caused a 40-story-high cloud of flying mud and debris, resulting in one death and 45 injuries. This
explosion also caused interruptions in telephone and Internet services, and businesses in the area of the explosion were said to have suffered financial losses of $30 million.

Civil disturbances have occurred during previous blackouts in the city. The blackout of 1977, occurring at a time of socioeconomic instability in the city, saw significant looting, disorderly conduct, vandalism, and arson in many areas. According to several New York Times articles, 1,600 stores were damaged, 1,000 fires reported, and 3,700 people arrested. These events resulted in $300 million worth of damage.

**Telecommunications**

Telecommunications disruptions are damaging to preparedness, response, and relief efforts. These disruptions can be detrimental for the general public and particularly for vulnerable populations during or after an emergency. They could cause failures in emergency messaging and communication to the general public and vulnerable groups disrupting their ability to send a text message to a family member or make a 911 call. For example, people harmed or trapped in their homes after a hazard event would have difficulties contacting local emergency services (FDNY or NYPD). This would also cause a breakdown in communication between friends and family networks.

During the 9/11 attacks, congestion in the telecommunications system led to breakdowns in response ability. For example, the radio system used by the New York City Emergency Medical Service was damaged due to increased demand on the communications system.

During Hurricane Sandy, telecommunications system failures were generally short-term, but flood damage at critical facilities in individual buildings and to cable infrastructure led to longer outages. These outages mostly occurred in southern Manhattan, Staten Island, southern Brooklyn, and the Rockaway Peninsula. Furthermore, backup power systems in critical facilities in these areas were damaged by floodwaters, causing services to go out in areas they served.

Telecommunication failures can create a flow of misinformation both into and out of the impacted area. It is usually easier to communicate out from a disaster than to reach someone located within an affected area. If people who are located in a disaster area are cut off from communications, they will be less informed. During these occurrences, rumors and false warnings could lead to widespread panic.

### ii. Built Environment

**Transportation, Water Systems, Energy, and Communications**

Infrastructure failures can compromise the structural stability of bridges, tunnels, and the water distribution system. This could result in the collapse of bridges and tunnels (transportation and water). Energy disruptions can also impact the built environment by
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severely damaging property and streets. Steam pipe explosions and water main breaks can destroy streets and compromise the structural stability of surrounding buildings. For instance, the steam pipe explosion in 2007 inflicted severe damage on the streets and caused several buildings to shake. Natural gas leaks can cause explosions in homes and in major natural gas distribution plants.

iii. Natural Environment

Transportation, Water Systems, Energy, and Telecommunications
Infrastructure failures may affect the natural environment by destroying the natural landscape or causing air, land, or water contamination. For example, the release of asbestos during a steam pipe explosion can contaminate the air. Infrastructure failures can also cause hazardous materials spills, resulting in land or water contamination, and they can cause fires that damage the natural environment. Systems that filter water or air may be interrupted.

Power outages can increase the risk of sewage discharges to surface waters around the city. During the 2003 Northeast Blackout, backup generators at some sewage treatment plants failed, causing the release of untreated sewage into surrounding waters. During Sandy, 10 of DEP’s 14 wastewater treatment plants were damaged or lost power. Three of the facilities were non-operational: Coney Island (two hours), North River (seven hours), and Rockaway (three days). As a result, approximately 560 million gallons of untreated sewage mixed with stormwater and seawater and another approximately 800 million gallons of partially treated and disinfected wastewater were released into local waterways. Not only were wastewater treatment plants impacted, but drainage systems were clogged with sand and debris due to storm surge, slowing the city’s drainage process. According to the city's 311 service, most drainage-related calls after Sandy came from the highly developed areas along the waterfront. In the three weeks following the storm, DEP cleaned more than 3,500 catch basins and flushed more than 190,000 linear feet of sewer lines.

iv. Future Environment

Transportation, Water Systems, Energy, and Telecommunications
If the city does not invest in new infrastructure or maintain and repair existing infrastructure, failures will continue to occur. Furthermore, as the population grows, the demands on aging infrastructure will increase, amplifying the impacts on transportation, water, energy, and telecommunication systems.

While well-maintained, the city's transportation, water, energy, and telecommunications systems are located in a dense urban environment, and these systems can fail for a variety of reasons. Con Edison has invested billions to upgrade all systems, and the age of equipment is not necessarily an indicator of its reliability. In
addition, DEP, NYC DOT, NYS DOT, MTA, and PANYNJ have made significant investments in repairing, maintaining, and enhancing the city's infrastructure. Constant maintenance and replacement improve reliability and safety.

Climate change and sea level rise amplify the risk of more intense and more frequent coastal storms and floods, which also heightens the probability of more power outages. Currently 88% of the city's steam, 53% of electric generation, 37% of transmission substation, and 12% of large distribution substation capacity is located in the 100-year floodplain. Sea level rise can also pose issues for wastewater treatment plants because they are located along the waterfront at low elevations.

Although critical telecommunications facilities are generally located farther inland, 13% of these sites are in the 100-year floodplain, according to the Preliminary Flood Insurance Rate Maps (see Flooding Hazard Analysis). Due to climate change and sea level rise, it is projected that by the 2020s the number of facilities in the floodplain will grow to 18% of the total, and by the 2050s it is expected to grow to 24%. Moreover, by the 2050s it is expected that 31 inches of projected sea level rise will occur, increasing the risk of flooding to these telecommunication facilities.

According to the New York City Panel on Climate Change, in the future more frequent and intense heat waves will likely occur. This will increase the electricity demand, straining electric generation and distribution equipment. Population growth combined with these more frequent and intense weather-related events will place the city at greater risk of infrastructure failures.
Bibliography


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