Introduction

Avalanche hazards in the Northwest are associated with winter storms in the Cascade and Olympic Mountain ranges. Avalanches occur when a snow pack loses its grip on a slope and slides downhill. Typically, slopes of between 20 to 30 degrees and snow packs of 34 inches or more may produce avalanches.[1]

There are two kinds of avalanches, loose and slab. Loose avalanches occur when light-grained snow exceeds its angle of repose, collapses a snow drift or bank and fans out as it slides downhill. A slab avalanche occurs when heavy or melting snow resting on top of looser snow breaks away from the slope and moves in a mass. The latter often occurs when rains soak the top layer of snow on moderately sloped terrain.

The factors that cause avalanches are numerous and complex. Scott Kruse lists twelve common factors: old snow depth, old snow surface, new snow depth, new snow type, snow density, snow fall intensity, precipitation intensity, settlement, wind direction and wind speed, temperature, subsurface snow crystal structure, and tidal effect.[2] Research done at Snoqualmie Pass indicates that most natural avalanches occur within one hour after the onset of rain over a weakened snow pack.[3]

High Probability Low Impact	**High Probability Moderate Impact**	**High Probability High Impact**
Moderate Probability Low Impact	**Moderate Probability Moderate Impact**	**Moderate Probability High Impact**
Low Probability Low Impact	**Low Probability Moderate Impact**	**Low Probability High Impact**

Avalanche Probability vs. Avalanche Impact

A variety of mitigation efforts have significantly reduced the potential impact on humans and property. See “History of Mitigation Efforts.”

Hazard Identification

Avalanche danger is highest during severe winter weather. It is also true that most natural avalanches occur in back country little used by humans during such weather conditions. This tends to minimize exposure to avalanche impacts. Most at risk are travelers and winter recreation enthusiasts using Steven’s Pass in northern King County, Snoqualmie Pass in central King County, and Crystal Mountain Ski Area near Chinook Pass in southern King

County. Recreational areas that support snowshoeing, alpine and cross-country skiing, snowmobile areas, and winter hikers and campers are most at risk from avalanche events. Typically, injuries to recreational hikers, skiers, snow boarders, and climbers occur outside managed areas.

Several stretches of Interstate 90 and Highway 2 in King County are vulnerable to avalanches between November and May each year, depending on snow packs and weather conditions.

Both Snoqualmie and Steven's Pass are significant commercial routes. Cargos are carried between the Ports of Tacoma and Seattle, and eastern Washington. When Stevens and Snoqualmie Passes are closed, air travel is the only practical way to travel between Spokane and Seattle.

History of Events

The most significant avalanche event in Washington State occurred in 1910 near Steven's Pass. A train carrying passengers was hit by an avalanche killing 96 people.[4] The table below represents recent and significant avalanche events in King County.

Table 5-3: Avalanche History

Year	Location	Impact
1910	Steven's Pass[5]	96 killed
1962	Steven's Pass	2 buried
1966	Snoqualmie Pass	1 buried
1971	Snoqualmie Pass	1 killed
1993	Snoqualmie Pass	5 injured
1994	Steven's Pass	11 injured
1996	Snoqualmie Pass	2 buried
1996	Alpental (Snoqualmie Pass)	2 dead
1996-97	Snoqualmie Pass, I-90	Repeated closure of Pass, stranding travelers several days
2002	Snoqualmie	I-90 road closures lasting multiple days

Source: Washington State Emergency Management Division, Hazard Identification and Vulnerability Analysis, June 1996.

Periodically each winter season, Snoqualmie and Stevens Passes both close for several hours for avalanche control measures. During the 2002-03 winter season, there were 30 deaths from avalanches in Washington State. Un-inhabited alpine areas in the Cascades north and south of I-90 experience hundreds of avalanches annually.[6]

Hazard Impacts

Impacts on King County from avalanche closures of Snoqualmie Pass include economic impacts to the Port of Seattle, ski areas, and the cities of Snoqualmie, North Bend, Skykomish, and Issaquah. Motorists and truckers are often re-routed through Interstate 84 in Portland.[7] Stranded motorists occupied shelters and hotel space in Snoqualmie, North Bend, Issaquah and Bellevue. During the winter of 1996-97, I-90 was closed for 276 hours. The later closures cost the State of Washington an estimated 144 million dollars (2002).[8]

Past Mitigation Efforts

Avalanche research began in the mid-1940s. By 1952 Stevens Pass was one of three research stations in the United States. The use of artillery for avalanche control was one of the developments of that research. Washington State Department of Transportation (WSDOT) is responsible for avalanche control. The WS DOT snow and ice removal budget was $20,000,000 in 1996, the most recent available data provided.[8] This money has been used to control avalanche hazards along major roadways. The roadway covering along I-90 near Snoqualmie and the 7.8 mile tunnel at Stevens Pass was constructed to protect rail lines from avalanches in 1929.[3] The National Weather Service Avalanche Center provides reports on avalanche conditions and issues advisories.

Avalanche Endnotes

[1] Washington State Department of Transportation, Prediction of Snow and Avalanches in Maritime Climates: Final Report, WA-RD 203.1, December 1989, p.3.
[2] Avalanche Evaluation Check List by Scott M. Kruse in the Avalanche Review vol. 8, No 4, February 1990
[3] Washington State Department of Transportation, Prediction of Snow and Avalanches in Maritime Climates: Final Report, WA-RD 203.1, December 1989, p.1.
[4] Description of the Wellington (Stevens Pass) avalanche, www.Northwestrailfan.com/scenic
[5] "In mountains, experience sometimes isn't enough" by Joe Nabbefeld, Seattle Times, December 27, 1996, p. B1
[6] "Cold Snap May Help Situation in Passes" by Richard Seven, Seattle Times, February 11, 1990, p. A1
[7] Washington State Emergency Management Division, Hazard Identification and Vulnerability Analysis, draft, May 2003
[8] Washington State Emergency Management Division, Hazard Identification and Vulnerability Analysis, June 1996, P. A2