WINTER WEATHER
CHAPTER 4.6

The winter months in New York City can be brutal. They are often characterized by periods of extremely cold temperatures and by storms that haul in large amounts of snow, ice, sleet, and freezing rain in addition to strong winds. The number of storms per season, the amount of snow from each storm, and prolonged periods of extreme cold can take a toll on people, buildings, infrastructure, and the economy. Hazardous wintry conditions also induce dangers like traffic accidents, power outages, and hypothermia and frostbite.

WHAT IS THE HAZARD?

SNOW AND ICE

The term heavy snow generally means snowfall accumulating to a depth of four inches or more within 12 hours or less, or six inches or more within 24 hours. Sleet is pellets of ice composed of frozen or mostly frozen raindrops, or refrozen partially melted snowflakes. Freezing rain is precipitation that falls as rain, but freezes on contact with a surface, forming a glaze of ice.

The severity of a winter storm depends on temperature, wind speed, type of precipitation, accumulation rate, and timing. A storm that occurs during early winter, when trees still have leaves, may result in more downed trees and power lines due to the additional weight of snow and ice.

Our city can experience a variety of winter storms:

Snow showers are brief, intense periods of snowfall resulting in accumulations of one inch or less.

A **blizzard** is a severe snowstorm with winds of 35 mph or greater and snow and blowing snow that reduce visibility to less than one-quarter mile for three hours or longer.

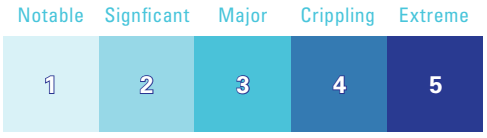
A **snowsquall** is moderate to heavy snowfall accompanied by strong, gusty winds and, sometimes, lightning.

Thundersnow events are snow accompanied by thunder and lightning.

Ice storms occur when freezing rain results in dangerous accumulations of ice, usually one-quarter inch or more.

The intensity of a winter storm can be classified by meteorological measurements and societal impacts. The Northeast Snowfall Impact Scale (NESIS) characterizes and ranks high-impact Northeast snowstorms – those with large areas of snowfall accumulations of 10 inches and greater. The National Climatic Data Center developed this scale because the transportation and economic impacts of Northeast snowstorms can significantly affect the rest of the country. The index uses population data and meteorological measurements to gauge a storm's impacts on society.

NESIS SCALE



WINTER WEATHER EXTREMES IN NEW YORK CITY

The largest snowstorm to hit New York City occurred on February 11-12, 2006, bringing in a total of 27 inches of snow.

The month with the most snowfall is February 2010: 37 inches fell.

One of the worst winters for snow was 1996-1997, when snowfall totaled 76 inches.

The coldest day of the year was recorded on February 9, 1934, with temperatures dipping 15 degrees below zero.

The coldest month was recorded in February 1934, with an average temperature of 20°F.

TOP FIVE SNOWSTORMS IN NEW YORK CITY FOR SNOW ACCUMULATION

DATE	INCHES OF SNOW	NESIS RATING
February 11 to 12, 2006	27 inches	3
December 26 to 27, 1947	26 inches	2
March 12 to 14, 1888	21 inches	4
February 25 to 26, 2010	21 inches	3
December 26 to 27, 2010	20 inches	3

SOURCE: WEATHER 2000/FORECAST RESEARCH

Winter storms are frequent here. Since 1798, New York City has experienced 19 snowstorms with snowfall totaling 16 inches or more. One was Extreme, five were Crippling, five were major, one was significant, and one was notable. The remaining six historical snowstorms did not qualify for a NEIS rank.

EXTREME COLD

While snow and ice are the defining features of winter storms, wind gusts and frigid temperatures can accompany these weather events. Extreme cold can occur independent of storms.

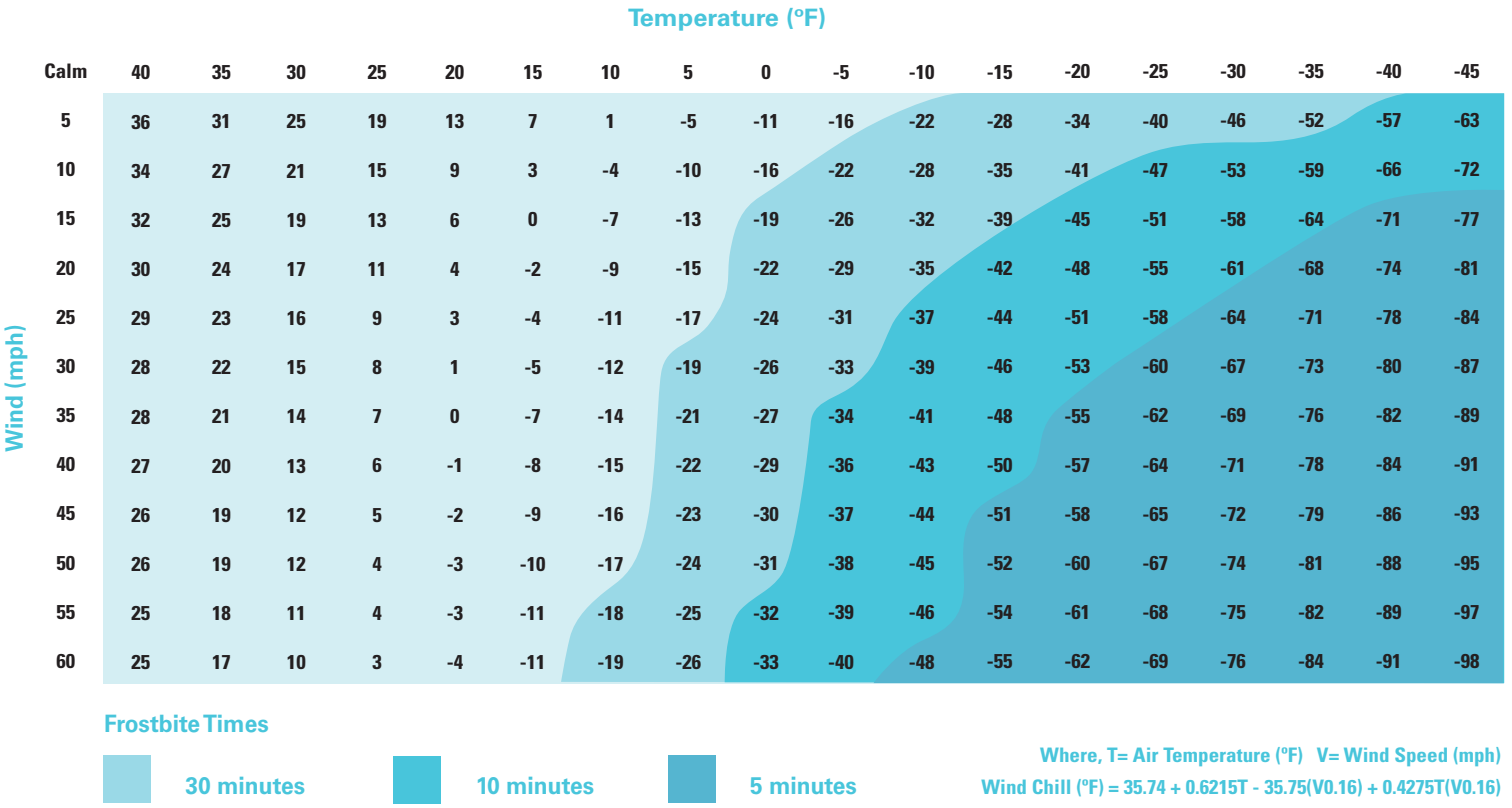
Extended periods of subfreezing temperatures are most common here between December and March. An extreme cold event typically involves an extended period with temperatures at or below 32°F. As the temperature drops and wind speed increases, heat drains from our bodies more rapidly. This "wind-chill effect" can make a person feel even colder.

In general, New York City experiences less severe cold due to the urban heat island effect (explained in the "Extreme Heat" profile) and proximity to the ocean. Areas right next to the shoreline are often slightly warmer during colder months, but wind-chill temperatures along the shore may be lower than temperatures several miles inland, due to stronger winds near the water, even if the actual air temperature is higher. Neighborhoods with lower population density, greater natural cover, and less heat-absorbing asphalt may be a few degrees cooler, though this effect is less pronounced during colder months.

A National Weather Service (NWS) wind-chill chart reports the temperature felt on exposed skin due to the combination of air temperature and wind speed. When conditions warrant, the NWS issues wind-chill advisories or wind-chill warnings for the New York City region. An advisory is issued when wind-chill values are expected to fall to between 24°F and minus 15°F. A warning is issued when values are expected to fall to minus 25°F or below.

According to the New York City Panel on Climate Change, the city experiences an average of 72 days per year with temperatures at or below 32°F. This annual average is projected to decrease by the 2020s to 52 to 58 days and by the 2050s to 42 to 48 days.

WIND CHILL CHART (Source: NWS)



WHAT IS THE RISK?

Accumulations of snow and ice, as well as cold temperatures, can impact public health, public safety, buildings, infrastructure, and the economy in ways that range from inconvenient to grave.

PEOPLE AT RISK: HEALTH AND PERSONAL SAFETY

Power outages caused by winter storms – typically, when trees topple onto power lines or the weight of ice brings power lines down – can trigger a cascade of problems. For example, during power outages, people living without backup power are at increased risk. If a winter storm interrupts the supply of fuel oil, natural gas, steam, or electricity to building heating systems, the drop in building temperatures can put occupants' health at risk.

One risk is hypothermia. When exposed to cold temperatures for an extended period, our bodies lose heat faster than we can generate it, causing our internal temperature to drop. Symptoms include shivering, fatigue, loss of coordination, blue skin, dilated pupils, slow pulse and breathing, and loss of consciousness. Death can result.

The NYC Department of Health and Mental Hygiene (DOHMH) reports nearly 200 hypothermia-related hospital admissions and emergency department visits on average each year from 2005 to 2010.

Another serious condition brought on by extreme cold is frostbite: a freezing of the body's outer tissue, most commonly the nose, ears, cheeks, chin, fingers, and toes. Symptoms include numbness, tingling or stinging, aching, and skin discoloration. Frostbite can cause permanent damage to body tissue and in severe cases may result in the need for amputation.

Exposure to cold can also exacerbate chronic illnesses, such as asthma and other respiratory diseases.

Another threat is carbon monoxide poisoning. Home appliances, notably gas kitchen ranges and space heaters emit carbon monoxide if not properly ventilated. While carbon monoxide poisoning can happen any time of the year, the danger is greater during winter.

Icy conditions may contribute to falls and other injuries for people who venture outdoors. Snow and ice storms can be especially hazardous for people who work outdoors, those who are homeless, and other vulnerable populations.

Falling icicles from buildings can be dangerous in a dense city such as New York. In the winter of 2013-14, icicles formed on 1 World Trade Center, and some fell, from great heights. As a safety measure, officials closed portions of the Westside Highway, the PATH train station next to 1 WTC, several side streets, and nearby sidewalks.

PEOPLE AT RISK: PUBLIC SAFETY

The downing of trees and power lines can put people at risk. Icicles falling from buildings can injure pedestrians, damage vehicles, and disrupt transportation if streets must be closed for safety reasons. When heavy snow and ice disrupt the city's infrastructure and services, commuters and travelers can be stranded, the flow of essential supplies (including food and medicines) can be interrupted, and emergency and medical services can be constrained.

All types of wintry precipitation contribute to hazardous travel conditions. Freezing rain is the most treacherous. The greatest danger during winter storms in New York City is the risk of traffic accidents. Even small accumulations of ice on roadways can cause accidents, resulting in injuries or fatalities of motorists, bicyclists, and pedestrians.

BUILDINGS THAT PUT PEOPLE AT RISK

Winter storms can disrupt utility services. Some building types handle temperature drops better than others. Three factors affect this: the type and size of windows, the amount of air escaping through cracks and leaks in the walls, and the amount of insulation in the walls and roof. Older buildings constructed to less-stringent building code standards are vulnerable to drafts due to leaks in the walls, windows, and doors. Buildings constructed to later standards have better thermal protections.

The Urban Green Council created computer models of representative buildings to determine indoor temperatures during a utility disruption and found that many older New York City buildings would drop below 40°F in three to five days. This same study also looked at how building typology influences the ability of a building to retain heat during a power outage. Their study found that:

- the temperature inside a single-family detached home would fall below freezing four days after an outage.
- a row house apartment, brick low- and high-rise apartments, and an all-glass high-rise apartment could fall below freezing one week after an outage occurred.

Residents' long-term exposures to low temperatures could cause significant health problems.

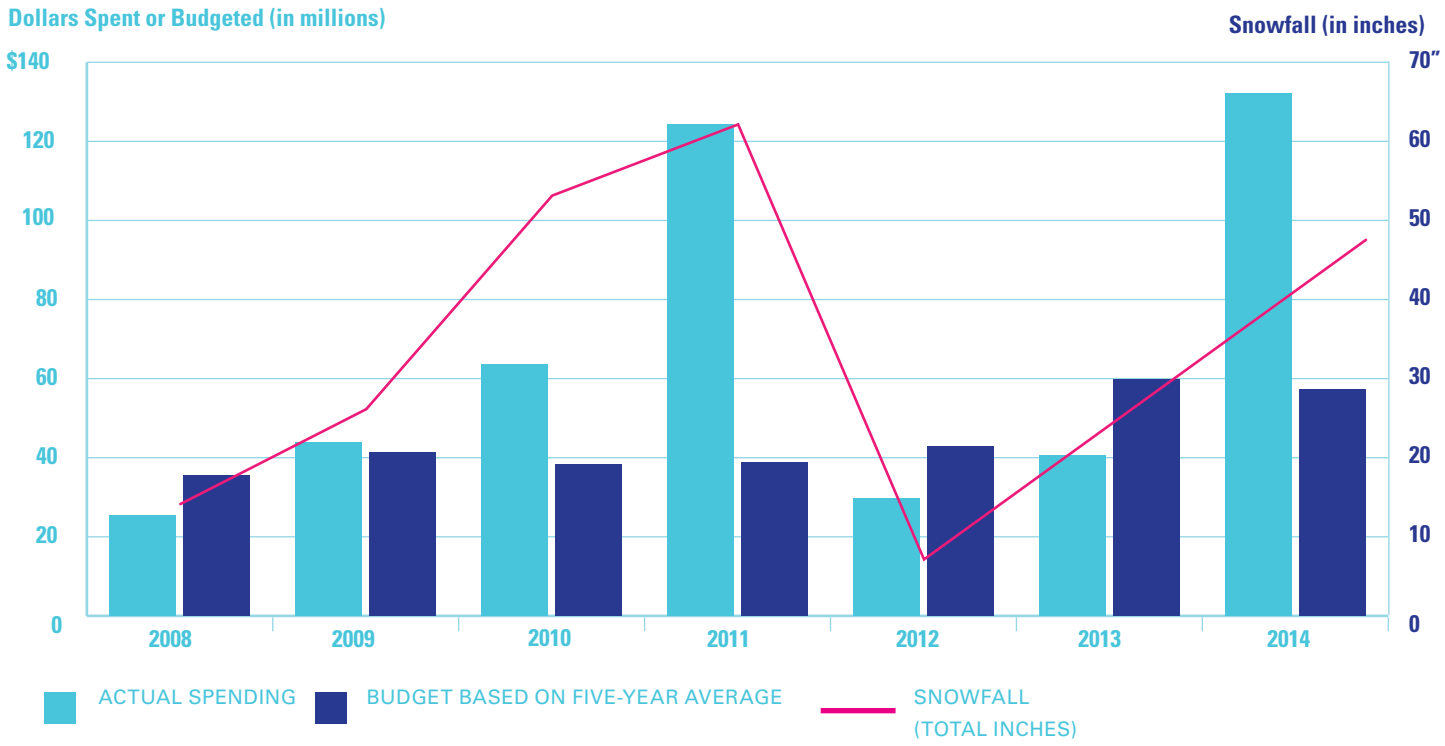
Structural damage or building collapses because of snow and ice are rare here. If the roof structure is poorly maintained, snow accumulation can cause damage, may cause leaks, and in the worst cases would result in roof collapse. Decaying wood or brick masonry can also worsen winter weather impacts. However, poorly maintained vacant buildings, which constitute a small portion of our total building stock, are most at risk to this type of damage.

INFRASTRUCTURE AT RISK

Winter storms can affect infrastructure dramatically, with follow-on effects. Streets covered with snow can cause traffic accidents and impede emergency access. Fire hydrants buried in snow may slow Fire Department response times. Ice accumulations can affect roads, rail beds, and mass transit rail switch systems, making travel dangerous. Bridges and overpasses are particularly dangerous because they freeze before other surfaces.

Retaining walls that are not well maintained may be structurally compromised if saturated with snow and ice.

HOW MUCH HAS SNOW REMOVAL COST THE CITY IN RECENT YEARS? (Source: NYC Independent Budget Office)



Ice storms can have a greater impact than heavy snowfalls because ice adds significant weight to tree limbs and overhead lines. While power lines can withstand one-quarter inch of ice accumulation, surrounding tree limbs can fail, especially under windy conditions, knocking out power and phone lines.

During winter months, freezing temperatures and repeated freeze-thaw cycles can cause potholes, which may damage vehicles and cause traffic accidents as vehicles swerve to avoid them.

The thaw phase of freeze-thaw cycles can dissolve rock salt that the Department of Sanitation spreads on roadways to melt snow and ice. That salty water can then seep into manholes, corroding and short-circuiting underground electric cables, in some cases interrupting service, in some cases causing fires in manholes and, in rare cases, causing explosions in them.

Frozen pipes, a common occurrence during cold spells, may interrupt water and gas supplies, and damage drainage systems.

Heavy snowfall and ice can overwhelm the capacity of the City's wastewater treatment plants, because, when snow and ice melt, the runoff flows into the city's sewer system, and if the combined volume of runoff and wastewater exceeds what treatment plants can handle, untreated sewage is discharged into local waterways.

ECONOMIC AND FINANCIAL RISKS

During and after major winter storms, businesses and government may see short-term revenue and productivity losses. And because New York is a global travel hub, winter storms that cause flight delays and cancellations can disrupt travel on a global scale, with resulting economic consequences.

The Departments of Sanitation, Transportation, and Parks and Recreation may bear additional costs related to snow and ice removal and pothole repair. The City's budget for snow removal is based on a rolling five-year average of actual expenditures. Fluctuations in annual snowfall make budgeting for snow removal challenging. For example, the City fell short by $87 million for the 2010/2011 winter season because average annual snowfall for the previous five years was less than the snowfall during that season.

The blizzard in late December 2010 is estimated to have cost the region over $68 million. This includes the $30M for that the Metropolitan Transportation Authority paid in overtime expenses and lost ridership revenue. Total costs to City government were reported to exceed $38.8 million – the entire City's snow budget for the year. A majority of the costs were due to overtime pay for Department of Sanitation workers.

HOW DO WE MANAGE RISK?

Strategies for managing winter-weather risks include regulatory controls on building design, as well as building maintenance routines and retrofits; infrastructure protections; environmental controls; and efforts to help New Yorkers prepare for and respond to severe weather events.

REGULATORY CONTROLS

Engineering standards

Regulatory controls take the form of provisions in our City's Construction Codes that require that new buildings and existing buildings that are undergoing major renovations be designed to withstand winter storms and extreme cold. Relevant Code provisions include the following:

- Roofs must be able to withstand snow-load (the weight of snow on the roof) and snowdrifts caused by parapets on adjacent buildings.
- Windows must provide thermal protection and buildings must be insulated against extreme cold.

Snow load is of moderate concern in New York City. Building Codes as early as 1899,specified minimum design loads (the weight a roof can hold), load combinations, and procedures for determining snow loads. The Department of Buildings bases snow loads on regional climate values for ground snow load and incorporates thermal factors for heated and unheated buildings. In July 2009, the Department adopted the latest national standards for determining snow load, snowdrift loads, and sliding snow loads when it adopted the International Code Council family of codes.

As stated above, the City's construction codes apply to newer buildings and to older buildings when substantial changes are being made to them. The Department of Buildings aims to adopt a code specific to existing buildings based on the International Existing Building Code. This will simplify the regulation of building upgrades and streamline permitting for resiliency improvements.

Building maintenance

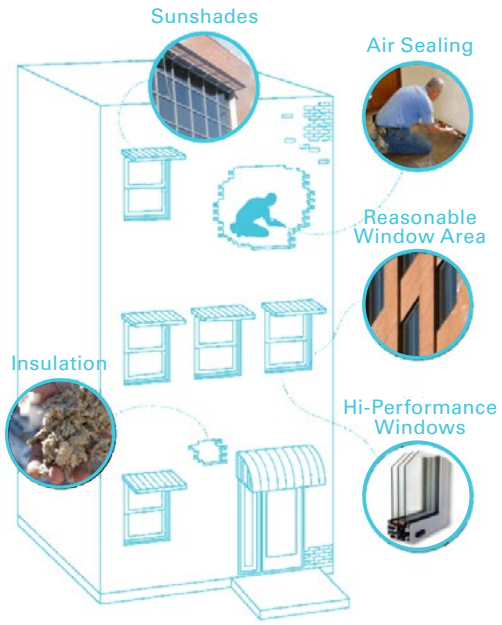
To protect buildings from extreme cold and heavy snowfall, regular maintenance and repairs are essential. The Department of Buildings encourages that buildings be periodically inspected to identify the need for repairs.

Maintenance measures include the following:

- Regularly inspect building elements including parapets, cornices, window lintels, exterior walls, and roofs.
- Clear roofs and overhangs of snow and ice, and clean gutters and roof drains before and after a snow or ice storm.
- Inspect and repair all wood that has rot (especially when rot is close to outside walls).
- Regularly inspect roof structure for wood rot.
- Repair sagging ceilings, to better withstand snow load.
- Replace all damaged roof joists.

Building retrofits and upgrades

Retrofits and upgrades to higher-performing building materials help buildings retain heat and better withstand severe winter weather in other ways, too. Measures include:



SOURCE: URBAN GREEN COUNCIL

HOW HIGH-PERFORMANCE OUT-PERFORMS

A high-performance building can retain heat longer than other building types during a power outage.

The Urban Green Council found that, during a weeklong power outage, the temperature differential inside a typical building and a high-performance building of the same type was 18°F to 27°F. And, the high-performance building retained heat longer, with temperatures above 54°F.

- Air-seal doors and windows by caulking them.
- Install insulation and high-performance windows: multi-paned windows with reflective coatings that lower winter heat loss and heating costs.
- Be aware that glass can never retain building heat as well as an insulated wall.
- Protect internal building infrastructure by fitting exposed pipes with insulation sleeves or otherwise wrapping them, to slow heat transfer.
- Seal cracks and holes in outside walls and foundations near water pipes with caulking.
- Add insulation indoors or as a new exterior layer.
- Eliminate drafts in air ventilation systems by caulking and sealing.

For old and new buildings, a backup generator is good insurance against possible power outages caused by winter storms.

PROTECTING INFRASTRUCTURE AND EQUIPMENT

One promising strategy is the use of alternative materials for streets and sidewalks that accelerate snowmelt and reduce reliance on the salt, snowplows, and chains on vehicle tires that damage city streets. The ability to clear paved areas more quickly reduces traffic accidents and improves emergency access, too.

The City's Department of Transportation is planning demonstration projects to monitor how well permeable pavement materials accelerate snow and ice melt at three locations. The projects are required by Local Law 80 (enacted in 2013), which directs the Departments of Transportation and Environmental Protection to study alternative roadway and sidewalk materials. Their study will examine the following:

- various types of permeable materials
- expected costs
- ease of installation
- how well materials perform
- how much stormwater they can absorb, and long-term maintenance requirements

One recent study suggests that permeable pavements noticeably improve snow and ice melt, reducing the need for plowing.

Another strategy complements investments in traditional "gray" infrastructure by relying on green infrastructure – such as bioswales and green roofs – to capture ice and snowmelt that might otherwise overwhelm wastewater treatment plants, causing the combined sewer overflows that discharge raw sewage directly into water bodies. The Department of Environmental Protection's *NYC Green Infrastructure Plan* employs such measures, which will help the City achieve compliance with federal water quality regulations.

A very simple measure for protecting infrastructure is one taken by the MTA. To protect its trains, the MTA stores them underground when forecasts predict temperatures 10°F below zero, ice storms, icing conditions, or more than five inches of snow.

ENVIRONMENTAL CONTROLS

Because the weight of snow and ice can break tree branches and take down power lines, tree pruning and tree maintenance strategies lower risk.

The Parks Department's Forestry Division oversees block pruning. Performed by contractors on a seven to eight year schedule, it requires pruning all street trees on a block. This Division also performs in-park pruning of trees.

Toward the goal of reliable service, the city's major utility, Con Edison, manages a tree maintenance program that trims branches along right of ways, so trees do not encroach on power lines.

PROMOTING PREPAREDNESS

Helping the public understand how to prepare for and respond to winter weather events is a major priority. Strategies range from communicating with the public immediately before and during a winter weather event, to longer-term educational measures aimed at households and property owners.

Short-term communication strategies include these:

- Sending emergency alerts prior to severe winter weather events, taking care to target populations with special needs, ensuring that communication is multi-lingual, and reaching out to populations who are homeless.

- Sending weather notifications to property owners, contractors, and developers, advising them of measures they can quickly take to prepare for a winter storm, such as clearing gutters and removing snow or ice from roofs.

- For major storms or prolonged periods of extreme cold, coordinating with multiple City agencies to communicate a consistent message about weather conditions and steps New Yorkers can take to prepare. Severe weather events may require mayoral press conferences.

- Communicating via as many media as possible: social media, press releases, notifications to elected officials, and alert systems. For social media platforms, providing real-time updates as conditions worsen or improve.

DOHMH declares a Cold Weather Alert whenever the temperature falls below 32°F between 4 PM and 8 AM. This temperature threshold may be affected by wind chill and other meteorological factors. During extreme cold events, the City increases outreach to the homeless population. The New York City Police Department monitors the city for homeless individuals and transports them to shelters run by the Department of Homeless Services or City hospitals. The Metropolitan Transportation Authority also monitors the transit system for individuals in need of sheltering and notifies appropriate responding agency.

NYC Emergency Management's Special Needs Advance Warning System reaches populations with access and functional needs through agencies and organizations that serve them as clients and are trusted by them. By means of email, conference calls, and a website, NYC Emergency Management delivers information targeted to individuals with special needs that can be relayed to them if they are at risk because of an impending hazard event.

The system is often used when winter storms or extended periods of extreme cold temperatures are forecast.

Notify NYC is the City's official source of information about emergency situations, including severe winter weather events. NYC Emergency Management sends notifications to a quarter million subscribers and Twitter followers.

Long-term strategies aim for these objectives:

- Help the public learn how to prepare for severe winter weather events.
- Help homeowners learn how to maintain buildings to reduce heat loss, roof leaks, and roof collapses.
- Help households understand the potentially lethal dangers of carbon monoxide poisoning that can be caused by gas appliances in their homes.

New York City Emergency Management's *Ready New York: Preparing for Emergencies in New York City* steps households can take to prepare for prolonged cold weather and winter storms. It includes guidance on safety precautions related to home heating equipment. The *Ready New York Reduce Your Risk Guide* explains how New Yorkers, and in particular homeowners, can reduce risks related to winter weather.

The Department of Buildings issues Inclement Weather Advisories that advise property owners, builders, and contractors to take precautionary steps to prepare for winter storms, such as clearing roofs, overhangs, and gutters of snow and ice; tying down and securing material and loose debris at construction sites; covering electrical equipment from exposure to the weather; and securing netting, scaffolding and sidewalk sheds.

DOHMH's website presents information about carbon monoxide poisoning that covers causes, symptoms, and preventive measures. A brochure developed jointly by the DOHMH, NYC Health and Hospitals Corporation, and NYC Poison Control Center explains how to prevent carbon monoxide poisoning. In addition, DOHMH provides general preparedness information about preventative measures to take to lessen the impact of cold weather.