SECTION III: HAZARD RISK ASSESSMENT

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Section III: Hazard Risk Assessment

1. Introduction

What would happen if a hazard event occurred in New York City? That is the fundamental question that fuels the hazard mitigation planning process—and it is also the question that this section of the report begins to address. The first step in planning for hazards is to assess the risks from them. This risk assessment involves evaluating the vulnerability of people, buildings, and infrastructure to estimate the potential loss of life, personal injury, economic losses, and property damage that may result.

A. The Risk Assessment process

To meet Federal Emergency Management Agency (FEMA) and New York State Office of Emergency Management (NYS OEM) requirements, the Hazard Mitigation Planning Team (Planning Team), composed of representatives of the New York City Office of Emergency Management (OEM), Department of City Planning (DCP), and Mayor's Office of Long-Term Planning and Sustainability (OLTPS), used a risk assessment process consistent with the procedures and steps presented in FEMA's How-To-Guide "Understanding Your Risks: Identifying Hazards and Estimating Losses." The four steps in the risk assessment process are:

- Determine which hazards pose a serious risk to New York City
- Describe what these hazards can do to physical, social, and economic assets of New York City
- Identify which areas of New York City are most vulnerable to damage from these hazards
- Determine damages that may result from the identified hazards

The Planning Team's four-step risk assessment process is shown in Figure 1.

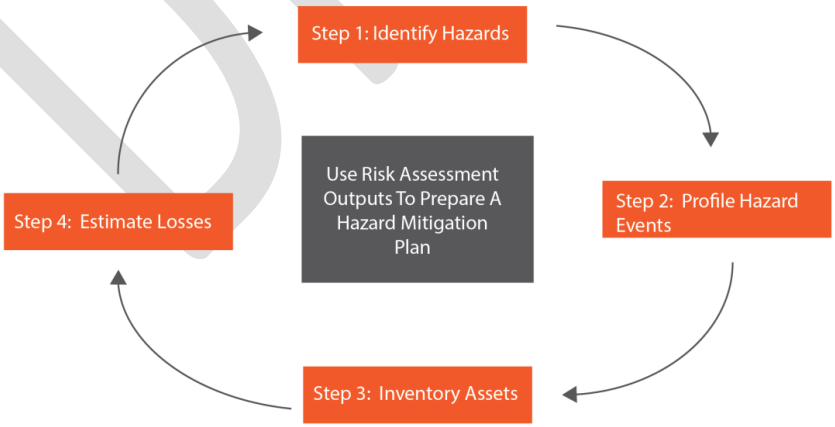

Figure 1: Risk Assessment Process

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B. FEMA and NYS OEM Requirements Addressed in this Section

The following FEMA requirements are addressed in this section:

- **FEMA Requirement §201.6(c)(2)(i):** [The risk assessment ***shall*** include a] description of the type… of all natural hazards that can affect the jurisdiction.

  [The risk assessment shall include a] description of the … location and extent of all natural hazards that can affect the jurisdiction. The plan ***shall*** include information on previous occurrences of hazard events and the probability of future hazard events.

- **FEMA Requirement §201.6(c)(2)(ii):** [The risk assessment ***shall*** include a] description of the jurisdiction's vulnerability to the hazards described in paragraph §201.6(c)(2)(i). This description ***shall*** include an overall summary of each hazard and its impact on the community.

  [The risk assessment] ***must*** also address National Flood Insurance Program (NFIP) insured structures that have been repetitively damaged by floods.

- **FEMA Requirement §201.6(c)(2)(ii)(A)**: [The plan ***should*** describe vulnerability in terms of types and numbers of] existing and future buildings, infrastructure, and critical facilities located in the identified hazard area….

- **FEMA Requirement §201.6(c)(2)(ii)(B):** [The plan ***should*** describe vulnerability in terms of types and numbers of an] estimate of the potential dollar losses to vulnerable structures identified in §201.6(c)(2)(ii)(A) of this description the methodology used to prepare the estimate….

- **FEMA Requirement §201.6(c)(2)(ii)(C)**: [The plan ***should*** describe vulnerability in terms of types and numbers of] providing a general description of land uses and development trends within the community so that mitigation options can be considered in future land use decisions.

The following NYS OEM requirements are addressed in this section:

- **NYS OEM Requirement §2:** The plan ***should*** identify any critical facility that has ever sustained flooding, even if it is not located in the 100-year floodplain on a current (adopted) or draft FEMA Flood Insurance Rate Map (FIRM). The plan should also analyze and document:

  1. The original problem and the estimated annual damages.

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- **NYS OEM Requirement §6:** The plan ***should*** take into account how climate change may affect their vulnerability to the following hazards, specifically the increased frequency or occurrence and/or severity for: Flooding, Wildfire, Drought and Extreme Temperatures.

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2. Hazard Identification

The first step in the risk assessment process is to identify hazards to include in the plan. To initiate this determination, the Planning Team, with input from the Mitigation Planning Council Steering Committee (Steering Committee), identified an initial list of hazards that could potentially impact the city and then selected the hazards of greatest concern for further profiling and analysis.

A. Potential Hazards

Since New York is such a large and dynamic city, it faces a broad spectrum of hazards, many of which are also caused or exacerbated by human activities. During the hazard identification process for the 2009 Natural Hazard Mitigation Plan (HMP), the Planning Team considered the full range of natural hazards identified in the 2008 New York State Multi-Hazard Mitigation Plan (NYS HMP) and made a few minor alterations, which included wording and organization, to produce a comprehensive natural hazard list. For this 2014 plan update, the Planning Team decided to expand upon this list, adding "non-natural" hazards to the required natural hazards.

To identify a preliminary list of non-natural hazards, as well as develop and refine its working list of natural hazards, the Planning Team reviewed existing plans from other local, regional, and national jurisdictions. The Planning Team also reviewed historic activations of the OEM Emergency Operations Center (EOC). Table 1 lists the full range of natural hazards that the Planning Team considered for inclusion in the HMP, and Table 2**: Non-natural Hazards Considered for Inclusion in the 2014 HMP, with Descriptions**

lists the full range of non-natural hazards.

Hazard	Description
Coastal erosion	Loss or displacement of land along the coastline due to the action of wind, waves, currents, tides, runoff of surface waters, or groundwater seepage
Coastal storms	Includes tropical cyclones (tropical storms and hurricanes) and nor'easters.
Dam failure	An uncontrolled release of impounded water resulting in downstream flooding.
Disease outbreaks	When disease cases exceed what would normally be expected in a defined community, geographic area, or season.
Drought	A prolonged period with below average precipitation.

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Hazard	Description
Earthquake	A sudden, rapid shaking of the earth caused by the breaking and shifting of rock beneath the earth's surface.
Extreme temperatures	*Extreme Heat:* Summertime temperatures that are well above average, usually combined with high levels of humidity. A heat wave is defined as three or more days with temperatures at or above 90°F. *Extreme Cold:* Wintertime temperatures that drop well below normal in an area.
Floods	A general and temporary condition of partial or complete inundation on normally dry land.
Hailstorms	Shower-like precipitation in the form of irregularly shaped ice pellets falling from a thunderstorm.
Landslides	The downward and outward movement of slope-forming materials reacting to the force of gravity.
Land subsidence	Depressions, cracks, and sinkholes in the earth's surface, which can threaten people and property.
Tornadoes/windstorms	Tornadoes are local atmospheric storms, generally of short duration, formed by winds rotating at very high speeds, usually in a counterclockwise direction, with vortices visible to the observer as whirlpool-like columns of winds rotating about a hollow cavity or funnel. Windstorms are non-rotating, straight-line winds which can knock down trees and power lines and cause damage to structures.
Wildfires	Uncontrolled burning in grasslands, brush, or woodlands, which can eventually spread to the built environment.
Winter storms	Ice storms, heavy snow, and blizzards, often accompanied by extreme cold. Heavy snow generally means snowfall accumulating to 6 inches or more in depth in 12 hours or less, or snowfall accumulating to 8 inches or more in depth in 24 hours or less. A blizzard has winds of 35 miles per hour or more with snow and blowing snow, reducing visibility to less than 1/4 mile for at least three hours.

Table 1: Natural Hazards Considered for Inclusion in the 2014 HMP, with Descriptions

Hazard	Description
Air contamination	Poor air quality resulting from a high concentration of primarily industrial pollutants (including particulate matter and ozone) near the ground.
Aviation incidents	Accidents involving aircraft departing from or arriving at the either Kennedy or LaGuardia Airports, which cause or have the potential to cause injury or loss of life.
Building collapses/fires/explosions	Damage to or destruction of a building resulting from collapse, fire, or explosion.

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Hazard	Description
Civil unrest	A public crisis that occurs without warning and may adversely impact a significant portion of the population.
Cyber threats	An adverse event in an information system or network in which the digital infrastructure of a person or organization is compromised.
Release of chemical, biological, radiological, or nuclear materials (CBRN)	A situation in which hazardous materials are released into the environment, causing a threat to human health and safety.
Infrastructure failure	Failure of the infrastructure systems—including transportation, water, and wastewater—to perform their intended functions.
Utility disruptions	Disruptions to essential utilities, including energy (electric, gas and steam) and communications.

Table 2: Non-natural Hazards Considered for Inclusion in the 2014 HMP, with Descriptions

B. Hazard Selection Process

i) Existing Plans and Procedures

When considering which hazards to include in the HMP, the Planning Team identified the City's existing emergency plans and procedures that address both natural and non-natural hazards. OEM and other City agencies have plans and procedures in place for many natural hazards, including coastal storms, drought, extreme temperatures, floods, tornadoes/windstorms, and winter storms. There are also plans in place for non-natural hazards, including various types of hazardous materials releases (chemical, biological, and radiological) and power disruptions. In addition, OEM is currently drafting an emergency plan for cyber threats. It was evident that all of these hazards can significantly affect New York City and should be included in the HMP.

ii) Hazard Selection Worksheet

The Steering Committee supported the hazard identification process by completing a hazard selection worksheet. The hazard selection worksheet asked members of the Steering Committee to indicate which hazards would affect their agencies' operations, policies, and/or physical infrastructure. Agencies were asked to indicate "Yes" if they felt strongly that the hazard posed a significant threat and "No" if they felt strongly that the hazard did not pose a significant threat. If they did not feel strongly one way or the other, they left the field blank. Since the Planning Team (OEM, DCP, and OLTPS) was involved in the initial hazard selection, these agencies did not fill out hazard selection worksheets. Table 3 summarizes the results of the worksheets.

Hazard	DEP	DOT	FDNY	MTA	DOHMH	DPR	RPA	DOB	NYPD	TOTAL (Yes/No)

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Hazard	DEP	DOT	FDNY	MTA	DOHMH	DPR	RPA	DOB	NYPD	TOTAL (Yes/No)	
Coastal erosion	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	8	0
Coastal storms	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	9	0
Dam failure	No	No						No	No	0	4
Drought	Yes	No	Yes	Yes		Yes	Yes	Yes	Yes	7	1
Earthquakes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	8	0
Extreme temperatures	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	9	0
Floods	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	9	0
Hailstorms	No	No	Yes				Yes	No	No	2	4
Landslides	No	Yes	No					Yes	Yes	3	2
Tornadoes and windstorms	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	8	0
Land subsidence	Yes	Yes	No					Yes	No	3	2
Wildfires	Yes	No	Yes			Yes		No	Yes	4	2
Winter storms	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	9	0
Air contamination	Yes	No	Yes		Yes		Yes			4	1
Aviation incident	No	Yes	Yes					No	Yes	3	2
Building collapses/ fires/explosions	Yes	Yes	Yes	Yes			Yes	Yes	Yes	7	0
Civil unrest	No	Yes	Yes					Yes	Yes	4	1
Cyber threats	No	No	Yes	Yes			Yes			3	2
Disease outbreaks	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	8	0

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Hazard	DEP	DOT	FDNY	MTA	DOHMH	DPR	RPA	DOB	NYPD	TOTAL (Yes/No)	
Hazardous materials release (CBRN)	Yes	No	Yes	Yes			Yes	Yes		5	1
Utility disruption	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes	8	0
Infrastructure failure*											

*This hazard was added after the selection worksheet was distributed to the Steering Committee

Table 3: New York City Hazard Selection Worksheet Results

A majority of Steering Committee members checked the following hazards: coastal erosion, coastal storms, drought, earthquakes, extreme temperatures, floods, tornadoes/windstorms, winter storms, diseases outbreaks, building collapses/fires/explosions, CBRN, and utility disruptions. The other hazards listed required additional research to determine whether they should be included in the HMP. The Planning Team collected and analyzed additional data on dam failure, hailstorms, landslides, subsidence, wildfires, air contamination, aviation incidents, civil unrest, and cyber threats from newspapers, City records, and the National Oceanic and Atmospheric Administration (NOAA), the National Weather Service (NWS), and FEMA databases.

After further consideration, the Planning Team decided to also include wildfires and cyber threats in the final list. In addition, several new categories were created to consolidate multiple hazards from the original list; severe weather (incorporates hail and tornadoes/windstorms) and infrastructure failures (incorporates utility disruptions and damage to other types of infrastructure). Air contamination was incorporated into the extreme temperatures and CBRN hazards.

C. Eliminated Hazards

The Planning Team chose to address only the most prevalent hazards affecting New York City for this plan submission, and hazards for which sufficient data was available to develop a full profile. After conducting additional research, the Planning Team completely eliminated dam failure, landslides, land subsidence, aviation incidents, and civil unrest from the HMP. Although building collapses/fires/explosions received a majority vote, it was determined at a later point in the process that these types of events are generally caused by other types of hazards (both natural and non-natural) and that the building collapses/fires/explosions themselves were generally the result of some other trigger event. Although a draft of a profile was written for this hazard, the Planning Team decided later to incorporate this information into other hazard profiles and omit this as a separate section.

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D. Final List of New York City Hazards

At the end of the hazard identification process, the Planning Team retained 10 natural hazards and three non-natural hazards for profiling and analysis in the HMP. They are as follows:

Natural hazards:

(1) Coastal erosion
(2) Coastal storms
(3) Disease outbreaks
(4) Drought
(5) Earthquakes
(6) Extreme temperatures
(7) Flooding
(8) Severe weather
(9) Wildfires
(10)Winter Storms

Non-natural hazards:

(1) CBRN
(2) Cyber threats
(3) Infrastructure failures

Since this plan was written shortly following Hurricane Sandy, the worst natural disaster in New York City's history, the Planning Team decided to include a retrospective analysis of this particular storm and what the City learned moving forward. This section was independent from the coastal storms profile.

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3. Hazard Risk Assessment Organization

The risk assessments for each hazard are divided into two primary components. The first section, the "Hazard Profile," is a description of the hazard itself and the City's physical risk. The second section, the "Vulnerability Assessment," is an analysis of how susceptible the city's social environment (population), built environment, natural environment, and future environment are to each hazard. The one exception to this organizational structure is the section on Hurricane Sandy because it is a description of a historic event rather than an assessment of risk to a potential hazard.

A. Hazard Profile

The Hazard Profile is intended to characterize each hazard and its risk of occurrence in New York City. This section is divided into five subsections, as follows:

1) **Hazard Description**: a general description of the natural or non-natural hazard that can affect New York City
2) **Severity**: a description of the strength or magnitude of the hazard, how it is measured, and the range of impacts it can have
3) **Probability**: a description of the likelihood of the hazard occurring in New York City
4) **Location**: the identification of the geographic areas within New York City that may be most significantly affected by the hazard
5) **Historic Occurrences**: a descriptive list of any previous occurrences of this type of event in New York City

This organization structure is in accordance with the requirements from FEMA, and most hazards fit these categories at least fairly well. However, complete information was not always available for every category of every hazard profile (for example, probability is generally not quantifiable for coastal erosion and most non-natural hazards).

B. Vulnerability Assessment

The Vulnerability Assessment is intended to characterize the hazard's potential impacts on different sectors and identify vulnerabilities within New York City. This section is divided into four subsections, as follows:

1) **Social Environment**: a description of the hazard's impact on the general public, including public health impacts and potential fatalities, with an emphasis on vulnerable and special needs populations
2) **Built Environment**: a description of structural vulnerabilities of the city's building stock and infrastructure. For flooding, coastal storms, and earthquakes, this

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section also includes a quantitative calculation of loss estimates (see Section i: Vulnerability Assessment Methodology, below)

3) **Natural Environment**: a description of the hazard's impact on the natural environment, resources, ecosystems, and recreational areas
4) **Future Environment**: a description of how trends such as climate change, population growth, aging infrastructure, and new technology may change the risk and/or impacts of hazards in the future

i. Vulnerability Assessment Methodology

To conduct the vulnerability assessment, address the requirements of the Disaster Mitigation Act of 2000, and better understand the potential vulnerability and losses associated with hazards of concern, New York City used standardized tools including the HAZUS-MH modeling software, combined with local, state, and federal data.

HAZUS-MH Methodology

HAZUS-MH is a nationally applicable standardized methodology and software program, developed by FEMA and under contract with the National Institute of Building Sciences. The program estimates potential losses from earthquakes, hurricane winds, and floods. In HAZUS-MH, current scientific and engineering knowledge is coupled with Geographic Information Systems (GIS) technology to produce estimates of hazard-related damage before or after a disaster occurs.

Potential loss estimates analyzed in HAZUS-MH include:

- **Physical damage** to residential and commercial buildings, schools, critical facilities, and infrastructure
- **Economic loss**, including lost jobs, business interruptions, and repair and reconstruction costs

HAZUS-MH is designed to generate estimates of hazard-related damage to a city or a region from a hypothetical "hazard event" of a fixed severity and location (that is, an earthquake, hurricane, or flood), also known as a "deterministic" event. This type of analysis can also be used to estimate damages from a historic event. Another type of analysis models the damage caused by an event that is likely to occur over a given period of time (return period), also known as a "probabilistic" event." For example, HAZUS-MH can estimate the damage caused by an earthquake that is likely to occur once every 500 years (which has a 1 in 500 or 0.2% chance of occurring in a given year).

HAZUS-MH uses demographic and general building stock (GBS) data to estimate hazard-related damage. The GBS data input into HAZUS-MH is a summary of building counts, values, construction types, and uses by census block or tract. The default GBS data provided with HAZUS-MH did not adequately reflect actual conditions. To refine the default GBS dataset, OEM provided an updated set of building data to Applied Research Associates, Inc. (ARA). This dataset consisted of Property Land Use Tax lot Output

(MapPLUTO) from the Department of City Planning (DCP) and mass appraisal data from the Department of Finance (DOF). ARA converted this dataset to a format that was usable by HAZUS-MH, which was further refined by FEMA to format with HAZUS-MH version 2.1. The resulting census block-based dataset provided a much more accurate starting point for subsequent analyses.

While the results of the HAZUS-MH analysis provide a good starting point for loss and damage estimation, they are approximate predictions. There is uncertainty inherent in any predictive model, and HAZUS-MH is no exception. This software is not meant for site-specific damage analysis. However, the use of HAZUS-MH as a tool for macro-level citywide analysis can provide a good overall view of potential exposure to various hazards based on the best available local data.

Methodology for Assessing Hazards Not Covered by HAZUS-MH

Non-HAZUS-MH hazards included in this report are coastal erosion, drought, extreme temperatures, severe weather, wildfires, winter storms, CBRN, cyber threats, and infrastructure failures. Vulnerable populations and infrastructure were evaluated using the best available data to assess vulnerability to these hazards and to help identify appropriate mitigation efforts.

While this risk assessment relies on the best available data and methodologies, uncertainties are inherent in any loss-estimation methodology. These uncertainties arise in part from incomplete scientific knowledge concerning hazards and their effects on the social, built, natural, or future environment. They can also result from the unique nature, geographic extent, and severity of each hazard. Therefore, potential exposure and loss estimates should be considered approximate

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