WINTER STORMS AND NOR'EASTERS

BACKGROUND

A winter storm can range from a moderate snow over a period of a few hours to blizzard conditions with blinding wind-driven snow that lasts for several days. Some winter storms may be large enough to affect several states, while others may affect only a single community. Many winter storms are accompanied by low temperatures and heavy and/or blowing snow, which can severely impair visibility.

Winter storms may include snow, sleet, freezing rain, or a mix of these wintry forms of precipitation. Sleet—raindrops that freeze into ice pellets before reaching the ground—usually bounce when hitting a surface and do not stick to objects; however, sleet can accumulate like snow and cause a hazard to motorists. Freezing rain is rain that falls onto a surface with a temperature below freezing, forming a glaze of ice. Even small accumulations of ice can cause a significant hazard, especially on roads, power lines and trees. An ice storm occurs when freezing rain falls and freezes immediately upon impact. Communications and power can be disrupted for days, and even small accumulations of ice may cause extreme hazards to motorists and pedestrians.

A VDOT snowplow plows I-64 East. (Photo by Tom Saunders, VDOT)

A freeze is weather marked by low temperatures, especially when below the freezing point (zero degrees Celsius or thirty-two degrees Fahrenheit). Agricultural production is seriously affected when temperatures remain below the freezing point.

The Northeast Snowfall Impact Scale (NESIS) developed by the NWS characterizes and ranks high-impact Northeast snowstorms. These storms have large areas of 10 inch snowfall accumulations and greater. NESIS has five categories: Extreme, Crippling, Major, Significant, and Notable. The index differs from other meteorological indices in that it uses population information in addition to meteorological measurements. Thus NESIS gives an indication of a storm's societal impacts. This scale was developed because of the impact Northeast snowstorms can have on the rest of the country in terms of transportation and economic impact.

NESIS scores are a function of the area affected by the snowstorm, the amount of snow, and the number of people living in the path of the storm. The aerial distribution of snowfall and population information are combined in an equation that calculates a NESIS score which varies from around one for smaller storms to over ten for extreme storms. The raw score is then converted into one of the five NESIS categories, with the largest NESIS values result from storms producing heavy snowfall over large areas that include major metropolitan centers (**Table 4.12**).

Table 4.12: Northeast Snowfall Impact Scale (NESIS)		
CATEGORY	NESIS VALUE	DESCRIPTION
1	1 - 2.499	Notable
2	2.5 – 3.99	Significant
3	4 – 5.99	Major
4	6 – 9.99	Crippling
5	10.0+	Extreme

Nor'easters are extra-tropical events that produce strong winds and precipitation in the form of heavy rain, ice or snow. They can cause increases in tidal elevations (storm surge), wind speed, and erosion. These cyclonic storms, called nor'easters because of the direction of the storm winds, can last for several days and can impact very large areas.

The presence of the Gulf Stream off the eastern seaboard in the winter season acts to dramatically enhance the surface horizontal temperature gradients within the coastal zone. This is particularly true off the Virginia coastline where, on average, the Gulf Stream is closest to land north of 32 degrees latitude. During winter offshore cold periods, these horizontal temperature gradients can result in rapid and intense destabilization of the atmosphere directly above and shoreward of the Gulf Stream. This air mass modification or conditioning period often precedes wintertime coastal extra-tropical cyclone development. The temperature structure of the continental air mass and the position of the temperature gradient along the Gulf Stream drive this cyclone development. As a low pressure deepens, winds and waves can increase and cause serious damage to coastal areas as the storm generally moves to the northeast.

The coastal communities of Virginia are most vulnerable to the impacts of nor'easters. Since the storms often occur at night, and typically make landfall with less warning than hurricanes (due to their rapid formation along the coast), residents may be caught at home unprepared. On the other hand, nor'easters typically occur during the tourist off-season when fewer non-residents are visiting the coast. As with hurricanes, structural vulnerability to nor'easters is proportional to the strength of the structure, with mobile homes being particularly vulnerable.

The Dolan-Davis Scale, **Table 4.13**, was developed by scientists at the University of Virginia to identify and classify the damages that may occur during nor'easters. Although rarely referenced by the NWS or other media in describing nor'easters, the scale provides a descriptive tool for the types and levels of damage associated with a nor'easter. Heavy precipitation in the form of rain or snow, beach and dune erosion from wave action, sand/water overwash associated with storm surge, and resultant coastal property damage are all commonly associated with strong nor'easters.

Table 4.13: DOLAN-DAVIS NOR'EASTER INTENSITY SCALE				
STORM CLASS	BEACH EROSION	DUNE EROSION	OVERWASH	PROPERTY DAMAGE
1 (Weak)	Minor changes	None	No	No
2 (Moderate)	Modest; mostly to lower beach	Minor	No	Modest
3 (Significant)	Erosion extends across beach	Can be significant	No	Loss of many structures at local level

Table 4.13: DOLAN-DAVIS NOR'EASTER INTENSITY SCALE				
STORM CLASS	**BEACH EROSION**	**DUNE EROSION**	**OVERWASH**	**PROPERTY DAMAGE**
4 (Severe)	Severe beach erosion and recession	Severe dune erosion or destruction	On low beaches	Loss of structures at community- scale
5 (Extreme)	Extreme beach erosion	Dunes destroyed over extensive areas	Massive in sheets and channels	Extensive at regional-scale; millions of dollars

LOCATION AND SPATIAL EXTENT

Winter storms impact each jurisdiction uniformly. All building stock, infrastructure and critical facilities are equally vulnerable to these hazards. Vulnerability maps showing infrastructure and critical facilities that are at risk to these hazards are found in **Appendix B**.

SIGNIFICANT HISTORICAL EVENTS

According to the NCDC, the Southside Hampton Roads region has experienced 28 significant winter storm events including snow and ice storms, extreme cold, and freezing rain since 1993 (**Table 4.14**). These events account for $20,120,000 in property damages for the affected areas. The region received presidential disaster declarations from major winter storms in 1996 (the Blizzard of '96) and 2000. Some of the more significant winter storms to impact the region in the twentieth century are discussed below.

On **March 1-3, 1927** a nor'easter hit the region with high winds gusting to 62 MPH at Cape Henry and 52 MPH at Norfolk. Heavy snow fell across North Carolina into Virginia and travel was delayed for two to three days. In Virginia Beach, high tide and heavy surf on March 2 inflicted considerable damage. The beaches in some places were washed back 50 feet and denuded of the overlying sand, exposing the clay beneath.

On **April 11, 1956**, a severe Nor'easter gave gale winds (greater than 40 MPH) and unusually high tides to the Tidewater Virginia area. At Norfolk, the strongest gust was 70 MPH. The strong northeast winds blew for almost 30 hours and pushed up the tide, which reached 4.6 feet above normal in Hampton Roads. Thousands of homes were flooded by the wind-driven high water and damages were large. Two ships were driven aground. Waterfront fires were fanned by the high winds. The flooded streets made access to firefighters very difficult, which added to the losses.

On **January 30-31, 1966**, a blizzard struck Virginia and the Northeast U.S. It was the second snowstorm to hit Virginia in a week. The first storm dumped 9 inches in Norfolk. With fresh snow on the ground, arctic air settled in and temperatures dropped into the teens. The second storm dumped one to two feet of snow over a large part of the state. Intense winds and drifting snow continued and kept roads closed for several days after the storm. Temperatures dropped into the single digits with some falling below zero. Wind chill temperatures were dangerously low.

The **winter of 1976-1977** was the coldest winter on the East Coast of the past century. Storms across the state dropped a few more inches every few days to keep a fresh coating on the streets that were just clearing from the previous storms. The average temperature for the month of January in Norfolk was 29.2°F which was 12° below normal. The prolonged cold wave caused oil and natural gas shortages and President Carter asked people to turn thermostats down to conserve energy. The major elements of this winter were the cold temperatures. There was little snowfall associated with this winter in the Southside Hampton Roads region.

The "**Presidents Day Storm**" of February 1979 dropped 7 inches on snow on Norfolk on February 18-19 and 13 inches of snow were recorded for the entire month. The following winter, 20 inches fell in Virginia Beach and a foot of snow fell in Norfolk in a storm that hit the region in February. On March 1, another foot of snow fell in Norfolk and the total snowfall amount of 41.9 inches for Norfolk was the snowiest winter ever recorded in eastern Virginia.

The "**Superstorm of March '93**," was also known as "The Storm of the Century" for the eastern United States, due to its large area of impact, all the way from Florida and Alabama through New England. Impacts in the Southside Hampton Roads region were not as severe, but this storm still caused major disruption across a large portion of the country.

The "**1996 Blizzard**" from January 6 to January 13, 1996 affected much of the eastern seaboard. In Virginia, the winter storm left up to 36 inches of snow in portions of the state. In the Southside Hampton Roads region, most of the communities saw at least a foot of snow between January 6 and January 12.

A major ice storm at the end of December 1998 resulted in approximately 400,000 customers being without power during the maximum outage period. Some customers were without power for about ten days during the holidays. Many accidents occurred due to slippery road conditions, especially bridges and overpasses and holiday travel. Many secondary roads were impassable due to fallen tree limbs or whole trees.

The **winter of 2010** was a memorable one for residents of Hampton Roads. The NWS compiled preliminary winter climate data for 2010-2011 at Norfolk, which indicate an average temperature of 38.9 degrees, or 3.2 degrees lower than the normal of 42.1 degrees. Total snowfall was 21.8 inches, which is remarkable when compared to the normal of 7.1 inches for an average winter. December 2010 was the 2nd-snowiest on record, at 17.8 inches, because most snow fell before January 1. There was 13.4 inches of snow for December 26, which is the fourth-biggest daily snowfall on record. (Source: *The Daily Press,* 3/11/2011, and NWS) The December 26 winter storm created havoc on the roadways. Between midnight and 10 pm December 26, State Police recorded 421 traffic crashes, 296 disabled vehicles and 1,159 total calls for service in Hampton Roads, Eastern Shore, Williamsburg, Franklin and Emporia. The NESIS ranking for the December, 2010 winter storm was a Category 3.

Many other descriptions of historical occurrences of winter storms and nor'easters can be found online at http://www.vaemergency.com/newsroom/history/winter.cfm

TABLE 4.14: WINTER STORM ACTIVITY (1993 - 2010)				
LOCATION	DATE OF OCCURRENCE	TYPE OF EVENT	PROPERTY DAMAGE	DETAILS
Isle of Wight County	12/28/1993	Winter Weather	$0	No description available.
9 jurisdictions, including Isle of Wight	1/6/1996	Winter Storm	$50,000	No description available. NESIS Category 5
17 jurisdictions, including Isle of Wight	2/2/1996	Winter Storm	$0	A winter storm tracked northeast from the gulf coast states to off the Virginia coast. It spread a mixture of snow, sleet and some freezing rain from the lower Chesapeake Bay southwest into south central Virginia.
20 jurisdictions, including Isle of Wight	2/16/1996	Winter Storm	$0	A storm tracked northeast from western South Carolina Thursday night to off the North Carolina coast Friday morning. Then it moved off north and spread heavy snow across Virginia.
33 jurisdictions, including Isle of Wight	3/7/1996	Winter Storm	$0	A low pressure area developed over the Carolinas and then tracked off Virginia coast. It spread light snow across central and eastern Virginia.
40 jurisdictions, including Isle of Wight	12/23/1998	Ice Storm	$20,000,000	A major ice storm affected central and eastern Virginia from Wednesday into Friday. A prolonged period of freezing rain and some sleet resulted in ice accumulations of one half inch to one inch in many locations. The heavy ice accumulations on trees and power lines caused widespread power outages across the region. Approximately 400,000 customers were without power during the maximum outage period. Some customers were without power for about ten days. Many accidents occurred due to slippery road conditions, especially bridges and overpasses. Many secondary roads were impassable due to fallen tree limbs or whole trees.
25 jurisdictions, including Isle of Wight	1/19/2000	Winter Storm	$0	Two to three inches of snow fell overnight as an area of low pressure passed south of the region. The highest amounts were measured along a line from Caroline county in the north, through the city of Richmond, then along the southern shore of the James River.
7 jurisdictions, including Isle of Wight	1/25/2000	Winter Storm	$20,000	A significant winter storm dropped 8 to 12 inches of snow across portions of eastern Virginia. There was blowing and drifting of snow from winds which gusted over 40 MPH at times. The snow mixed with sleet and freezing rain occasionally during the late morning hours. In Isle of Wight County, strong winds pushed the Pagan River onto South Church Street. Isle of Wight County snowfall totaled 7 to 8 inches. NESIS Category 2

TABLE 4.14: WINTER STORM ACTIVITY (1993 - 2010)				
LOCATION	DATE OF OCCURRENCE	TYPE OF EVENT	PROPERTY DAMAGE	DETAILS
4 jurisdictions, including Isle of Wight	12/3/2000	Winter Storm	$50,000	A winter storm struck parts of extreme southern and southeastern Virginia. The storm affected a relatively small area, but the areas that had snow received some hefty totals. Windsor reported 4 inches of snowfall. Local law enforcement agencies reported scores of accidents, several of which involved injuries. Schools were closed the following day.
27 jurisdictions, including Isle of Wight	2/22/2001	Winter Storm	$0	A winter storm produced 1 to 4 inches of snow across south central and eastern Virginia. Local law enforcement agencies reported numerous accidents, some of which involved injuries. Many schools were dismissed early on the day of the storm, and several schools in the area were either closed or had a delayed opening the following day due to slippery road conditions.
18 jurisdictions, including Isle of Wight	1/2/2002	Winter Storm	$0	A winter storm produced 8 to as much as 12 inches of snow across south central and southeast Virginia. Local law enforcement agencies reported numerous accidents. Most schools in the area were closed Thursday and Friday due to very slippery road conditions.
19 jurisdictions, including Isle of Wight	12/4/2002	Winter Storm	$0	A winter storm produced 1 to 4 inches of snow along with 1/4 to 1/2 inch of ice from south central Virginia northeast through the middle peninsula and Virginia northern neck. Numerous trees and power lines were reported down due to ice accumulations, resulting in scattered power outages. Local law enforcement agencies also reported numerous accidents. Most schools in the area were closed Thursday and Friday due to power outages and very slippery road conditions.
43 jurisdictions, including Isle of Wight	1/6/2003	Winter Weather/ mix	$0	A weak winter storm produced only a dusting to 1 inch of snow across portions of central and eastern Virginia. Accumulations from this storm were mostly on cars and grassy areas, with roadways remaining generally wet although some slush was reported.
27 jurisdictions, including Isle of Wight	1/16/2003	Winter Storm	0	A winter storm produced 4 to 8 inches of snow across portions of central and eastern Virginia. Local law enforcement agencies reported numerous accidents. Most schools in the area were closed Friday due to very slippery road conditions.
12 jurisdictions, including Isle of Wight	1/23/2003	Winter Weather/ mix	$0	A winter storm produced around one inch of snow across portions of south central and southeast Virginia. Local law enforcement agencies reported several accidents.
17 jurisdictions, including Isle of Wight	2/15/2003	Winter Storm	$0	A winter storm produced 1 to 3 inches of snow, along with sleet and 1/4 to 1/2 inch of ice accumulation, across central and eastern Virginia. Local law enforcement agencies reported numerous accidents. Most schools in the area were closed Monday due to very slippery road conditions. NESIS Category 4

TABLE 4.14: WINTER STORM ACTIVITY (1993 - 2010)				
LOCATION	DATE OF OCCURRENCE	TYPE OF EVENT	PROPERTY DAMAGE	DETAILS
24 jurisdictions, including Isle of Wight	1/9/2004	Winter Storm	$0	Two to as much as five inches of snow fell across portions of central, south central, and southeast Virginia. The snow produced very slippery roadways, which resulted in several accidents.
14 jurisdictions, including Isle of Wight	1/25/2004	Winter Storm	$0	Two to as much as four inches of snow and sleet fell across portions of eastern and southeast Virginia. The snow and sleet produced very slippery roadways, which resulted in numerous accidents and school closings for a few days.
22 jurisdictions, including Isle of Wight	2/15/2004	Winter Storm	$0	One to three inches of snow fell across portions of south central and southeast Virginia. The snow produced very slippery roadways, which resulted in several accidents and school closings for a few days.
43 jurisdictions, including Isle of Wight	12/19/2004	Winter Weather/ mix	$0	One half inch to as much as three inches of snow fell across central and eastern Virginia. The snow produced slippery roadways, which resulted in several accidents.
10 jurisdictions, including Isle of Wight	12/26/2004	Winter Storm	$0	A winter storm produced a narrow band of six to as much as fourteen inches of snow across the Virginia Eastern Shore, Hampton Roads, and interior southeast Virginia. The snow caused very hazardous driving conditions, which resulted in numerous accidents. Smithfield in Isle of Wight county reported 12 inches and Isle of Wight reported 11 inches.
43 jurisdictions, including Isle of Wight	1/19/2005	Winter Weather/ mix	$0	One half inch to as much as two inches of snow fell across central and eastern Virginia. The snow produced slippery roadways, which resulted in several accidents.
41 jurisdictions, including Isle of Wight	1/20/2005	Winter Weather/ mix	$0	One half inch to as much as three inches of snow fell across much of central and eastern Virginia. The snow produced slippery roadways, which resulted in several accidents. NESIS Category 4
36 jurisdictions, including Isle of Wight	2/3/2005	Winter Weather/ mix	$0	One half inch to two inches of snow fell across much of central and eastern Virginia. A few isolated areas reported close to four inches. The snow produced slippery roadways, which resulted in several accidents. Smithfield in Isle of Wight county reported 2.3 inches of snow.
14 jurisdictions, including Isle of Wight	3/1/2009	Winter Weather	$0	Snowfall amounts were generally between one and three inches across the county. Painter reported 2.5 inches of snow. Coastal low pressure produced between one half inch and three inches of snow across portions of south central and southeast Virginia from late Sunday afternoon, March 1st, into Monday morning March 2nd. NESIS Category 1

TABLE 4.14: WINTER STORM ACTIVITY (1993 - 2010)				
LOCATION	DATE OF OCCURRENCE	TYPE OF EVENT	PROPERTY DAMAGE	DETAILS
9 jurisdictions, including Isle of Wight	2/5/2010	Winter Weather	$0	Snowfall amounts were generally between one and two inches across the county. Chesapeake (Western Branch) reported 1.3 inches of snow. Low pressure moving off the coastal Carolinas produced between one and five inches of snow across portions of south central and southeast Virginia from Friday afternoon, February 5th, through Saturday afternoon February 6th. NESIS Category 3
16 jurisdictions, including Isle of Wight	2/13/2010	Winter Weather	$0	Snowfall amounts were generally around one inch across the county. Low pressure moving off the coastal Carolinas produced between one and two inches of snow across portions of south central and southeast Virginia from Friday night, February 12th, through midday Saturday February 13th.
18 jurisdictions, including Isle of Wight	3/2/2010	Winter Weather	$0	Snowfall amounts were generally between one and two inches across the county. Chesapeake reported 1.0 inch of snow. Low pressure moving off the coastal Carolinas produced between one and three inches of snow across portions of south central and southeast Virginia from Tuesday night, March 2nd, through Wednesday morning March 3rd.
TOTAL	**24 Events**		**$20,120,000** [12]	

Source: NCDC

PROBABILITY OF FUTURE OCCURRENCES

Winter storms remain a likely occurrence for the region. While storms will be more likely to produce small amounts of snow, sleet or freezing rain, larger storms, though less frequent in occurrence, could also impact the region.

Historical evidence indicates that the Southside Hampton Roads region has been impacted by varying degrees of snow storms and ice storms over the last century. In terms of receiving measurable snowfall, the NCDC estimates that there is between 83.3 and 89.8 percent probability that the region will receive measurable snowfall in any given year (**Table 4.15**).

TABLE 4.15: PROBABILITY OF RECEIVING A MEASURABLE SNOWFALL				
JURISDICTION	ANNUAL PROBABILITY	WINTER PROBABILITY	SPRING PROBABILITY	FALL PROBABILITY
Isle of Wight	83.3%	94.1%	25.0%	4.0%
Norfolk	89.8%	88.7%	36.4%	5.5%
Portsmouth	No data	No data	No data	No data
Suffolk	No data	90.0%	63.6%	29.1%
Virginia Beach	84.0%	85.7%	23.5%	2.7%

Source: NOAA, NCDC, Snow Climatology Page, 2011

[12] Damages are based on the methodological assumption that damages were equally distributed among impacted counties. While this may not produce an exact estimate of property damage within the region, it is deemed sufficient for planning purposes within this context.

Figure 4.24 indicates the frequency with which the region will experience 3 or more days with at least 3 inches of snow. Data produced for the *Commonwealth of Virginia Hazard Mitigation Plan 2010* indicate the following frequency characteristics about winter storm characteristics for Southside Hampton Roads:

- 1.5 or fewer days per year with at least 3 inches of snow;
- 0.5 or fewer days per year with at least 6 inches of snow; and,
- 3 or fewer days per year entirely at or below 32°F.

Figure 4.24: Frequency of 3 or more days with at least 3 inches of snow