Section 5. Risk Assessment

5.11 Severe Winter Weather

2014 Plan Update Changes

- The extreme cold temperature hazard has been combined with the severe weather hazard (Section 5.10).
- Previous occurrences were updated.
- New and updated figures from the Office of the New Jersey State Climatologist are incorporated.
- Potential change in climate and its impacts on the flood hazard is discussed.
- The vulnerability assessment is a new addition for the severe winter weather hazard.
- As for all hazards, the vulnerability assessment now directly follows the hazard profile.
- Environmental impacts is a new subsection.

For the 2014 Plan update, the hazard profile and vulnerability assessment were enhanced to reflect the best-available data and information updates on severe winter weather incidence since 2011. The updated profile features detailed descriptions of past occurrences along with discussions of the most significant incidents affecting the State of New Jersey. The extreme cold temperature hazard has been moved to Section 5.10 (Severe Weather). Past occurrences were updated using both reports of recent incidents and new data available through several agencies, including National Weather Service (NWS), the Federal Emergency Management Agency (FEMA), and the Office of the New Jersey State Climatologist (ONJSC). The vulnerability assessment was also updated to reflect updated, best-available data.

5.11.1 Profile

Hazard Description

Some winter storms are large enough to immobilize an entire region while others may only affect a single community. Winter storms are typically accompanied by low temperatures, high winds, freezing rain or sleet, and heavy snowfall. The aftermath of a winter storm can have an impact on a community or region for days, weeks, or even months; potentially causing cold temperatures, flooding, storm surge, closed and/or blocked roadways, downed utility lines, and power outages. In New Jersey, winter storms include blizzards, snow storms, and ice storms. Nor'Easters are also a common type of storm that may occur during winter months within the State of New Jersey; however, given the frequency of these types of storms in the State and their severe potential impact, Nor'Easters are considered by the SHMT and MCT as a separate hazard and are further discussed in Section 5.9 (Nor'Easters) within this plan. Extreme cold temperatures and wind chills are also associated with winter storms; however, based on input from the SHMT and MCT, these events are further discussed in this plan in Section 5.10 (Severe Weather).

A winter storm is considered a storm with significant snowfall, ice, and/or freezing rain. The quantity of precipitation varies by elevation. Heavy snowfall in non-mountainous areas is four inches or more in a 12-hour period, or six inches or more in a 24-hour period. In mountainous areas, heavy snowfall is considered 12 inches or more in a 12-hour period or 18 inches or more in a 24-hour period. Blizzards are storms with considerable falling and/or blowing snow combined with sustained winds or frequent wind gusts of 35 mph or greater that frequently reduce visibility to less than 0.25 mile for at least three hours.

Heavy Snow

According to the National Snow and Ice Data Center, snow is precipitation in the form of ice crystals. It originates in clouds when temperatures are below the freezing point (32°F), when water vapor in the atmosphere condenses directly into ice without going through the liquid stage. Once an ice crystal has formed, it absorbs and freezes additional water vapor from the surrounding air, growing into a snow crystals or snow pallet, which then falls to the earth. Snow falls in different forms: snowflakes, snow pellets, or sleet. Snowflakes are clusters of ice crystals that form from a cloud. Snow pellets are opaque ice particles in the atmosphere. They form as ice crystals fall through super-cooled cloud droplets, which are below freezing but remain a liquid. The cloud droplets then freeze to the crystals. Sleet is made up of drops of rain that freeze into ice as they fall through colder air layers. They are usually smaller than 0.30 inches in diameter (NSIDC 2013).

Heavy snow accumulations can immobilize a region and paralyze a city, stranding commuters, stopping the flow of supplies, and disrupting emergency and medical services. Ice storms can be accompanied by high winds, and they have similar impacts, especially to trees, power lines, and residential utility services. New Jersey, because of its unique location at a climactic crossroads and distinctive geography, experiences the full effect of all four seasons, and winter is no exception. Snowstorms are the most obvious manifestation of intense winter weather.

Blizzards

A blizzard is a winter snowstorm with sustained or frequent wind gusts of 35 mph or more, accompanied by falling or blowing snow reducing visibility to or below 0.25 mile. These conditions must be the predominant over a 3-hour period. Extremely cold temperatures are often associated with blizzard conditions, but are not a formal part of the definition. The hazard, created by the combination of snow, wind, and low visibility, significantly increases when temperatures are below 20°F. A severe blizzard is categorized as having temperatures near or below 10°F, winds exceeding 45 mph, and visibility reduced by snow to near zero. Storm systems powerful enough to cause blizzards usually form when the jet stream dips far to the south, allowing cold air from the north to clash with warm, moister air from the south. Blizzard conditions often develop on the northwest side of an intense storm system. The difference between the lower pressure in the storm and the higher pressure to the west creates a tight pressure gradient, resulting in strong winds and extreme conditions caused by the blowing snow (The Weather Channel 2012).

Ice Storms

An ice storm describes those events when damaging accumulations of ice are expected during freezing rain situations. Significant ice accumulations are typically accumulations of ¼" or greater (NWS 2013). Heavy accumulations of ice can bring down trees, power lines and utility poles, and communication towers. Ice can disrupt communications and power for days. Even small accumulations of ice can be extremely dangerous to motorists and pedestrians (NWS 2008).

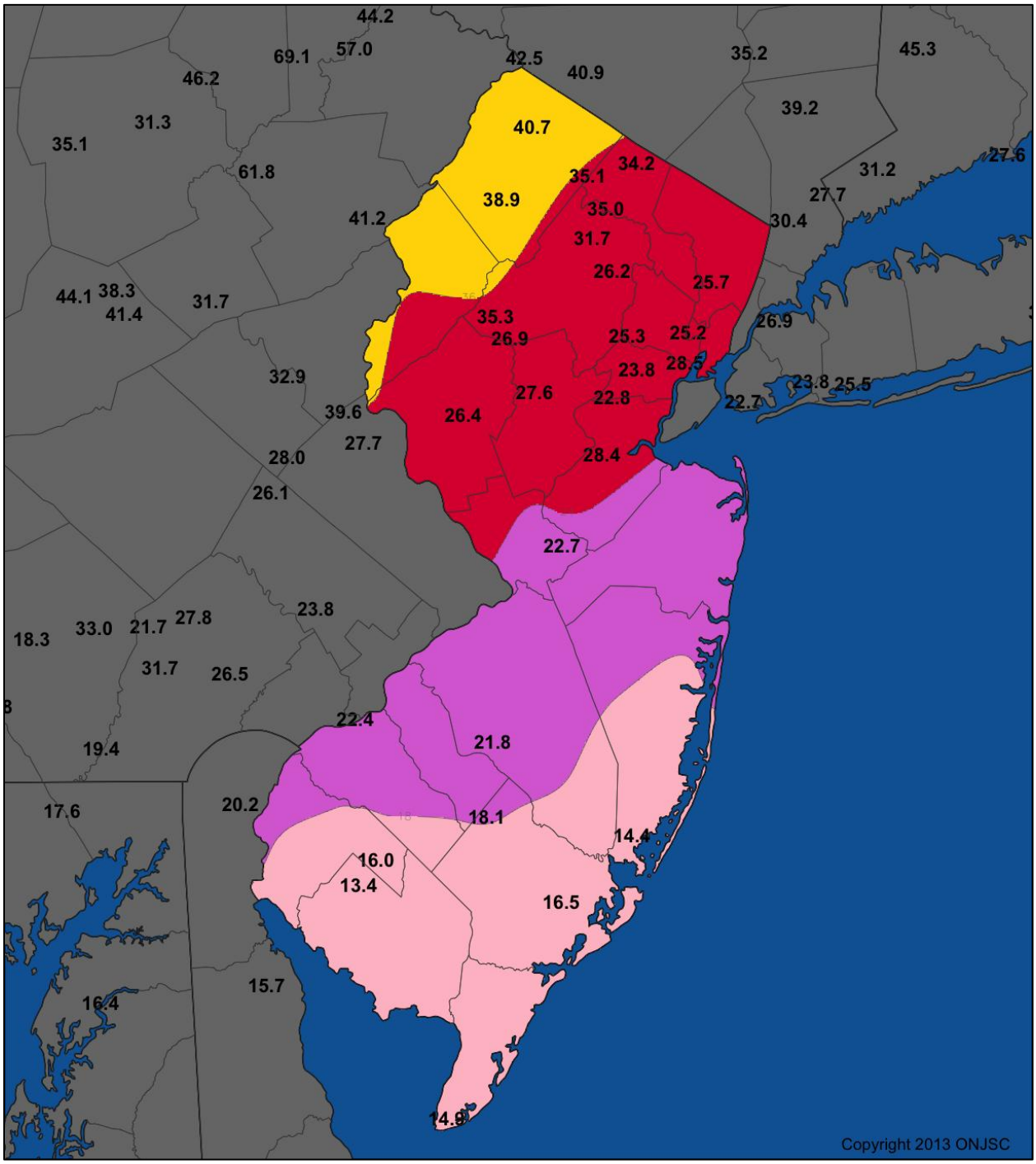
Location

Snow and Blizzards

The trajectory of the storm center—whether it passes close to the New Jersey coast or at a distance—largely determines both the intensity and the duration of the snowfall over the State. Winter storms tend to have the heaviest snowfall within a 150-mile wide swath to the northwest of what are generally southwest to northeast moving storms. Depending on whether all or a portion of New Jersey falls within this swath, the trajectory determines which portion of the State (or all of the State) receives the heaviest amount of snow.

Normal seasonal snowfall in New Jersey varies from 14.9 inches annually in Cape May County to over 40 inches in Sussex County. However, there is great variability from year to year. Figure 5.11-1 illustrates the normal seasonal snowfall for the State of New Jersey from 1981 to 2010.

Figure 5.11-1. Normal Seasonal Snowfall, 1981-2010



Source: ONJSC Rutgers University 2013a
Note: The numbers on the map represent the normal seasonal snowfall totals in inches.

Although the entire State may be considered at risk for snow and blizzards, higher snow accumulations are prevalent in northern New Jersey, primarily in the northwestern corner of the State that borders Pennsylvania and New York State. The lower snow accumulations appear to be prevalent along the eastern coastal areas of the State buffered by the ocean.

Ice Storms

All regions of New Jersey are subject to ice storms. The distribution of ice storms often coincides with general distribution of snow within several zones in the State. A cold rain may be falling over the southern portion of the State, freezing rain over the central region, and snow over the northern counties as a coastal storm moves northeastward offshore. A locality's distance to the passing storm center is often the crucial factor in determining the temperature and type of precipitation during a winter storm.

Normally experiencing lower temperatures on most winter days, the north has a greater chance of all types of winter storms occurring. Elevation can play a role in lowering the temperature to cause ice and snow to form on hilltops while valley locations remain above freezing, receiving only rain or freezing rain. Often a difference of only 100 to 200 feet can make a difference between liquid rain, adhering ice, and snow. Essex County's Orange Mountains, with an elevation of only 200 feet above the valley, have on occasion been locked in an icy sheath while valley residents have experienced only rain. Conversely, ice storms may occur in valleys and not on hilltops if cold air gets trapped in the valleys of regions with greater relief.

Extent

The magnitude or severity of a severe winter storm depends on several factors including a region's climatological susceptibility to snowstorms, snowfall amounts, snowfall rates, wind speeds, temperatures, visibility, storm duration, topography, and time of occurrence during the day (e.g., weekday versus weekend), and time of season.

The extent of a severe winter storm can be classified by meteorological measurements and by evaluating its societal impacts. NOAA's National Climatic Data Center (NCDC) is currently producing the Regional Snowfall Index (RSI) for significant snowstorms that impact the eastern two-thirds of the United States. The RSI ranks snowstorm impacts on a scale from one to five. It is based on the spatial extent of the storm, the amount of snowfall, and the interaction of the extent and snowfall totals with population (based on the 2000 Census). The NCDC has analyzed and assigned RSI values to over 500 storms since 1900 (NOAA-NCDC 2011). Table 5.11-1 presents the five RSI ranking categories.

Table 5.11-1. RSI Ranking Categories

Category	Description	RSI Value
1	Notable	1-3
2	Significant	3-6
3	Major	6-10
4	Crippling	10-18
5	Extreme	18.0+

Source: NOAA-NCDC 2011
Note: RSI = Regional Snowfall Index

Previous Occurrences and Losses

Snow and Blizzards

Snow may fall in New Jersey from October 15th to April 30th in the Highlands and from about November 15th to April 15th in the southern counties (ONJSC Rutgers University 2013b). Many sources provided historical information regarding previous occurrences and losses associated with winter storm events throughout the State of New Jersey. With so many sources reviewed for the purpose of this HMP, loss and impact information for many events could vary depending on the source. Therefore, the accuracy of monetary figures discussed is based only on the information available during research for this HMP. Table 5.11-2 outlines the history of winter storms in New Jersey.

The 2011 State Plan did not discuss specific snow and blizzard events; however, the plan did indicate that between 1926 and 2010, significant snowfalls occurred in the region in 1933, 1947, 1958, 1961, 1978, 1996, 2001, 2003, and 2010. For the 2014 Plan update, snow and blizzard events that occurred in the State from January 1, 2010 to December 31, 2012 will be further discussed. Table 5.11-2 outlines these events in the State but does not include all incidents.

Table 5.11-2. Snow and Blizzard Incidents in New Jersey

Date(s) of Event	Event Type	Counties Affected	Description
January 30-31, 2010	Heavy Snow	Southern and Coastal	Snow fell across southern New Jersey from the morning of January 30, into the early morning of January 31, 2010. Heavy accumulations occurred in Salem, Cumberland, Atlantic, and Cape May Counties. Snowfall averaged 4 to 10 inches with the highest amounts in Cape May County. Elsewhere in southern New Jersey, snowfall averaged one to four inches.
February 6, 2010	Blizzard	Statewide	A major winter storm dropped 20 to 30 inches of snow across the southern third of New Jersey, 10 to 20 inches across the central third of New Jersey, and less than 10 inches of snow north of Interstate 78 in the northern third of New Jersey from the afternoon of the February 5 into the afternoon of February 6, 2010. Blizzard conditions occurred in the southeastern part of the State during the early morning of February 6th, as winds gusted up to 50 mph. The 18.2 inches of snow that fell at the Atlantic City International Airport (Atlantic County) was the 3rd-highest single snowfall event on record. Cape May County was particularly hard hit by this storm with more than 70,000 homes and businesses losing power.
February 10, 2010	Blizzard	Statewide	For the second time within one week a major winter storm affected New Jersey. Blizzard conditions occurred at times across the extreme southern part of the state during the afternoon and early evening of February 10th. Snowfall averaged seven to 15 inches across northwest New Jersey, 12 to 20 inches across central New Jersey, and six to 12 inches across the southern third of New Jersey. Ice accretions were less than one tenth of an inch. Two storm-related deaths occurred in Burlington and Middlesex Counties.
February 22-23, 2010	Winter Storm	Northwest	A protracted winter storm dropped a wintry mix of snow, sleet, and freezing rain from in northwest New Jersey and affected Sussex County the most.
March 25-26, 2010	Heavy Snow	Northeast	A weather low brought a combination of heavy snow, heavy rain, coastal flooding, and strong winds to the region from March 25th through the 26th. Accumulations of one to two feet of snow were common across the region.
December 26-27, 2010	Heavy Snow	Statewide	See Appendix D for detailed information regarding this event.
January 8, 2011	Heavy Snow	Statewide	Snowfall averaged four to eight inches across the southeast part of the State, one to four inches across the southwest and central part of the State, and less than two inches in the northwest part of the State.
January 11-12, 2011	Heavy Snow	Statewide	Heavy snow fell across most of New Jersey from the early evening of January 11th through the early morning on the 12th. Snowfall averaged one to four inches in the southeast part of the State where some rain, freezing rain, and sleet occurred and five to nine inches of snow fell across the rest of the State.
January 17-18, 2011	Winter Storm	Statewide	A winter storm produced a protracted mix of snow, sleet, and freezing rain across most of the northern half of New Jersey with less of an impact across southwest and coastal central New Jersey. Snow and sleet accumulations in most of the northern half of New Jersey averaged one to three inches, and ice accretions averaged two tenths to five tenths of an inch. Across southwest and coastal central New Jersey snow and sleet accumulations were around an inch

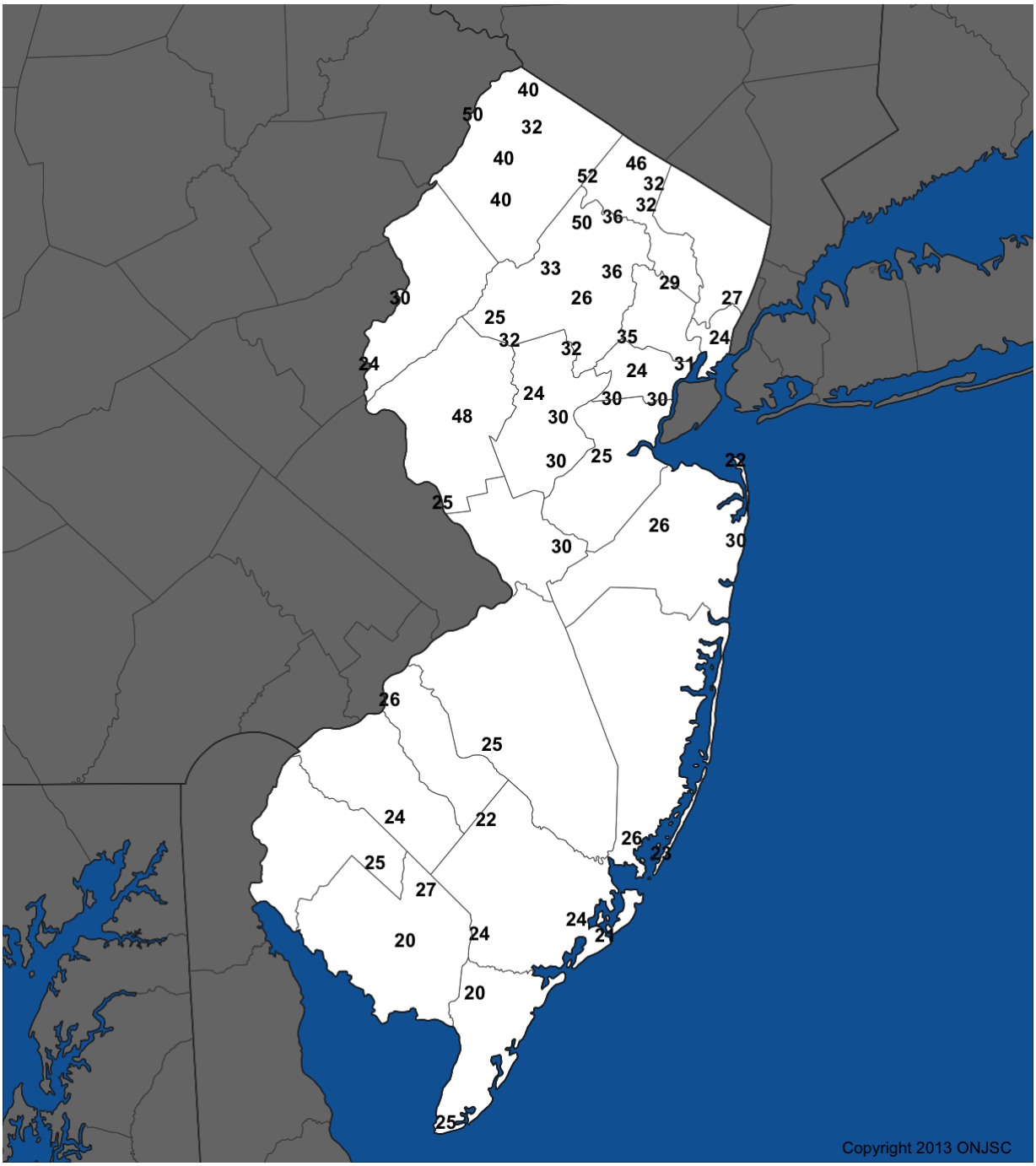
Table 5.11-2. Snow and Blizzard Incidents in New Jersey

Date(s) of Event	Event Type	Counties Affected	Description
			or less and ice accretions averaged around one tenth of an inch. Mainly rain fell across southeast New Jersey.
January 26-27, 2011	Heavy Snow	Statewide	Snow and sleet accumulations reached 12 to 18 inches in southwest New Jersey and the Passaic and Raritan Basins with lesser amounts elsewhere, especially toward and along the southeast coast.
February 1-2, 2011	Winter Storm	Northwest	A protracted winter storm dropped several inches of sleet and snow in Sussex County and included a long period of freezing rain that produced ice accretions of around half an inch in the Raritan Basin and the rest of northwestern New Jersey. The ice accretions took down weak trees, tree limbs and power lines.
February 21, 2011	Heavy Snow	Southern	A winter storm dropped three to six inches of snow across most of the southern half of New Jersey from the evening of February 21st into the early morning of the 22nd. Little if any snow fell north of Interstate 195 in New Jersey.
March 4-5, 2011	Heavy Snow	Statewide	An intensifying low-pressure system brought a protracted wintry mix of precipitation to central and southern New Jersey on March 4th and 5th and to northwestern New Jersey on March 4th through the 6th. Accumulations ranged from one to 15 inches throughout the state.
March 23-24, 2011	Winter Storm	Northwest	Snow accumulations averaged two to 10 inches in northwestern New Jersey and one to four inches in the Raritan Basin. A band of heavier snow that fell across southern Sussex County, Warren County, and western Morris County accounted for the highest snowfall totals. Ice accretions averaged a tenth of an inch or less.
October 29, 2011	Heavy Snow	Northeast	See Appendix D for detailed information regarding this event.
January 21, 2012	Heavy Snow	Bergen, Passaic	Between five to seven inches of snow fell across Western Bergen County by Saturday afternoon, with Oakland reporting 6.5 inches.
December 26-27, 2012	Winter Storm	Northwest	An intense low-pressure system brought a winter storm to Sussex County and a wintry mix in the rest of northwestern New Jersey. A combination of snow, sleet, and freezing rain occurred. Snowfall averaged one to four inches, except around six inches in Sussex County. Ice accumulations averaged one tenth of an inch.
January 7-8, 2012	Winter Storm	Statewide	A strong Nor'Easter caused high winds along the coast, heavy snow in east central New Jersey, 10-foot waves along the oceanfront, and minor tidal flooding along the oceanfront with the overnight high tide on January 7th

Source: NOAA-NCDC 2013; New Jersey State HMP 2011

Figure 5.11-2 illustrates the extreme depth of snow (in inches) on ground at individual weather stations across New Jersey. The numbers indicated on the figure are the greatest amount of snow depth at each of the stations over a minimum of 20 years. The maximum snow depth on record in New Jersey was a depth of 52 inches at Canistear Reservoir (Sussex County) on February 5, 1961.

Figure 5.11-2. Extreme Depth of Snow on Ground



Source: ONJSC Rutgers University 2013a

Ice Storms

Ice storms are not a frequent occurrence in the State of New Jersey. However, locations across the State experience icing conditions each winter. The events that do occur have the potential to impact the State, causing travel delays and cancellations, creating hazardous travel conditions, and causing power outages from snapped tree limbs breaking power lines.

Many sources provided historical information regarding previous occurrences and losses associated with icing/ice storm events throughout the State of New Jersey. With so many sources reviewed for the purpose of this HMP update, loss and impact information for many events could vary depending on the source. Therefore, the accuracy of monetary figures discussed is based only on the available information identified during research for this HMP. Table 5.11-3 outlines the history of winter storms in New Jersey.

The 2011 State Plan did not discuss specific ice storm events; however, for this Plan update, icing/ice storm events that occurred in the State from January 1, 2010 to December 31, 2012 will be further discussed. Table 5.11-3 outlines these events in the State but does not include all incidents. Because the 2011 Plan did not include ice events, Table 5.11-3 includes events prior to 2010. Incidents occurring prior to 2010 are based on the NOAA-NCDC database and other research.

Table 5.11-3. Ice Events in New Jersey

Date(s) of Event	Event Type	Counties Affected	Description
January 3-18, 1994	Ice Storm	Statewide	A series of ice storms impacted the state from January 3rd – 18th coating much of the State with ice in various amounts. During the January 17th ice storm, many portions of central, southwestern, and northeastern the State received a coating of ¼ to ½ inch of ice. The incident started as snow event but then warming temperatures led the participation to change over to freezing rain. In total the storm caused massive disruptions to power, in total causing around 549,000 outages.
February 13, 2000	Freezing Rain/Drizzle	Morris, Passaic, Sussex	Freezing rain and drizzle developed across northwestern New Jersey during the evening of February 13th. As warmer air moved in near the ground, the freezing rain warmed to rain. This occurred before a significant accumulation of ice occurred in Warren and Morris Counties. But in sections of Sussex County, around one-third of an inch of ice accrued on exposed surfaces.
December 14, 2000	Freezing Rain/Sleet	Passaic	A mixture of freezing rain and sleet created treacherous travel for the morning commute on December 14th. In addition, power outages resulted as tree limbs fell because of significant ice accretion. Ice accumulated at least one quarter inch throughout the area, with some locations receiving up to 0.5 inch of ice.
February 16, 2001	Ice	Sussex	Ice accretions reached around 0.25 inch in some of the higher terrain locations in the county. Untreated roadways were treacherous.
February 25, 2001	Freezing Rain	Hunterdon, Morris, Somerset, Sussex, Warren	Precipitation started as sleet and freezing rain. By 6 a.m. EST enough warm air had arrived for the precipitation to change to rain in Hunterdon and Somerset Counties with little ice accretion. It took until around 9 a.m. to scour the cold air from Warren and Morris Counties where up to one tenth of an inch of ice accrued. The cold air lasted the longest in Sussex County as freezing rain persisted in some of the colder spots until around noon.
March 12-13, 2001	Ice	Morris, Sussex, Warren	About 0.1 of an inch of ice accrued on exposed surfaces in Warren and Morris Counties. But totals reached as much as 0.5 inch in the higher terrain of northwest Sussex County. Any untreated roadways or walkways were extremely hazardous.
March 29-30, 2001	Ice Storm	Sussex	An ice storm affected higher-terrain locations of northwest Sussex County during the night of March 29th and the morning of the 30th. Around 0.75 inch of ice accrued on exposed surfaces. The ice took down tree limbs.
March 26, 2002	Freezing Rain/Sleet	Sussex	Precipitation started as freezing rain with some sleet falling around daybreak on March 26th. It changed quickly to rain in many of the warmer valleys, but persisted into the early evening across the higher terrain in the northwestern part of the state. The indirection insolation through the clouds was enough to keep most road surfaces wet and not icy. But, around one-quarter of an inch of ice did accrue on other exposed surfaces.
November 16, 2002	Ice Storm	Sussex	An ice storm affected higher elevations (mainly above 1,000 feet) of Sussex County during the night of November 16th. Between one and two inches of ice accrued on exposed surfaces. Numerous trees were knocked down and they toppled onto electrical transmission lines. Hardest hit were Vernon and Wantage Townships.

Table 5.11-3. Ice Events in New Jersey

Date(s) of Event	Event Type	Counties Affected	Description
December 11, 2002	Sleet/Freezing Rain	Hunterdon, Mercer, Morris, Somerset, Sussex, Warren	A winter storm of sleet and freezing rain affected northwestern New Jersey, affecting Sussex County the most. Precipitation changed to snow before it ended in the county during the night of December 11th. About two inches of snow accumulated on top of the ice. A shorter duration event of sleet and freezing rain affected sections of Mercer, Hunterdon, and Somerset Counties.
January 4, 2004	Ice	Sussex	Around 0.5 inch of ice accrued on exposed surfaces in the higher terrain of Sussex County from the evening of January 4th into the morning of the 5th. Untreated roadways were extremely hazardous.
January 8, 2005	Ice Storm	Hunterdon, Morris, Sussex, Warren	An ice storm affected the higher terrain of northwestern New Jersey on January 8th. Some freezing rain fell as far south as Hunterdon County. Precipitation type was elevation-dependent as rain fell in the valleys, but fell as freezing rain over the higher terrain. Ice accretions averaged from 0.25 to 0.5 inch, with the highest accretions in northwestern Sussex County.
December 13, 2007	Snow and Sleet	Hunterdon, Mercer, Middlesex, Morris, Sussex, Warren	This storm produced from one to as much as six inches of snow and sleet across northern New Jersey; however, warmer air arrived well above the surface allowing freezing rain to fall for a time in parts of northern New Jersey. Some places picked up 0.25 inch of ice with more isolated areas getting as much as 0.5 inch of ice.
February 1, 2008	Freezing Rain	Passaic	A low pressure system over the Lower Mississippi Valley occurred Thursday night (January 31) and lifted Northeast and into the Ohio Valley by Friday afternoon, February 1. Light-to-moderate freezing rain broke out across the Lower Hudson Valley and northeastern New Jersey Friday morning ahead of a warm front over the Mid-Atlantic states. The precipitation went over to rain from south to north by late afternoon, leaving about 0.5 inch of ice across western Passaic County in northeast New Jersey.
December 10-12, 2008	Ice	Sussex	Up to one inch of ice accrued on exposed surfaces and knocked down numerous tree limbs, trees, and power lines. Hardest hit was the Highland Lakes region of Vernon Township, but ice damage also affected in Sandyston, Sparta, Walpack, Wantage, and Montague Townships. Ice damage started at elevations greater than 1,000 feet.
January 6-7, 2009	Ice	Passaic	The combination of a weak high retreating over the northeast and deepening low pressure over the Great Lakes resulted in a significant accumulation of ice across portions of interior northern New Jersey from the evening of January 6 into the afternoon of January 7. A warm front extending east from the developing low worked northward from the Mid-Atlantic states, with overrunning precipitation to its north. Ice amounts averaged a little more than 0.5 inch across the western half of Passaic County, with the highest amount of 0.8 inch reported at Awosting.
February 1-2, 2011	Freezing Rain	Atlantic, Burlington, Camden, Cumberland, Monmouth, Ocean, Salem	Freezing rain fell across central and southern New Jersey overnight on February 1st. Ice accretions were 0.1 inch to 0.25 of an inch with the highest accretions in Monmouth County. At the peak of the storm, PSE&G reported nearly 20,000 customers without power from Gloucester County to northeastern New Jersey. All told, nearly 31,000 customers across the State lost power during the storm.

Source: NOAA-NCDC 2013; NJ.com 2011; Philly.com 2011

FEMA Disaster Declarations

Between 1954 and 2012, FEMA declared that the State of New Jersey experienced seven winter storm-related disasters (DR) or emergencies (EM) classified as one or a combination of the following disaster types: ice conditions, blizzard, snowstorm, or winter storm. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. However, not all counties were included in the disaster declarations as determined by FEMA (FEMA 2013).

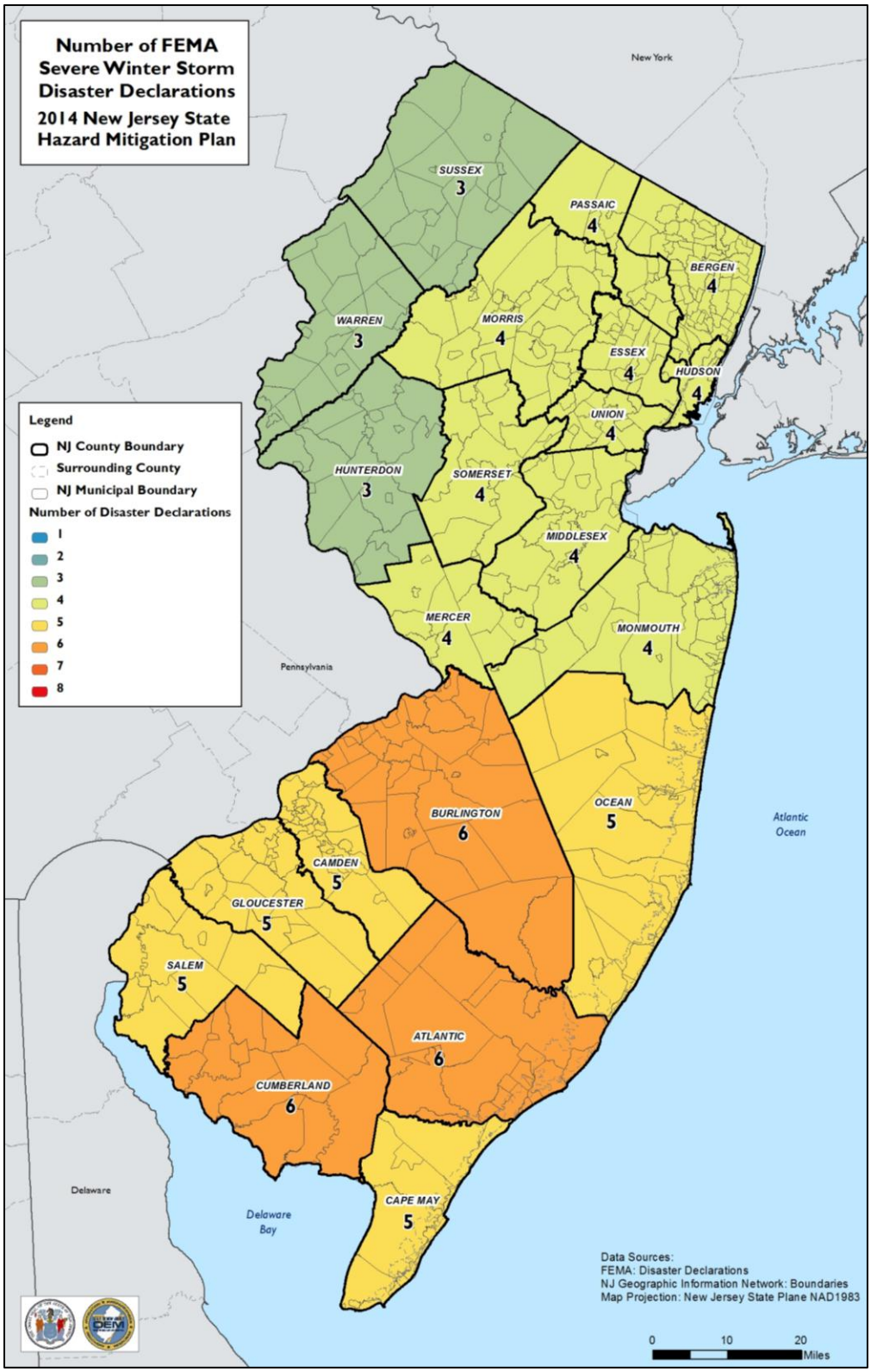
Based on all sources researched, known winter storm events that have affected New Jersey and were declared a FEMA disaster are identified in Table 5.11-4. This table provides detailed information concerning the FEMA disaster declarations for winter storms. Figure 5.11-3 illustrates the number of FEMA-declared disasters by county. Please refer to Appendix D for detailed information regarding those FEMA-declared disaster events that occurred between January 1, 2010 and December 31, 2012.

Table 5.11-4. FEMA Winter Storm-Related Disaster Declarations, 1954 to 2012

Disaster Number	Declaration Date	Incident Period	Disaster Type	Atlantic	Bergen	Burlington	Camden	Cape May	Cumberland	Essex	Gloucester	Hudson	Hunterdon	Mercer	Middlesex	Monmouth	Morris	Ocean	Passaic	Salem	Somerset	Sussex	Union	Warren	Total Counties Declared
DR-528	2/8/1977	2/8/1977	Ice Conditions	Not Available																					
EM-3106	3/17/1993	3/13/1993 - 3/17/1993	Severe Blizzard	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	21
DR-1088	1/13/1996	1/7/1996 - 1/12/1996	Blizzard	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	21
EM-3181	3/20/2003	2/16/2003 - 2/17/2003	Snowstorm	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	21
DR-1873	2/5/2010	12/19/2009 - 12/20/2009	Snowstorm	X		X	X		X		X							X		X					7
DR-1889	3/23/2010	2/5/2010 - 2/6/2010	Severe Winter Storm and Snowstorm	X		X	X	X	X		X									X					7
DR-1954	2/4/2011	12/26/2010 - 12/27/2010	Severe Winter Storm and Snowstorm	X	X	X		X	X	X		X		X	X	X	X	X	X		X		X		15

Source: *FEMA 2013*
DR *Disaster Declaration*
EM *Emergency Declaration*

Figure 5.11-3. FEMA Winter Storm-Related Declared Disasters by County (1954 to 2012)



Source: FEMA 2013

Probability of Future Occurrences

Severe winter weather is a common occurrence each season in New Jersey. The majority of the State will receive at least one measureable snow event during the winter months. The months of January, February, March, April, October, November, and December are typically when a vast majority of New Jersey has been observed to receive measurable snow. Generally, counties in the northern region experience more snow events than those in the southern region.

Severity

Winter weather affects the entire State of New Jersey and brings the threats of Nor'Easters, blizzards and snow, wind chill, frostbite and hypothermia, ice and road hazards, flooding, and power outages. Winter storm conditions and cold waves can be one of the deadliest types of weather. Cold temperatures can put an extra strain on your heart; heavy exertion (shoveling snow, clearing debris, etc.) can increase a person's risk of a heart attack. Accumulation of ice has the potential of causing collapse of trees, utility poles, and communication towers. Ice can disrupt communications and power for days. Even small amounts of ice can create dangerous conditions for motorists and pedestrians (NJOEM 2006).

Warning Time

The NWS operates a widespread network of observing systems such as geostationary satellites, Doppler radars, and automated surface observing systems that feed into the current state-of-the-art numerical computer models to provide a look into what will happen next, ranging from hours to days. The models are then analyzed by NWS meteorologists who then write and disseminate forecasts (NWS 2013).

The NWS uses winter weather watches, warnings, and advisories to ensure that people know what to expect in the coming hours and days. A winter storm watch means that severe winter conditions (heavy snow, ice, etc.) may affect a certain area, but its occurrence, location, and timing are uncertain. A watch is issued to provide 12 to 48 hour notice of the possibility of severe winter weather. A watch is upgraded to a winter storm warning when hazardous winter weather, in the form of heavy snow, heavy freezing rain or heavy sleet, is imminent or occurring. They are usually issued 12 to 24 hours before the event is expected to begin. Winter weather advisories inform people that winter weather conditions are expected to cause significant inconveniences that may be hazardous. The NWS may also issue a blizzard warning when snow and strong winds combine and produce a blinding snow, deep drifts, and wind chill (NWS 2013).

Secondary Hazards

The secondary hazards resulting from severe winter weather include structural damage (snow and ice load), wind damage, impact to life safety, disruption of traffic, loss of productivity, economic impact, loss of ability to evacuate, taxing first-responder capabilities, service disruption (power, water, etc.), and communication disruption.

Climate Change Impacts

Providing projections of future climate change for a specific region is challenging. Shorter term projections are more closely tied to existing trends making longer term projections even more challenging. The further out a prediction reaches the more subject to changing dynamics it becomes.

The New Jersey Climate Adaptation Alliance is a network of policymakers, public and private-sector practitioners, academics, non-governmental organizations (NGO), and business leaders aligned to build

climate change preparedness in the state of New Jersey. The Alliance is facilitated by Rutgers University, which provides science and technical support, facilitates the Alliance's operations and advances its recommendations. A document titled *Change in New Jersey: Trends and Projections* was developed to identify recommendations for State and local public policy that will be designed to enhance climate change preparedness and resilience in New Jersey (Rutgers 2013).

Temperatures in the Northeast United States have increased 1.5 degrees Fahrenheit (°F) on average since 1900. Most of this warming has occurred since 1970. The State of New Jersey, for example, has observed an increase in average annual temperatures of 1.2°F between the period of 1971-2000 and the most recent decade of 2001-2010 (ONJSC, 2011). Winter temperatures across the Northeast have seen an increase in average temperature of 4°F since 1970 (Northeast Climate Impacts Assessment [NECIA] 2007). By the 2020s, the average annual temperature in New Jersey is projected to increase by 1.5°F to 3°F above the statewide baseline (1971 to 2000), which was 52.7°F. By 2050, the temperature is projected to increase 3°F to 5°F (Sustainable Jersey Climate Change Adaptation Task Force 2013).

Both northern and southern New Jersey have become wetter over the past century. Northern New Jersey's 1971-2000 precipitation average was over five inches (12%) greater than the average from 1895-1970. Southern New Jersey became two inches (5%) wetter late in the 20th century (Office of New Jersey State Climatologist). Average annual precipitation is projected to increase in the region by 5% by the 2020s and up to 10% by the 2050s. Most of the additional precipitation is expected to come during the winter months. (New York City Panel on Climate Change [NYCPCC] 2009).

In terms of snowfall and ice storms, there is a lack of quantitative data to predict how future climate change will affect this hazard. It is likely that the number of winter weather events may decrease, and the winter weather season may shorten; however, it is also possible that the intensity of winter storms may increase. The exact effect on winter weather is still highly uncertain (Sustainable Jersey Climate Change Adaptation Task Force 2013).

5.11.2 Vulnerability Assessment

According to the NOAA National Severe Storms Laboratory (NSSL), every year, winter weather indirectly and deceptively kills hundreds of people in the United States, primarily from automobile accidents, over-exertion, and exposure. Injuries and fatalities may occur because of traffic accidents on icy roads, heart attacks while shoveling snow, or of hypothermia from prolonged exposure to cold.

Heavy snow can immobilize a region and paralyze a city, shutting down air and rail transportation, stopping the flow of supplies, and disrupting medical and emergency services. Accumulations of snow can collapse buildings and knock down trees and power lines. In rural areas, homes and farms may be isolated for days, and unprotected livestock may be lost. Storms near the coast can cause coastal flooding and beach erosion as well as sink ships at sea. In the mountains, heavy snow can lead to avalanches (NSSL 2006).

To understand risk, this section identifies assets exposed to the hazard areas in New Jersey. The entire State can be exposed to the severe winter weather hazard. The following sections discuss New Jersey's vulnerability to the severe winter weather hazard and addresses vulnerability and estimating potential losses by jurisdiction and to state facilities.

Assessing Vulnerability by Jurisdiction

A review of the historic record indicates that all counties have experienced severe winter weather events. Further, all counties identified severe winter weather as a hazard of concern in their hazard mitigation plans (hazards are summarized in Table 5.1-2 in Section 5.1, State Risk Assessment Overview). Of the five counties that ranked their hazards, the severe winter weather hazard was ranked medium to high. If severe winter weather was not ranked by a local HMP, the jurisdictions identified their most significant hazards using other methods.

As mentioned earlier, the entire State may be considered at risk to this hazard. In terms of snow accumulation, risk levels depend on the trajectory of the storm center. According to the normal (30-year average) snowfall seasonal totals (1981 to 2010), the highest snow accumulations were recorded in Sussex and Warren Counties with totals near 40 inches, and western portions of Morris and Passaic Counties with totals greater than 35 inches (shown on Figure 5.11-1 earlier in this section). This is also consistent with the extreme depth of snow on the ground record with the exception of the addition of Hunterdon County (refer to Figure 5.11-2 earlier in this section).

It is interesting to note that Essex, Monmouth, and Somerset Counties all rank severe winter weather as a high hazard in their hazard mitigation plans, although they are located outside of the highest normal snowfall seasonal totals. Therefore, for the purposes of this risk assessment, all counties are considered vulnerable to this hazard of concern.

The elderly are considered most susceptible to severe winter weather because of their increased risk of injury and death from falls, overexertion, and/or hypothermia from attempts to clear snow and ice, or related to power failures. In addition, severe winter weather events can reduce the ability of these populations to access emergency services. Residents with low incomes may not have access to housing or their housing may be less able to withstand cold temperatures (e.g., homes with poor insulation and heating supply). As of November 2013, the 2010 U.S. Census population spatial files do not include statistics on vulnerable population (e.g., elderly, low income); therefore a spatial analysis could not be conducted to summarize their vulnerability.

A specific area that is vulnerable to the winter storm hazard is the floodplain. Snow and ice melting can cause both riverine and urban flooding. At-risk general building stock and infrastructure in floodplains are presented in the flood hazard profile (Section 5.6). Estimated losses caused by flooding in the State are discussed in Sections 5.6 (Flood) and 5.8 (Hurricane/Tropical Storms).

Assessing Vulnerability to State Facilities

All State buildings are considered exposed and may potentially be impacted by severe winter weather events. Potential structural damage to buildings may include damage to roofs and building frames. State facilities may not be fully operational because of loss of power or workers' inability to travel to ensure continuity of operations pre- and post-event.

Similarly, all critical facilities and infrastructure in the State may be exposed to the severe winter weather hazard. Full functionality of critical facilities that provide essential state and emergency services such as police, fire, and medical facilities is critical during and after a severe winter weather event. Because power interruption can occur, backup power is recommended. Infrastructure at risk for this hazard includes roadways that could be damaged because of the application of salt and intermittent freezing and warming conditions that can damage roads over time. Section 5.1 (Risk Assessment Overview) summarizes the number of State buildings and their replacement values, and the number of critical facilities and infrastructure elements vulnerable to severe winter weather.

Estimating Potential Losses by Jurisdiction

The entire general building stock inventory in the State may be exposed to the severe winter weather hazard. In general, structural impacts include damage to roofs and building frames, rather than building content. Current modeling tools are not available to estimate specific losses for this hazard. Based on industry practices and consistent with FEMA-approved local hazard mitigation plans, as an alternate approach, for the purposes of this plan, potential damage to a building's structure that could result from winter storm conditions was estimated by calculating 1-percent of the building's structural replacement cost value. Table 5.11-5 below summarizes the State's total general building stock (structure only) estimated potential loss that may be caused by a severe winter weather event.

Given professional knowledge and the currently available information, the potential loss for this hazard is many times considered to be overestimated because of varying factors (building structure type, age, load distribution, building codes in place, etc.). Therefore, the following information should be used as estimates only for planning purposes with the knowledge that the associated losses for severe winter storm events can vary greatly.

Table 5.11-5. General Building Stock Estimated Potential Loss Caused by a Winter Weather Event

County	Total Building RCV	1% of Total RCV
Atlantic	$23,142,856	$231,429
Bergen	$91,039,406	$910,394
Burlington	$37,659,649	$376,596
Camden	$41,977,439	$419,774
Cape May	$15,436,786	$154,368
Cumberland	$10,537,520	$105,375
Essex	$66,795,156	$667,952

County	Total Building RCV	1% of Total RCV
Gloucester	$20,197,020	$201,970
Hudson	$48,334,851	$483,349
Hunterdon	$13,018,726	$130,187
Mercer	$33,228,183	$332,282
Middlesex	$70,463,724	$704,637
Monmouth	$58,556,919	$585,569
Morris	$51,460,938	$514,609
Ocean	$45,614,169	$456,142
Passaic	$39,156,823	$391,568
Salem	$4,878,456	$48,785
Somerset	$31,484,212	$314,842
Sussex	$12,782,756	$127,828
Union	$47,036,825	$470,368
Warren	$8,662,001	$86,620
Total	**$771,464,415**	**$7,714,644**

Source: HAZUS-MH 2.1
Notes:
RCV = Replacement cost value, provided by the Department of Treasury (structure only)

In addition to building damage, heavy accumulations of ice can bring down trees, electrical wires, telephone poles and lines, and communication towers. Communications and power can be disrupted for days while utility companies work to repair the extensive damage. Even small accumulations of ice may cause extreme hazards to motorists and pedestrians. Bridges and overpasses are particularly dangerous because they freeze before other surfaces (NSSL 2006).

The cost of snow and ice removal and repair of roads from the freezing and thawing process can drain local financial resources. The potential secondary impacts from winter storms also impact the local economy including loss of utilities, interruption of transportation corridors, and loss of business function.

Estimating Potential Losses to State Facilities

As stated earlier, full functionality of essential State services and critical facilities is necessary for response during and after a winter storm event. Potential structural damage to the facilities themselves may include damages to roofs and building frames. However, these facilities may not be fully operational because workers may be unable to travel to ensure continuity of operations pre- and post-event, and losses could include lost productivity and wages. For future plan updates, the State may consider determining which critical facilities have back-up power to enhance their critical facility inventory.

As noted above, potential damages to a building's structure that could result from winter storm conditions is considered. Table 5.11-6 below summarizes the State's total general building stock (structure only) estimated potential loss caused by a severe winter weather event. This was estimated by calculating 1-percent of the buildings structural replacement cost value.

Given professional knowledge and the currently available information, the potential loss for this hazard is often considered to be overestimated because of varying factors (building structure type, age, load distribution, building codes in place, etc.). Therefore, the following information should be used as estimates only for

planning purposes with the knowledge that the associated losses for severe winter storm events can vary greatly.

Table 5.11-6. State Facilities by Agency Estimated Potential Loss Due to a Severe Winter Weather Event

State Agency	Total (Leased and Owned)			
	Count	Total RCV	Count Noted as Critical in LBAM	1% Potential Loss (RCV)
Agriculture	1	$1,438,307	0	$14,383
Banking and Insurance	1	$41,888,820	0	$418,888
Chief Executive	1	$6,326,688	0	$63,267
Children and Families	90	$429,350,797	0	$4,293,508
Community Affairs	9	$71,066,977	1	$710,670
Corrections	696	$1,029,104,820	85	$10,291,048
Education	64	$169,630,022	0	$1,696,300
Environmental Protection	330	$237,788,403	8	$2,377,884
Health	3	$73,216,852	0	$732,169
Human Services	463	$911,399,594	19	$9,113,996
Judiciary	4	$57,010,526	0	$570,105
Juvenile Justice Commission	181	$153,607,218	25	$1,536,072
Labor and Work Force Development	6	$121,331,938	1	$1,213,319
Law and Public Safety	11	$249,332,826	1	$2,493,328
Legislature	4	$82,542,694	0	$825,427
Military and Veterans Affairs	262	$515,136,263	53	$5,151,363
Miscellaneous Commissions	1	$7,825,328	0	$78,253
Motor Vehicles Commission	69	$464,016,658	2	$4,640,167
Personnel	1	$4,256,708	0	$42,567
State	9	$104,408,353	1	$1,044,084
State Police	122	$236,847,627	5	$2,368,476
Transportation	565	$261,616,942	0	$2,616,169
Treasury	17	$200,357,468	2	$2,003,575
Total	**2,910**	**$5,429,501,828**	**203**	**$54,295,018**

Source: Department of Treasury 2013
Notes:
LBAM = Land and Building Asset Management System
RCV = Replacement cost value, provided by the Department of Treasury (structure only)

Environmental Impacts

The environmental impacts of a severe winter weather event are associated with the heavy snow and/or ice accumulations that can bring down vegetation and tree limbs. The rapid snowmelt may lead to flood events causing further environmental impacts. The extreme cold temperatures that can accompany these events may also impact wildlife depending upon the duration of the event.