

CHAPTER 15. SEVERE WEATHER

15.1 GENERAL BACKGROUND

Western Washington has a predominantly marine climate. Two key factors affect the state's climate:

- **Mountain ranges**—The Olympic Mountains and the Cascade Mountains affect rainfall. The first major release of rain in weather systems coming off the Pacific Ocean occurs along the west slopes of the Olympics, and the second is along the west slopes of the Cascade Range. Air warms and dries as it descends along the eastern slopes of the Cascades, resulting in near desert conditions in the lowest section of the Columbia Basin in eastern Washington.
- **Semi-permanent high- and low-pressure areas over the North Pacific Ocean**—During summer and fall, the circulation of air around a high-pressure area over the North Pacific brings a prevailing westerly and northwesterly flow of comparatively dry, cool and stable air into the Pacific Northwest. As the air moves inland, it becomes warmer and drier, resulting in a dry season. In the winter and spring, the high pressure is further south and low pressure prevails in the Northeast Pacific. Circulation of air around both pressure centers brings a prevailing southwesterly and westerly flow of mild, moist air into the Pacific Northwest. Condensation occurs as the air moves inland over the cooler land and rises along the windward slopes of the mountains. This results in a wet season beginning in late October or November, reaching a peak in winter, and gradually decreasing by late spring.

West of the Cascade Mountains, summers are cool and relatively dry and winters are mild, wet and generally cloudy. Measurable rainfall occurs on 150 days each year in interior valleys and on 190 days in the mountains and along the coast. Thunderstorms occur up to 10 days each year over the lower elevations and up to 15 days over the mountains. Damaging hailstorms are rare in Western Washington. During July and August, the driest months, two to four weeks can pass with only a few showers; however, in December and January, the wettest months,

DEFINITIONS

Freezing Rain—The result of rain occurring when the temperature is below the freezing point. The rain freezes on impact, resulting in a layer of glaze ice up to an inch thick. In a severe ice storm, an evergreen tree 60 feet high and 30 feet wide can be burdened with up to six tons of ice, creating a threat to power and telephone lines and transportation routes.

Severe Local Storm—“Microscale” atmospheric systems, including tornadoes, thunderstorms, windstorms, ice storms and snowstorms. Typically, major impacts from a severe storm are on transportation infrastructure and utilities. These storms may cause a great deal of destruction and even death, but their impact is generally confined to a small area.

Thunderstorm—Typically 15 miles in diameter and lasting about 30 minutes, thunderstorms are underrated hazards. Lightning, which occurs with all thunderstorms, is a serious threat to human life. Heavy rains over a small area in a short time can lead to flash flooding. Strong winds, hail and tornadoes are also dangers associated with thunderstorms.

Tornado—Funnel clouds that generate winds up to 500 miles per hour. They can affect an area up to three-quarters of a mile wide, with a path of varying length. Tornadoes can come from lines of cumulonimbus clouds or from a single storm cloud. They are measured using the Fujita Scale, ranging from F0 to F6.

Windstorm—A storm featuring violent winds. Southwesterly winds are associated with strong storms moving onto the coast from the Pacific Ocean. Southern winds parallel to the coastal mountains are the strongest and most destructive winds. Windstorms tend to damage ridgelines that face into the winds.

Winter Storm—A storm having significant snowfall, ice, and/or freezing rain; the quantity of precipitation varies by elevation.

precipitation is frequently recorded on 25 days or more each month. Snowfall is light in the lower elevations and heavy in the mountains. During the wet season, rainfall is usually of light to moderate intensity and continuous over a long period rather than occurring in heavy downpours for brief periods; heavier intensities occur along the windward slopes of the mountains.

The strongest winds are generally from the south or southwest and occur during fall and winter. In interior valleys, wind velocities reach 40 to 50 mph each winter, and 75 to 90 mph a few times every 50 years. The highest summer and lowest winter temperatures generally occur during periods of easterly winds.

15.2 HAZARD PROFILE

15.2.1 Past Events

Table 15-1 summarizes severe weather events in Snohomish County since 1970, as recorded by the National Oceanic and Atmospheric Administration. In addition to the events listed, notable windstorms in Snohomish County occurred in 1976, 1979, 1981, 1993 and 2006. Power outages from the Inauguration Day windstorm of January 20, 1993 lasted from three to five days. The most powerful windstorm since the Inauguration Day Storm of 1993 was in December 2006, with gusts up to 70 mph in the Puget Sound basin. Severe snowstorms occurred in the planning area in 1969, 1971, 1980, and 2009.

Date	Type	Deaths or Injuries	Property Damage
11/24/1970	Tornado (F2)	0	\$25,000
10/26/1971	Tornado (F1)	0	\$25,000
04/28/1976	Thunderstorm Wind	0	\$5,000
05/13/1986	Tornado (F2)	0	\$7,500
09/09/1988	Thunderstorm Wind	0	0
10/27/1994	Funnel Cloud	0	0
<i>Description: A funnel cloud was reported west of Paine Field, near Everett.</i>			
09/15/1996	Lightning	1	0
<i>Description: A 14 year old boy was struck by lightning while standing under a tree, next to his dirt bike in Marysville.</i>			
04/10/1997	Lightning	0	\$35,000
<i>Description: A lightning strike, which hit a house and a tree, peeled the bark off the tree, cracked a concrete patio, broke several windows and damaged electrical outlets and a natural gas line. It also damaged several appliances and parts of the drywall in the house.</i>			
05/31/1997	Funnel Cloud	0	0
<i>Description: A funnel cloud was detected on radar and observed by a spotter northeast of Lake Stevens. Showers and thunderstorms dropped a record 1.41 inches of rain at SeaTac airport for 24 hours on this day.</i>			
08/06/1997	Lightning	1	0
<i>Description: Two people were struck by lightning. Only one was injured with burns on his leg. Lightning also damaged a church furnace and split trees. Power was knocked out to about 1000 customers.</i>			
08/24/1997	Tornado (F0)	0	\$2,500
<i>Description: A weak tornado damaged a barn.</i>			

**TABLE 15-1 (continued).
SEVERE WEATHER EVENTS IN SNOHOMISH COUNTY SINCE 1970**

Date	Type	Deaths or Injuries	Property Damage
12/08/1997	Funnel Cloud	0	0
<i>Description: A funnel cloud was spotted by two members of the public and a police cadet.</i>			
06/08/1998	Lightning	0	0
<i>Description: Lightning struck the roof of a county courthouse complex, damaging parts of computers and the counties telephone network. Lightning also struck transformers on three power poles.</i>			
08/03/1999	Lightning	0	0
<i>Description: Over 1000 lightning strikes were recorded in a four hour period. One man was struck by lightning while standing under a tree, and another man while standing in water next to his boat. At its peak the storm knocked out power to about 20,000 customers.</i>			
04/22/2000	Funnel Cloud	0	0
<i>Description: A cold air funnel dropped down to about 2,000 feet above ground level from a cloud deck about 4,000 feet above ground level</i>			
03/13/2001	Hail	0	0
<i>Description: There was little damage with the severe thunderstorm that hit Snohomish county. 700 customers in Monroe lost power for about 2 hours.</i>			
05/28/2004	Funnel Cloud	0	0
<i>Description: A funnel cloud, lasting less than a minute, was spotted near Mill Creek.</i>			
06/05/2004	Tornado (F0)	0	0
<i>Description: A tornado briefly touched down on I-5 just south of the Stanwood exit.</i>			
09/01/2004	Lightning	0	\$5,000
<i>Description: A lightning strike destroyed a tree and fried the electrical system in the nearby home.</i>			
05/18/2005	Tornado (F1)	0	\$6,000
<i>Description: A tornado was on the ground near Lake Ki for about a minute. It snapped a cedar tree that collapsed a car port and fell on a roof.</i>			
05/19/2005	Hail	0	\$50,000 (Crop Damage)
<i>Description: Small hail pelted the ground for about 15 minutes. It destroyed almost all the lettuce and spinach, and most of the mixed vegetables that were due for harvest at a local farm.</i>			
06/21/2005	Thunderstorm Wind	0	0
<i>Description: Several trees were downed over State Route 530 and a hiker near the area reported "giant" hail.</i>			
09/09/2005	Lightning	0	\$2,000
<i>Description: A lightning strike blew a small hole in a house and damaged some electrical outlets.</i>			
10/01/2005	Lightning	0	\$2,000
<i>Description: 3 lightning strikes knocked out power to nearly 6000 homes in the Edmonds area. One strike ruptured a natural gas line, which started a small fire.</i>			
04/15/2006	Hail	0	0
06/16/2006	Tornado (F0)	0	0
<i>Description: Tornado stayed on ground for about a minute. No damage.</i>			
04/24/2007	Funnel Cloud	0	0
<i>Description: A funnel cloud was sighted over Puget Sound west of Everett for 3 minutes.</i>			
11/04/2008	Lightning	0	\$25,000
<i>Description: A lightning strike started a fire that scorched a few nearby trees, and damaged a garage and storage shed near a home in Edmonds.</i>			

15.2.2 Location

Severe weather events have the potential to happen anywhere in the planning area. Communities in low-lying areas next to streams or lakes are more susceptible to flooding. Wind events are most damaging to areas that are heavily wooded. Maps 15-1, 15-2, 15-3 and 15-4 show the distribution of average weather conditions over the Snohomish County planning Area.

15.2.3 Frequency

According to the Washington State Enhanced Hazard Mitigation Plan, Snohomish County experiences at least one high wind event every year. The state plan indicates a 58 percent probability that Snohomish County will have a severe winter storm at least once every two years.

15.2.4 Severity

The effects on Snohomish County of a strong thunderstorm, tornado, windstorm or ice storm are likely to be similar: fallen trees, downed power lines and interruption of transportation lifelines, damaged homes and public buildings. Weather-related fatalities are uncommon in western Washington, but they can occur. The most common problems associated with severe storms are immobility and loss of utilities. Roads may become impassable due to ice or snow, or from a secondary hazard such as a landslide. Power lines may be downed due to high winds and other services, such as water or phone, may not be able to operate without power. Lightning can cause severe damage and can be deadly. The following is a summary of recorded or potential extreme weather conditions:

- **Rain**—SeaTac Airport reported 5.02 inches of rain in a 24-hour period. This rain event caused flooding problems for several homes as well as the closure of some sections of road.
- **Tornado**—A tornado is formed by the turbulent mixing of layers of air with contrasting temperature, moisture, density and wind flow. This mixing accounts for most of the tornadoes occurring in April, May and June, when cold, dry air moving into the Puget Sound region from the north or northwest meets warm, moister air moving up from the south. If a major tornado were to strike a populated area in Snohomish County, damage could be widespread. Businesses could be forced to close for an extended period or permanently, fatalities could be high, many people could be homeless for an extended period, and routine services could be disrupted. Some buildings could be damaged or destroyed. Due to the often short warning period, livestock are commonly the victims of a tornado or windstorm.
- **Ice and Snow**—The effects of an ice storm or snowstorm are downed power lines and trees, a large increase in traffic accidents, collapse of structures due to heavy snow load on roofs, and frozen pipes. These storms can cause death by exposure, heart failure due to shoveling or other strenuous activity, traffic accidents (over 85 percent of ice storm deaths are caused by traffic accidents), and carbon monoxide poisoning. They have the potential to cause large losses among livestock (primarily by dehydration rather than cold or suffocation). The National Weather Service defines a winter storm as having significant snowfall, ice, or freezing rain. Heavy snowfall is 4 inches or more in a 12-hour period, or 6 inches or more in a 24-hour period in non-mountainous areas; and 12 inches or more in a 12-hour period or 18 inches or more in a 24-hour period in mountainous areas.
- **Wind**—The National Weather Service defines high winds as sustained winds of 40 mph or gusts of 58 mph or greater, not caused by thunderstorms and expected to last for an hour or more. Although windstorms are not a frequent problem in Snohomish County they have been known to cause substantial damage. The predicted wind speed given in wind warnings issued by the National Weather Service is for a one-minute average; gusts may be 25 to 30 percent higher. Under most conditions the County's highest winds come from the southeast, although

they have been known to blow from the south or southwest. The highest recorded wind gust in the Everett area was more than 81 miles per hour.

15.2.5 Warning Time

Meteorologists can often predict the likelihood of a severe storm. This can give several days of warning time. However, meteorologists cannot predict the exact time of onset or severity of the storm. Some storms may come on more quickly and have only a few hours of warning time.

15.3 SECONDARY HAZARDS

The most significant secondary hazards associated with severe local storms are floods, falling and downed trees, landslides and downed power lines. Rapidly melting snow combined with heavy rain can overwhelm both natural and man-made drainage systems, causing overflow and property destruction. Landslides occur when the soil on slopes becomes oversaturated and fails.

15.4 CLIMATE CHANGE IMPACTS

Climate change presents a significant challenge for risk management associated with extreme weather. The frequency of extreme weather events has increased steadily over the last century. The number of weather-related disasters during the 1990s was four times that of the 1950s, and cost 14 times as much in economic losses. Historical data shows that the probability for severe weather events increases in a warmer climate (see Figure 15-1). The changing hydrograph caused by climate change could have a significant impact on the intensity, duration and frequency of storm events. All of these impacts could have significant economic consequences.

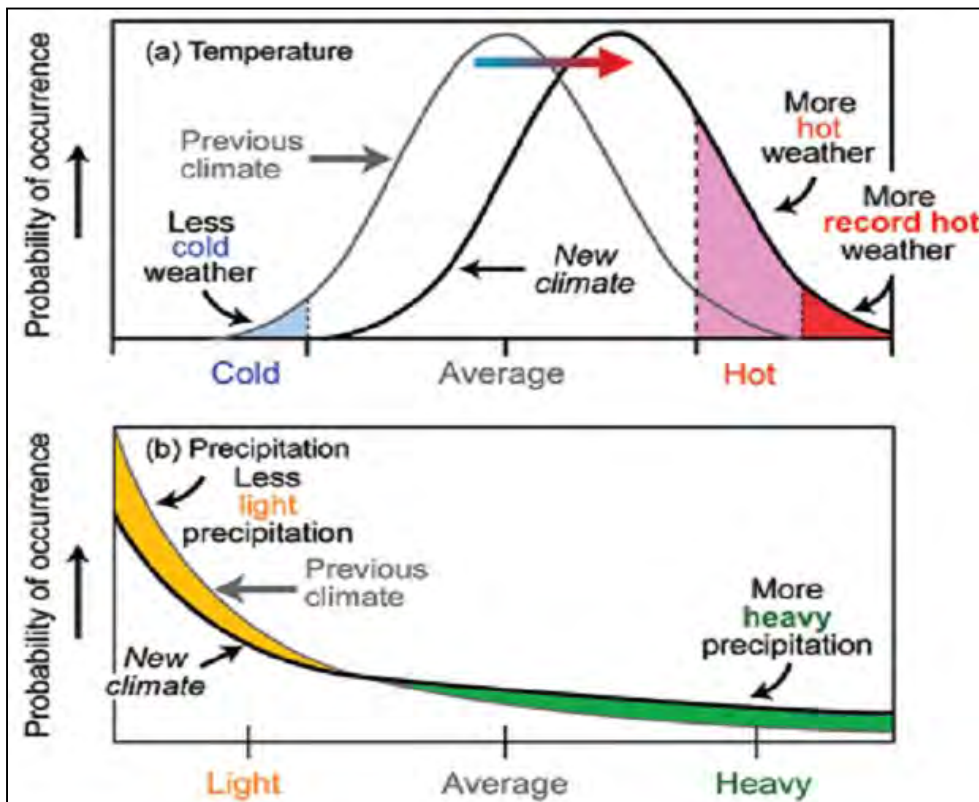


Figure 15-1. Severe Weather Probabilities in Warmer Climates

15.5 EXPOSURE

15.5.1 Population

A lack of data separating severe weather damage from flooding and landslide damage prevented a detailed analysis for exposure and vulnerability. However, it can be assumed that the entire county is exposed to some extent to severe weather events. Certain areas are more exposed due to geographic location and localized weather patterns. Populations living at higher elevations with large stands of trees or power lines may be more susceptible to wind damage and black out, while populations living in low lying areas are at risk for possible flooding.

15.5.2 Property

According to the Snohomish County Assessor, there are 235,928 buildings within the census tracts that define the planning area. Most of these buildings are residential. It is estimated that 20 percent of the residential structures were built without the influence of a structure building code with provisions for wind or snow loads. All of these buildings are considered to be exposed to the severe weather hazard, but structures in poor condition or in particularly vulnerable locations (such as near Puget Sound) may risk the most damage. The frequency and degree of damage will depend on specific locations.

15.5.3 Critical Facilities and Infrastructure

All critical facilities exposed to flooding (Chapter 13) are also likely exposed to severe weather. Additional facilities on higher ground may also be exposed to wind damage or damage from falling trees. The most common problems associated with severe weather are loss of utilities. Downed power lines can cause blackouts, leaving large areas isolated. Consequently phone, water and sewer systems may not function. Roads may become impassable due to ice or snow or from secondary hazards such as landslides.

15.5.4 Environment

The environment is highly exposed to severe weather events in Snohomish County. Severe storm events can drastically affect the physical environment, changing natural landscapes and affecting property and people. Natural habitats such as streams and trees are exposed to the elements during a severe storm and risk major damage and destruction. Prolonged rains can saturate soils and lead to slope failure. Flooding events caused by severe weather can produce channel migration affecting property. Storm surges can erode beachfront bluffs and redistribute sediment loads. Severe local storms can have significant effects on the environment. Heavy rains will cause the ground to become saturated, and rivers and streams to rise. This will result in the potential for flooding and landslides. Additionally, snowmelt after snowstorms can cause riverine flooding, which has the potential to damage riparian habitat.

15.6 VULNERABILITY

15.6.1 Population

Vulnerable populations are the elderly, low income or linguistically isolated populations, people with life-threatening illnesses, and residents living in areas that are isolated from major roads. Power outages can be life threatening to those dependent on electricity for life support. Isolation of these populations is a significant concern. These populations face isolation and exposure during severe weather events and could suffer more secondary effects of the hazard.

15.6.2 Property

All property is vulnerable during severe weather events, but properties in poor condition or in particularly vulnerable locations may risk the most damage. Those in higher elevations and on ridges may be more prone to wind damage. Those that are located under or near overhead lines or near large trees may be vulnerable to falling ice or may be damaged in the event of a collapse.

There are currently no generally accepted damage function values for estimating damage from severe storm events. This can be attributed to the variety of impacts that severe weather events generate and the variation of severity with location. There are too many intangible components to consider in establishing regional damage functions. For the purposes of this risk assessment, a damage function was established by looking at reported state-wide damages from the December 1996 winter storms (DR-1159) and the December 14, 2006 windstorm (DR-1682) and comparing those numbers to assessed building values in the communities that reported damages. It was determined that the average damage from this event was between 15 and 24 percent percent of the assessed value for buildings in the affected areas. To estimate vulnerability for planning purposes, an 18-percent damage function ratio was applied to the building stock for each planning partner. These values are presented in Table 15-2.

Jurisdiction	Assessed Building Value	Estimated Damage
Arlington	\$2,247,404,600	\$404,532,828
Bothell	\$2,936,385,360	\$528,549,365
Brier	\$672,468,450	\$121,044,321
Darrington	\$138,104,890	\$24,858,880
Edmonds	\$6,564,104,540	\$1,181,538,817
Everett	\$16,026,290,740	\$2,884,732,333
Gold Bar	\$175,439,420	\$31,579,096
Granite Falls	\$410,145,815	\$73,826,247
Index	\$23,149,310	\$4,166,876
Lake Stevens	\$1,561,434,060	\$281,058,131
Lynnwood	\$5,532,735,484	\$995,892,387
Marysville	\$4,170,848,400	\$750,752,712
Mill Creek	\$3,101,222,600	\$558,220,068
Monroe	\$2,275,095,630	\$409,517,213
Mountlake Terrace	\$2,149,016,050	\$386,822,889
Mukilteo	\$3,969,143,970	\$714,445,915
Snohomish	\$1,243,558,280	\$223,840,490
Stanwood	\$945,661,570	\$170,219,083
Sultan	\$483,837,280	\$87,090,710
Woodway	\$364,685,960	\$65,643,473
Arlington	\$2,247,404,600	\$404,532,828
Unincorporated County	\$38,540,998,340	\$6,937,379,701
Total	\$95,779,135,349	\$17,240,244,363

These estimates are based on a past occurrence, and may be understated or overstated compared to future events. However, they represent the best available information at this time and can be used by the planning partners to rank risk and establish mitigation priorities. As new science and technology become available specific to severe weather events, this vulnerability assessment should be updated. The vulnerability assessments for hazards that are secondary effects of severe weather events (e.g., flooding, landslides or wildland fires) can provide a further gage of the economic impact of severe weather events.

15.6.3 Critical Facilities and Infrastructure

Incapacity and loss of roads are the primary transportation failures, most of which are associated with secondary hazards. Events such as landslides that block roads are caused by heavy prolonged rains. High winds can cause significant damage to trees and power lines, blocking roads with obstructing debris, incapacitating transportation, isolating population, and disrupting ingress and egress. Snowstorms in higher elevations can significantly impact the transportation system and the availability of public safety services. Of particular concern are roads providing access to isolated areas and to the elderly.

Prolonged obstruction of major routes due to landslides, snow, debris or floodwaters can disrupt the shipment of goods and other commerce. Large and prolonged storms can have negative economic impacts for an entire region.

Severe windstorms, downed trees, and ice can create serious impacts on power and above-ground communication lines. Freezing of power and communication lines can cause them to break, disrupting electricity and communication for households. Loss of electricity and phone connection would leave certain populations isolated because residents would be unable to call for assistance.

15.6.4 Environment

Severe storm events can drastically affect the physical environment, changing natural landscapes and affecting property and people. Prolonged rains can saturate soils and lead to slope failure. Flooding events caused by severe weather can produce channel migration affecting property. Storm surges can erode beachfront bluffs and redistribute sediment loads. Severe local storms can have significant effects on the environment. Heavy rains will cause the ground to become saturated, and rivers and streams to rise. This will result in the potential for flooding and landslides. Additionally, snowmelt after snowstorms can cause riverine flooding, which has the potential to damage riparian habitat.

15.7 FUTURE TRENDS IN DEVELOPMENT

All future development will be affected by severe storms. The ability to withstand impacts lies in sound land use practices and consistent enforcement of codes and regulations for new construction. The County and City planning partners have adopted the International Building Code in response to Washington State mandates. This code is equipped to deal with the impacts of severe weather events. Land use policies identified in comprehensive plans within the planning area also address many of the secondary impacts (flood and landslide) of the severe weather hazard. Equipped with these tools, the planning partnership is well equipped to deal with future growth and the associated impacts of severe weather.

15.8 SCENARIO

Although severe local storms are infrequent, impacts can be significant, particularly when secondary hazards of flood and landslide occur. A worst-case event would involve prolonged high winds during a snowstorm accompanied by freezing temperatures, followed by warmer weather and continued rain. Such an event would have both short-term and longer-term effects. Initially, schools and roads would be closed due to snow and downed tree obstructions. Power outages would be common throughout the county. In

more rural areas, some subdivisions could experience limited ingress and egress. Later, as the weather warms and snow turns to rain, the sudden run-off could produce flooding, overtopped culverts with ponded water on roads, and landslides on steep slopes. Flooding and landslides could further obstruct roads and bridges, further isolating residents.

The most common severe storm system in Snohomish County usually occurs between early November and late February, bringing long periods of warm rainfall and mild temperatures following fairly heavy low-level snow. These storm patterns can cause widespread flooding and county-wide impacts, slowing response because services cannot be concentrated

15.9 ISSUES

In general, every household and resident in the county is likely to be exposed to severe weather, but some are more likely than others to experience isolation as a result. Those residing in higher elevations with limited transportation routes may have the greatest vulnerability to isolation from storms. Another group at risk is the portion of the county population that is over the age of 65. Important issues associated with a severe weather in the Snohomish County planning area include but are not limited to the following:

- The older building stock within the planning area is built to low code standards or none at all. These structures could be highly vulnerable to severe weather events such as windstorms.
- Redundancy of power supply must be evaluated.
- The capacity for backup power generation is limited.
- The County's capacity to deal with snow and ice removal is limited and reliant on outside sources.
- There are isolated population centers in the eastern portions of the County.

