# 2015 Snohomish County Hazard Mitigation Plan Update

Public Workshop

Hazards and Risks Information

## Overall County Hazards Ranking

1. Earthquake
2. Severe Weather
3. Flooding
4. Landslide & Mass Movements
5. Climate Change
6. Dam Failure
7. Tsunami/Seiche
8. Wildland Fire
9. Avalanche & Volcano
10. Hazardous Materials – Tier II/ Pipelines
11. Levy Failure

## Overall County Impacts Ranking

1. Resilience of infrastructure
2. Reliability of local emergency operations
3. Vulnerability of structures
4. Insufficient warning of damaging events
5. Disruption of local government operations
6. Cost-effectiveness of mitigation projects
7. Isolation & Insufficient incentives for hazards mitigation
8. Insufficient actionable risk reduction information available to public
9. Threats posed by competing floodplain management and agricultural objectives
10. Threatened natural values (ecosystem goods and services)
11. Reduced available open space
12. Reduce the adverse impact of disasters on isolated communities.
13. Reduce the adverse impacts, and exploit beneficial functions, of natural hazards to resource lands.

# Snohomish County Hazards Overview

Hazards were based on the 2010 Snohomish County Natural Hazard Mitigation Plan and then updated by the 2015 Hazard Mitigation Plan Planning Committee. Additional hazards addressed in the 2015 plan include hazardous materials/pipelines and levee failure.

## Avalanche

- Avalanches occur when stress on a snowpack exceeds the strength of the snowpack. Most avalanches are naturally triggered, where the weather (wind, snow, rain or sun) stress the snowpack to its breaking point.
- Although most avalanches are naturally triggered, in 92 percent of avalanche accidents the avalanche is triggered by the victim or someone in the victim's party.
- Avalanches can occur whenever a sufficient depth of snow is deposited on slopes steeper than about 20 degrees, with the most dangerous coming from slopes in the 35- to 40-degree range.
- Although terrain features, weather conditions and snow pack profiles can indicate areas of higher risk, avalanches can occur with little or no warning.
- Avalanches regularly close SR-2 above Index, as well as many of the smaller access roads at higher elevations.
- The rise in winter recreation has increased the number of people exposed to avalanches.
- Critical facilities in the county exposed to avalanches include SR 2 and the BNSF railroad.
- The Northwest Avalanche Center (NWAC) is a regional source of information on avalanche danger that can be accessed via the internet.

## Dam/Levee Failure

- Dam and levee failures are uncontrolled releases of water due to structural deficiencies.
- High risk dams in the Snohomish County, which with failure would likely cause fatalities, include:
    - Cedar Way Stormwater Detention Dam on Lyons Creek
    - Chaplin lake North Dam on Woods Creek
    - Chaplin Lake South Dam on Chaplin Creek
    - Culmback Dam on the Sultan River
    - Everett Reservoir #3 on Pigion Creek

  - Tolt River Dam on the South Fork of the Tolt River

- At this time, dam owner Emergency Action Plans that include dam failure inundation mapping are not available for every dam in the County. Inundation data are available for the Culmback Dam and Tolt Dam.

- Warning time for dam or levee failure can vary depending on the cause of failure. Large floods due to precipitation and snow melt can often be anticipated, giving time for evacuation if structure failure is anticipated. Also, dams and levees tend not to fail completely or instantaneously.

- More flooding, which is anticipated with climate change, increases the risk of spillway releases from dams and structural failure of levees.

## Earthquake

- Earthquakes are a shaking of the ground caused by an abrupt shift of rock along a fracture in the earth or a contact zone between tectonic plates. Earthquakes are typically measured in both magnitude and intensity.

- There are three types of earthquakes in the region:

  - Cascade Subduction Zone – inter-plate movement

  - Benioff – deep intra-plate movement

  - Shallow "Crustal" zone movement

- Earthquakes are common in the region. Between January 2010 and August 2014 the Puget Sound region experienced 21 earthquakes of a 3.0 magnitude or greater. With the strongest having a 3.9 magnitude.

- Snohomish County is in an active seismic zone, with South Whidbey Island fault, the Devil's Mountain fault and possibly the Everett fault presenting the greatest risks to county residents.

- The USGS estimated that a Cascadia Subduction Zone earthquake has a 10 to 15 percent probability of occurrence in 50 years, and has a recurrence interval of about 500 to 600 years. In general, it is difficult to estimate the probability of occurrence of crustal earthquake events. Earthquakes on the South Whidbey Island and Seattle Faults have a 2 percent probability of occurrence in 50 years. A Benioff zone earthquake has an 85 percent probability of occurrence in 50 years, making it the most likely of the three types.

- There is no reliable way to predict a day or more in advance that an earthquake will occur. However, new warning systems may be able to provide approximately 40 seconds notice prior to a large earthquake.

- Intensity experienced depends on strength of earthquake, geological substrate, and distance from source.

- Vulnerability is greater for unreinforced masonry and concrete structures, and buildings built before 1994.

- Snohomish County is running scenarios to estimate the potential impacts from a South Whidbey Island Fault and a Devil's Mountain Fault.

- Earthquakes in the region outside of the county could also impact Snohomish County as regional transportation, electrical and communications networks could be disrupted.

- A flood is the inundation of normally dry land resulting from the rising and overflowing of a body of water. A floodplain is the land area along the sides of a river that becomes inundated with water during a flood.

- A 100-year floodplain is the area flooded that has a 1-percent chance of being equaled or exceeded each year. This is a statistical average only; in fact, a 100-year flood can occur more than once in a short period of time. The 1-percent annual chance flood is the standard used by most federal and state agencies.

- Flooding is the natural hazard of most concern in Washington and affects lives in the state every winter and spring. Flood monitoring, forecasting, and warning methods allow for planning of responses to potential floods, but flood-inundation maps needed by local planning agencies to assess flooding and floodplain issues are seriously outdated. Flood frequency and magnitude are the basis for many planning decisions, but limited databases and changing conditions make determination of 100-year floods and other frequency discharges an uncertain science.

- Human activities tend to concentrate in floodplains for a number of reasons: water is readily available; land is fertile and suitable for farming; transportation by water is easily accessible; and land is flatter and easier to develop. But human activity in floodplains frequently interferes with the natural function of floodplains. It can affect the distribution and timing of drainage, thereby increasing flood problems. Human development can create local flooding problems by altering or confining drainage channels. This increases flood potential in two ways: it reduces the stream's capacity to contain flows, and it increases flow rates or velocities downstream during all stages of a flood event.

- The National Flood Insurance Program (NFIP) makes federally backed flood insurance available to homeowners, renters, and business owners in communities participating in the program.

- Currently, 20 jurisdictions in Snohomish County participate in the NFIP. Participants in the NFIP must, at a minimum, regulate development in floodplain areas in accordance with NFIP criteria. Before issuing a permit to build in a floodplain, participating jurisdictions must ensure that three criteria are met:
    - New buildings and developments undergoing substantial improvements must, at a minimum, be elevated to protect against damage by the 100-year flood.
    - New floodplain developments must not aggravate existing flood problems or increase damage to other properties.
    - New floodplain development must exercise a reasonable and prudent effort to reduce its adverse impacts on threatened salmonid species, per the biological opinion issued by the National Marine Fisheries Service.

- Snohomish County and all participating cities in the planning area are currently in compliance and good standing with the provisions of the NFIP. The current effective date for the countywide FIRM is September 16, 2005.

- Preliminary Digital Flood Insurance Maps (DFIRMs) were released in 2010, however their adoption has been put on hold pending FEMA's resolution of the levee and analysis and mapping approach. The DFIRMs, when adopted, are expected to more accurately depict special flood hazard areas and floodways.

- The Community Rating System (CRS) is a voluntary incentive program that offers discounted flood insurance premiums to encourage floodplain management activities beyond the minimum NFIP

requirements. CRS class ratings are assigned to participating communities based on 18 activities in the following categories:
  - Public information
  - Mapping and regulations
  - Flood damage reduction
  - Flood preparedness

- In Snohomish County, the Cities of Monroe and Sultan, and the Town of Index are currently participating in the CRS program.

- Winter floods occur in most of the County's floodplains every 2 to 5 years. Major floods on rivers and streams within Snohomish County are caused by rainstorms between October and March. Though floodwaters are primarily from rainfall, they are often augmented by snowmelt.

- The potential for flooding in low-lying coastal areas exists when favorable atmospheric conditions (i.e., very low pressure) occur simultaneously with periods of unusually high tides. No significant damage has been experienced in Snohomish County in the recent past due to tidal flooding. Storm surges, also known as storm tides, can affect a number of beachfront areas in the County. Generally, storm surges are caused by an increase in the usual tide level by a combination of low atmospheric pressure and onshore winds. During a storm surge, tides may run 2 to 4 feet above the predicted tide level.

- Storm surges can usually be predicted up to 12 hours before occurrence; however, only an approximate height can be predicted because of the large number of variables.

- The effects of a storm surge generally range from saltwater inundation to the battering of beachhead property by water driven debris. The beachfront areas in Snohomish County most likely to receive storm surge damage are near Mukilteo, Marysville, the Tulalip Reservation, Hat Island and Stanwood.

- The two key factors that contribute to urban flooding are rainfall intensity and duration. Topography, soil conditions, urbanization and groundcover also play an important role. Urban flooding occurs when available conveyance systems lack the capacity to convey rainfall runoff to nearby creeks, streams and rivers. As drainage facilities are overwhelmed, roads and transportation corridors become conveyance facilities.

- According to University of Washington scientists using moderate emissions scenarios, global climate changes resulting in warmer, wetter winters are projected to increase flooding frequency in most Western Washington river basins. Future floods are expected to exceed the capacity and protective abilities of existing flood protection facilities, threatening lives, property, major transportation corridors, communities and regional economic centers.

## Landslides

- A landslide is the sliding movement of masses of loosened rock and soil down a hillside or slope. Slope failures occur when the strength of the soils forming the slope is exceeded by the pressure, such as weight or saturation, acting upon them.

- Mudslides or mudflows (or debris flows) are rivers of rock, earth, organic matter and other soil materials saturated with water. They develop in the soil overlying bedrock on sloping surfaces when water rapidly accumulates in the ground, such as during heavy rainfall or rapid snowmelt.

- A sinkhole is a collapse depression in the ground with no visible outlet. Its drainage is subterranean, and it is commonly vertical-sided or funnel-shaped.

- All these mass movements are caused by a combination of geological and climate conditions. The cool, rainy Pacific Northwest climate ensures that soil moisture levels remain high throughout most of the year, and in fact are often at or near saturation during wet winter months. The region is also shaped by soils deposits from glaciers, which are highly erodible. In addition, these vulnerable natural conditions are being steadily affected by human residential, agricultural, commercial and industrial development and the infrastructure that supports it.

- In general, landslide hazard areas are where the land has characteristics that contribute to the risk of the downhill movement of material, such as the following:
    - A slope greater than 33 percent
    - A history of landslide activity or movement during the last 10,000 years
    - Stream or wave activity, which has caused erosion, undercut a bank or cut into a bank to cause the surrounding land to be unstable
    - The presence or potential for snow avalanches
    - The presence of an alluvial fan, indicating vulnerability to the flow of debris or sediments
    - The presence of impermeable soils, such as silt or clay, which are mixed with granular soils such as sand and gravel.
- Current land-slide hazards maps do not identify areas at risk of slide run-out. The length of slide run-out is affected by many factors such as substrate composition, saturation and slope angle and height. Scientific research is ongoing to understand how these and other factors determine slide run-out.

- Landslides are often triggered by other natural hazards such as earthquakes, heavy rain, floods or wildland fires. In Snohomish County, landslides typically occur during and after major storms.

- Mass movements can occur suddenly or slowly. The velocity of movement may range from a slow creep of inches per year to many feet per second, depending on slope angle, material and water content.

- It is possible to determine what areas are at risk during general time periods. Assessing the geology, vegetation, and amount of predicted precipitation for an area can help in these predictions. However, there is no practical warning system for individual landslides.

- Landslides destroy property and infrastructure and can take the lives of people. Slope failures in the United States result in an average of 25 lives lost per year and an annual cost to society of about $1.5 billion. The Hwy 530 landslide in 2014 resulted in 43 lives lost and is estimated to cost more than $50 million in damage and recovery costs.

- Projected changes in winter weather, snowpack ability to hold water and impacts on vegetation due to climate change would increase the probability of landslides in the County.

## Severe Weather

- 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.

- 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. Funnel clouds or tornados occasionally form. The highest summer and lowest winter temperatures generally occur during periods of easterly winds.

- Severe winter storms have a 58% probability of occurring in Snohomish County within a two year time period.

- July and August are the driest months where two to four weeks can pass with only a few or no rain showers.

- 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. Immobility and loss of utilities are the most common impacts. Weather-related fatalities are uncommon in western Washington, but they can occur.

- 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.

- 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.

## Tsunami/Seiche

- A tsunami is a series of traveling ocean waves of extremely long wavelength usually caused by displacement of the ocean floor and typically generated by seismic or volcanic activity or by underwater landslides.

- A seiche is a standing wave in an enclosed or partly enclosed body of water, normally caused by earthquake activity, and can affect harbors, bays, lakes, rivers and canals.

- Tsunamis are typically classified as local or distant. Locally generated tsunamis have minimal warning times.

- In the open ocean, a tsunami may be only a few inches or feet high, but it can travel with speeds approaching 600 miles per hour. As a tsunami enters the shoaling waters near a coastline, its speed diminishes, its wavelength decreases, and its height increases greatly.

- No written records exist of damaging waves in Puget Sound. However, verbal accounts among the Snohomish Tribe reported by Colin Tweddell in 1953 describe a great landslide-induced wave caused by the collapse of Camano Head at the south end of Camano Island around the 1820s and 1830s.

- Area lakes have experienced seiches in historical times. In 1891, an earthquake near Port Angeles caused an 8-foot seiche in Lake Washington. Seiches generated by the 1949 Queen Charlotte Islands earthquake were reported on Lake Union and Lake Washington.

- The Washington Department of Natural Resources (DNR), working with the National Oceanic and Atmospheric Administration (NOAA) and the National Tsunami Hazard Mitigation Program, is in the process of modeling tsunami impacts in Puget Sound using computer models of earthquake-generated tsunamis from nearby seismic sources.

- The Cascadia subduction zone will produce the state's largest tsunami, although it is not likely to significantly impact Snohomish County.

- Typical signs of a tsunami hazard are earthquakes and/or sudden and unexpected rise or fall in coastal water. The large waves are often preceded by coastal flooding and followed by a quick recession of the water. Tsunamis are difficult to detect in the open ocean; with waves less than 3 feet high.

- The tsunami's size and speed, as well as the coastal area's form and depth, affect the impact of a tsunami; wave heights of 50 feet are not uncommon. In general, scientists believe it requires an earthquake of at least a magnitude 7 to produce a tsunami.

- Seiches are usually earthquake-induced but typically do not occur close to the epicenter of an earthquake, but hundreds of miles away.

- The Pacific tsunami warning system evolved from a program initiated in 1946. It is a cooperative effort involving 26 countries along with numerous seismic stations, water level stations and information distribution centers. The warning system only begins to function when a Pacific basin earthquake of magnitude 6.5 or greater triggers an earthquake alarm.

- This system is not considered to be effective for communities located close to the tsunami because the first wave would arrive before the data were processed and analyzed. In this case, strong ground shaking would provide the first warning of a potential tsunami.

- Low elevation coastal areas could experience tsunami inundation, and steep slopes adjacent to the coast could experience erosion from a tsunami.

- Sea level rise from climate change could increase tsunami inundation and erosion impacts.

## Volcano/Lahar

- The hazards related to volcanoes and volcanic eruptions are distinguished by the different ways in which volcanic materials and other debris flow from the volcano. The lava may flow out as a viscous liquid, or it may explode from the vent as solid or liquid particles.

- A lahar is a rapidly flowing mixture of water and rock debris that originates from a volcano.

- Glacier Peak in eastern Snohomish County is one of the major Cascade volcanoes. The mountain is thought to have erupted as recently as the 18th century. Since the end of the last glacial episode about 14,000 years ago, Glacier Peak has erupted at least a dozen times.

- Although a major volcanic debris flow is a rare occurrence, its potential volume and destructive force are such that the possibility deserves mention. The Town of Darrington and much of northeast Snohomish County could be affected by a large flow following the White Chuck and Sauk River drainage channels. Most of the County would be exposed to ash fall and accumulation in the event of a volcanic eruption.

- Three major Cascade volcanoes other than Glacier Peak are relatively close to Snohomish County: Mount Rainier is 60 miles to the south; Mount St. Helens is 110 miles to the south; and Mount Baker is 35 miles to the north. Mount Adams, also 110 miles to the south but on the east side of the Cascade Range, poses a lower threat because of the direction of prevailing winds.

- The explosive disintegration of Mount St. Helens' north flank in 1980 vividly demonstrated the power that Cascade volcanoes can unleash.

- A 1-inch deep layer of ash weighs an average of 10 pounds per square foot, causing danger of structural collapse. Ash is harsh, acidic and gritty, and it has a sulfuric odor. When an ash cloud combines with rain, sulfur dioxide in the cloud combines with the rain water to form diluted sulfuric acid that may cause minor, but painful burns to the skin, eyes, nose, and throat.

- Constant monitoring of all active volcanoes means that there will likely be more than adequate time for evacuation before an event.

## Wildland Fire

- The wildland fire season in Washington usually begins in early July and ends with precipitation in late September. However, wildland fires have occurred in every month of the year.
- How a fire behaves depends on fuels available, weather, thunderstorm activity, terrain, and time of day.

- Fires historically burn on a fairly regular cycle, recycling carbon and nutrients stored in the ecosystem, and strongly affecting the species within the ecosystem. The burning cycle in western Washington is every 100 to 150 years. Controlled burns have also been conducted because the fire cycle is an important aspect of management for many ecosystems.

- According to data tracked by the DNR on lands that it is responsible for protecting, Snohomish County has had 905 wildland fire incidents since 1970. This is an average of a little over 20 per year, with a high of 45 incidents in 1974 and 1990 and a low of 1 incident in 1971.

- Potential losses from wildland fire include human life, structures and other improvements, and natural resources. There are no recorded incidents of loss of life from wildland fires in Snohomish County, and the risk from wildland fire has been deemed moderate by the state.

- Wildland fires are typically caused by humans, whether intentionally or accidentally. There is no way to predict when one might break out.

- Reliable National Weather Service lightning warnings are available on average 24 to 48 hours prior to a significant electrical storm. Dry seasons and droughts are factors that greatly increase fire likelihood. Once a fire has started, fire alerting is reasonably rapid in most cases.

- Projected warming, and increase in summer drought and forest diseases, associated with climate change, would be expected to increase the risk of wildland fire in the county.

## Hazardous Materials/Pipelines

- Hazardous materials are materials with a chemical, physical, or biological nature which can pose a potential risk to human health, property, or the environment when released.

- Hazardous materials incidents can occur naturally and during the manufacture, transportation, storage and use of hazardous materials. These incidents can occur as a result of human error, natural hazards, deliberate deed, or a breakdown in equipment or monitoring systems.

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- The impact depends upon the quantity and physical properties of the hazardous material, environmental and weather factors at the point of release, the type of release, and its proximity to human and wildlife populations and valuable ecosystems.

- There are 668 reported Tier II facilities located in Snohomish County. However, the majority of these are smaller facilities, such as gas stations, that don't pose a serious threat to a wide area.

- The main local routes for hazardous materials transport are Interstate 5 (I-5) and I -405, State Route (SR) 2 and 9 and Highway 99 and the BNSF railroad located throughout the County. Natural gas, commercial propane and commercial butane, and liquefied petroleum gas (LPG) gas pipelines serve several storage farms in Snohomish County, as well as all major cities and towns.

- Olympic Pipeline Company maintains two major liquid petroleum product pipelines through Snohomish County. Williams Natural Gas also operates a major north-south pipeline carrying vapor petroleum products.

- Many factors determine the severity of a potential incident including quick and solid decision-making by emergency officials, location and type of release, evacuation and shelter-in-place needs, public health concerns, and relevant economic considerations. Additionally, while most incidents are generally brief, the resulting recovery and cleanup may take time to exact.

- Hazardous materials releases can occur at any time without warning. Once the release has occurred the potentially affected areas may have little or no warning time, depending on which chemical was released and the method by which the chemical will travel. The initial identification of specific hazardous materials types can increase response capabilities.

- Vulnerable populations are all populations that may be exposed to an incident and are incapable of escaping the area within the allowable time frame.

- Hazardous materials incidents can have a significant effect on the environment. Releases into the environment have the potential to significantly damage soils, water quality, wildlife habitat, and vegetation.

## Climate Change Considerations for Hazard Mitigation

For hazards that are affected by climate conditions, the assumption that future behavior will be equivalent to past behavior is not valid if climate conditions are changing. Climate change is expected to affect the following hazards:

### Severe Weather

- Most regional climate models project an increase of summer drought, with averages ranging from 6 to 8 percent decrease in summer precipitation by 2050.
- Winter, spring and fall precipitation is projected to increase over the same period.
- For high greenhouse gas scenario events, heavy rainfall events of 1 inch or greater are projected to increase from 6 to 20 % by 2050 than the average from the late 1800's through 2000.

### Flooding

- Peak streamflows are projected to occur 4 to 9 weeks earlier by the 2080s.
- Flooding is projected more often, with the streamflow volume of the historic 100 year flood event potentially occurring as frequent as a 15 year event.
- Sea level rise will increase coastal flooding. Projections range from a rise of 4 to 56 inches along the Washington Coast.

### Landslides

- Sea level rise is expected to increase coastal landslides.
- Projected increases in winter, spring and fall precipitation and increased frequency of heavy rain events is expected to increase the frequency of landslides on vulnerable slopes.

### Wildfire

- Increases in summer drought and insect infestation of forests are expected to increase the risk of wildfires.

### Tsunami

- Higher sea levels would result in more coastal flooding and erosion in the event of a tsunami.

Avalanche

- The effects of climate change on avalanche frequency, magnitude and location are uncertain. Projected decreases in low elevation snow pack may result in fewer low elevation avalanches. However, snowfall may increase in higher elevation below freezing zones, which could increase avalanche hazard. Also, the type of avalanche could change, potentially increasing the number of wet snow avalanches.

Dam/Levee Failure

- Increased winter, spring and fall precipitation and severe storm events are not expected to increase the risk of catastrophic dam failure. However, design failure, where water is released over the spillway would be expected to become more frequent.
- The risk of levee failure could increase with an increased frequency of flood events.

Hazardous Materials/Pipelines

- Hazardous materials sites in flood prone areas could be a greater risk of a spill or release from the projected increases in frequency of flood events.