4-2: Snow Storm & Ice Storm

Hazard Impacts	Probability	Potential Impact					Score*:
		Infrastructure	Life	Economy	Environment	**Average:**	
Ice	3	3	3	3	2	2.75	8.25
Snow	4	1	3	2	1	1.75	7

*Score = Probability x Average Potential Impact

Strong winter weather can include any of the following, alone or in conjunction:

- **Snow Storms:** a heavy accumulation of snow, which can be accompanied by high wind causing drifting snow, low visibility and hazardous travel.
- **Ice Storms:** ice accretion from freezing rain, which can weigh down trees and power lines, causing outages and potentially occuring in conjunction with flooding (see: Inundation Flooding & Fluvial Erosion).
- **Blizzard:** a storm which contains large amounts of snow and/or blowing snow, with winds in excess of 35mph and visibilities of less than 1/4 mile for an extended period of time (for wind impacts, see: Wind).
- **Extreme Cold:** see Extreme Cold.

Severe winter storms bring the threat of heavy accumulations of snow, cold/wind chills, strong winds, and power outages that result in high rates of damage and even higher rates of expenditures.

A heavy accumulation of snow, especially when accompanied by high winds, causes drifting snow and very low visibility. Sidewalks, streets, and highways can become extremely hazardous to pedestrians and motorists. Severe winter storms develop through the combination of multiple meteorological factors. In Vermont and the northeastern United States, these factors include the moisture content of the air, direction of airflow, collision of warm air masses coming up from the Gulf Coast, and cold air moving southward from the Arctic.

Heavy ice accumulation weighing down mature trees and weighing down power lines in northern, VT 2013.
Photo Credit: Vermont Public Radio

Significant accumulations of ice can cause hazardous conditions for travel, weigh down trees and power lines, and cause power outages. Freezing rain can also be combined with snowfall, hiding ice accumulation and further hindering travel, or with mixed precipitation and potentially ice jams or flooding (see: Inundation Flooding & Fluvial Erosion).

NOAA's Weather Predictions Center is in the process of developing a new prediction tool, the Winter Storm Severity Index (WSSI)[1], to provide an indication of the level of winter event severity and impacts (Table 28). The WSSI does not depict official warnings or exact event timing, but provides severity level over a given period.

Table 28: Winter Storm Severity Index (still under development in 2018)	
WSSI Descriptor	**General Description of Expected Storm Severity Impacts**
None	No snow or ice forecast. No potential for ground blizzard conditions.
Limited	Small accumulations of snow or ice forecast. Minimal impacts, if any, expected. In general, society goes about their normal routine.
Minor	Roughly equates to NWS Advisory Level criteria. Minor disruptions, primarily to those who were not prepared. None to minimal recovery time needed.
Moderate	Roughly equates to NWS Warning Level criteria. Definite impacts to those with little preparation. Perhaps a day or two of recovery time for snow and/or ice accumulation events.
Major	Significant impacts, even with preparation. Typically several days recovery time for snow and/or ice accumulation events.
Extreme	Historic. Widespread severe impacts. Many days to at least a week of recovery needed for snow and/or ice accumulation events.

The WSSI is broken down into six components that are individually weighted based on the WSSI categories and then summarized into overall severity:

- **Snow Amount:** to depict severity due to total amount of snow or rate of snowfall accumulation. (Adjustments are made based on climatology and urban areas, e.g. 4" of snow in Atlanta is more severe than 4" in Minneapolis.)
- **Snow Load:** to depict severity due to total weight of snow on trees and power lines.
- **Blowing Snow:** to depict severity mainly to transportation due to blowing and drifting snow.
- **Ice Accumulation:** to depict severity of transportation and downed trees/powerlines due to the accumulated ice in combination with wind.
- **Ground Blizzard:** to depict severity to mainly transportation of ground blizzards that develop due to a pre-existing snowpack and strong winds.
- **Flash Freeze:** to depict severity primarily to transportation of situations where temperatures rapidly fall below freezing during precipitation.

Snow Storm & Ice Storm History

- **Blizzard, February 15-17, 1958:** More than 30" of snow and 26 deaths in New England.
- **Blizzard, December 26-27, 1969:** Snow amounts between 18–36" in northwestern Vermont and 45" in Waitsfield. Governor Dean Davis declared a State disaster. Drifts of snow from the storm piled up to 30' in places.
- **Ice Storm, January 6, 1998 (DR-1201):** An unusual combination of precipitation and temperature led to the accumulation of more than 3" of ice in many locations, causing closed roads, downed power lines, and damage to thousands of trees. This storm was estimated as a 200-500 year event. Power was out up to 10 days in some areas and 700,000 acres of forest were damaged in Vermont. Vermont suffered no fatalities, unlike Quebec where 3 million people lost power and 28 were killed. Temperatures rose after the storm, causing the ice to melt and permitting crews to reopen roads, which kept many residents from freezing in their unheated homes. Over $6 million worth of estimated property damage.
- **Snow Storm, December 19, 2000 (DR-1358):** Snow amounts between 7-10". A few reports included: Berkshire: 9.7", Eden: 8.2", Jay Peak 8", St. Johnsbury: 7.1", and Worcester: 7".

1 http://www.wpc.ncep.noaa.gov/wwd/wssi/wssi.php

- **Snow Storm, March, 2001:** A string of storms hit Vermont in March 2001, beginning with 15-30" of snow on March 5-6, 10-30" on March 22, and 10-20" on March 30.
- **Snow Storm, February 14, 2007:** The second heaviest snowfall ever recorded in the month of February. Some areas of Vermont received from 28-36" of snow in a 24 to 48-hour period. Heavy snow loads on roofs led to the collapse of at least 10 barns, causing the death of some cows and other livestock. Estimated nearly $3 million in property damage.
- **Ice Storm, December 11, 2008 (DR-1816):** Winter storms and high winds resulted in extensive power outages, primarily in southern Vermont counties. Upward of 40,000 homes were without power for several days during this period.
- **Snow Storm, January 2-3, 2010:** Burlington experienced the most significant snowfall on record from one event with 33.1" of snow.
- **Winter Snow Totals, 2010-2011:** The winter of 2011 was the second snowiest on record for Vermont, with a total of 128.4" of snow. A March blizzard in Burlington brought 25.8" of snow in two days. The storm closed schools for days, and many people were without power. Driving was hazardous due to a 1" layer of ice beneath several inches of snow.
- **Snow Storm, December 28, 2011:** A strong cold front moved across Vermont during the late morning and afternoon hours accounting for a rapid cool down and localized snow squalls with heavy snow. The western slopes of the Green Mountains saw 5-12" of snow along foothill communities. Near white-out conditions in snow squalls and rapidly freezing road ways accounted for numerous vehicle accidents as well as a closure of I-89 between Richmond and Waterbury.
- **Ice Storm, December 20-21, 2013 (DR-4163):** Approximately 1/4-1/3" of ice accumulation from freezing rain on December 20 with an additional 1/2-3/4" of ice accumulation as well as 1- 2" of sleet December 21 in portions of northern Vermont. Very cold temperatures (-10°F to teens) followed the event with no melting, thus ice stayed on trees and utility lines through December, prolonging recovering. The greatest impact was in northwest Vermont, with widespread tree and utility line damage as well as numerous vehicle accidents. More than 75,000 customers were without power from hours to days. Over $4 million in property damage estimated.
- **Snow Storm, November 26, 2014:** The storm began late morning November 26 and increased in intensity, falling at rates at or greater than 1" per hour. Snowfall caused slow and difficult travel the day before Thanksgiving. Snow continued through the day and evening with heavy bands at times and tapered off overnight. By the early morning on Thanksgiving, most of southern Vermont saw snowfall of 8-15" with the heaviest amounts across the higher elevations of the southern Green Mountains.
- **Snow Storm, December 9-13, 2014 (DR-4207):** Rain and wet snow moved into Vermont midday December 9 and changed to a heavy, wet snow during the evening. A band of moderate snowfall impacted much of central and northern Vermont during the afternoon and evening hours of December 10, then scattered snow showers ending on December 11-12. Total snowfall totals across Vermont ranged from 3-6" in Essex County to 12-20" across the Green Mountains into the Champlain Valley. The heavy, wet nature of the snowfall with snow to water ratios of 8:1 or less accounted for snow-loaded trees that resulted in more than 175,000 power outages in the region. This was the 2nd most power outages due to weather in Vermont. Over $4 million in property damages estimated.

Downed tree in Richmond, VT following heavy snowfall in 2014.
Photo Credit: Angela Evancie / Vermont Public Radio

Table 29: Top 20 Greatest Snowstorms in Burlington (NOAA)

Rank	Snowfall	Month/Year	Rank	Snowfall	Month/Year
1	33.1”	January 2-3, 2010	11	19.1”	March 16,-17, 1937
2	30.4”	March 14-15, 2017	12	18.8”	December 14-15, 2003
3	29.8”	December 25-26, 1969	13	18.7”	March 12-13, 2014
4	25.8”	March 6-7, 2011	14	18.3”	December 6-7, 2003
5	25.7”	February 14-15, 2007	15	17.8”	January 3-4, 2003
6	24.7”	January 13-14, 1934	16	17.8”	February 4-5, 1995
7	22.9”	March 5-6, 2001	17	17.7”	March 3-4, 1994
8	22.4”	March 13-14, 1993	18	17.2”	February 6-8, 2008
9	20.0”	November 25, 2000	19	17.1”	February 25-26, 1966
10	19.7”	January 25-28, 1986	20	16.9”	December 25, 1978

Data Source: www.weather.gov/media/btv/climo/extremes/top20snow.pdf

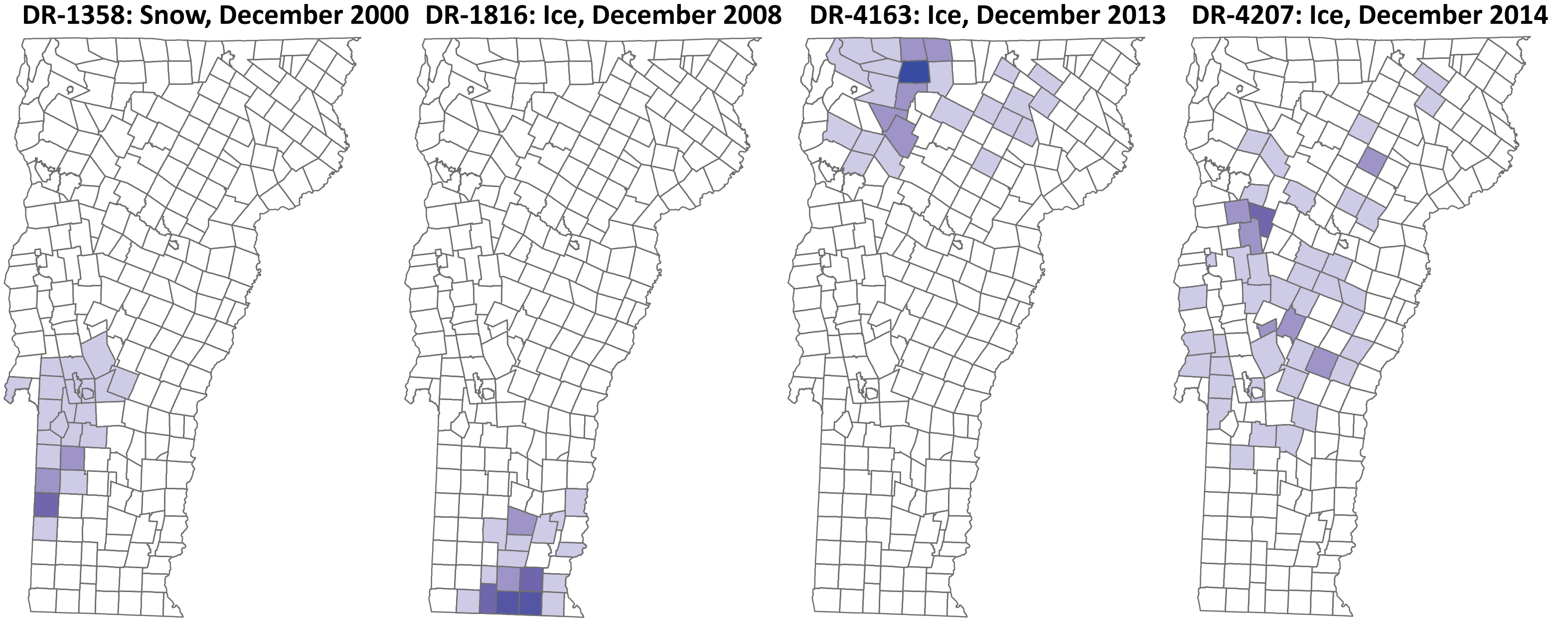
Snow Storm & Ice Storm Trends & Vulnerability

Impacts from ice are considered to be more significant than those associated with snow. The Steering Committee considered the probability of a plausibly significant extreme ice event to be Likely, with moderate impacts on infrastructure, people and the economy. A significant snow event has a probability of Highly Likely, with moderate impacts on people and minor impacts on the economy.

There is no specific region of Vermont that is more vulnerable to ice or snow storms. Snow accumulation is highest at the upper elevations of the Green Mountains, including Mt Mansfield, Killington, Mt Ellen, Camel’s Hump, Mt Abraham, Lincoln Peak, Pico Peak, Jay Peak, Bromley, and Stratton Mountain.

Figure 37: Federally-declared ice and snow disaster public assistance expenditure by municipality (2000-2016)
Data Source: www.fema.gov/openfema

DR-1358: Snow, December 2000 **DR-1816: Ice, December 2008** **DR-4163: Ice, December 2013** **DR-4207: Ice, December 2014**



Total: $687,000 Total: $1,338,000 Total: $6,342,000 Total: $3,949,000

≤ $50,000 $50,001 - $100,000 $100,001 - $250,000 $250,001 - $500,000 $500,001 - $1,000,000

Table 30: Snowfall Extremes by Vermont County — 1-Day, 2-Day and 3-Day Storms						
County	**1-Day**	**Amount**	**2-Day**	**Amount**	**3-Day**	**Amount**
Addison	3/14/1933	25.6”	2/25/2010	28.8”	3/14/1993	28.2”
Bennington	3/14/1984	37.0”	3/14/1984	38.0”	3/5/1947	42.0”
Caledonia	2/25/1969	33.0”	2/26/1969	34.5”	2/26/1969	35.5”
Chittenden	2/14/2007	25.3”	1/3/2010	35.3”	1/3/2010	37.6”
Essex	12/7/2003	24.0”	12/8/2003	43.0”	12/9/2003	43.0”
Franklin	3/14/1993	24.0”	12/27/1969	30.0”	3/18/1937	33.0”
Grand Isle	3/7/2011	19.0”	3/7/2011	23.3”	3/7/2011	23.3”
Lamoille	4/10/2000	25.0”	2/15/2007	36.0”	2/16/2007	36.0”
Orange	3/13/2014	24.5”	12/8/2003	26.0”	12/22/2008	29.2”
Orleans	2/5/1995	42.0”	2/6/1995	48.0”	2/6/1995	48.0”
Rutland	12/7/2003	25.0”	12/7/2003	27.0”	12/8/2003	28.5”
Washington	3/14/1993	31.0”	12/28/1969	36.0”	12/29/1969	44.0”
Windham	12/19/1986	34.0”	12/19/1986	34.5”	3/5/1947	41.0”
Windsor	2/14/2014	30.0”	11/23/1943	39.0”	12/4/1942	41.0”

Source: https://www.ncdc.noaa.gov/snow-and-ice/snowfall-extremes/VT

There are no standard loss estimation models or methodologies for the winter storm hazards. Potential losses from winter storms are, in most cases, indirect and therefore difficult to quantify.

According to the 2014 National Climate Assessment, there is an observable increase in severity of winter storm frequency and intensity since 1950[2]. While the frequency of heavy snowstorms has increased over the past century, there has been an observed decline since 2000 and an overall decline in total seasonal snowfall.

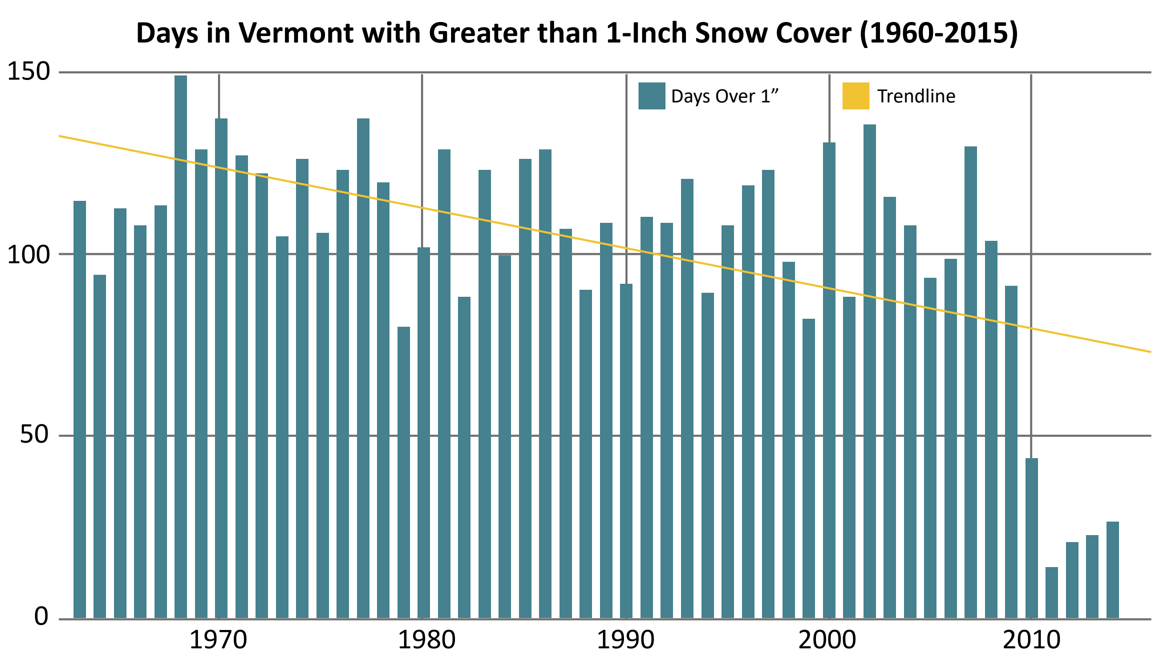


Figure 38: Number of days in Vermont with greater than 1-Inch snow cover (1960-2015)
Data Source: http://climatechange.vermont.gov

2 https://nca2014.globalchange.gov/report/our-changing-climate/changes-storms

The National Centers for Environmental Information within NOAA manage data pertaining to snow coverage across the country[3]. Due to rising minimum temperatures and a shortening winter season, snow cover on the ground has also seen significant decreases. Seven weather stations, located in Bethel, Burlington Airport, Cavendish, Newport, Rochester, Rutland and St. Johnsbury have consistently recorded the number of days with greater than 1" of snow cover since 1963. The results (Figure 38) indicate that this number is trending downward, with the most significant decreases occurring in the past decade. Expected reductions in snow cover leave the exposed ground more vulnerable to freezing during extreme cold events, which can cause significant impacts to building infrastructure (see: Extreme Cold), and also lead to decreased tourism revenues across the State (see: Extreme Heat).

Snow Storm & Ice Storm Mitigation

State facilities and individual towns are generally well prepared to deal with winter storms. VTrans winter maintenance road crews are experienced and well-equipped to keep highways open and municipal road crews are also generally well-prepared. Most critical State facilities have emergency backup generators in case of loss of power due to icing, and in 2014 the State of Vermont applied for a Statewide Generator Project under DR-4022 for local emergency shelters and critical facilities.

This Plan has identified a mitigation strategy to develop resilient design and construction standards (see: Mitigation Strategy) in the form of auditing existing building codes, which would include standards for snow loading and ice accumulation. Additionally, several strategies aimed at increasing public knowledge about hazards and mitigation, supporting vulnerable populations and coordinating hazard mitigation mapping must consider snow and ice storm events during implementation.

This Plan also includes a strategy to identify and protect vulnerable structures and critical infrastructure, with an action to provide technical assistance to utilities in long-range planning for transmission and distribution line upgrades and relocation to improve resilience, which would include impacts due to ice events and snow loading. Additionally, this strategy includes an action to adapt the VTrans Methods and Tools for Resilience project (2018 SHMP subgrant) for use in mapping utilities and identifying vulnerabilities, which should not be a significant lift given that the majority of utility lines in Vermont run along roadways.

Though several towns in the State are considering burying power lines for long-term mitigation against both wind and ice events, a statewide approach to power line burying is not being considered at this time due to being cost prohibitive.

3 https://www.ncdc.noaa.gov/cdo-web/datatools