Snohomish County Multi-Jurisdictional Hazard Mitigation Plan 2020 Update

Volume I

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Snohomish County 2020 Hazard Mitigation Plan

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View the Snohomish County Hazard Mitigation Plan online at:

https://snohomishcountywa.gov/2429/Hazard-Mitigation-Plan

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Executive Summary

The Snohomish County 2020 Hazard Mitigation Plan (HMP) is a multi-jurisdictional plan which identifies and prioritizes actions to reduce or alleviate risks from all hazards. The HMP also enables partnering jurisdictions and agencies to maintain eligibility for disaster-related federal grant assistance (Disaster Mitigation Act 2000). In addition, the HMP helps meet the planning requirements of the Federal Emergency Management Agency (FEMA) Community Rating System (CRS), which allows partners that participate in the CRS program to maintain or enhance their CRS classifications.

Previous Hazard Mitigation Planning in Snohomish County

Federal regulations require a strategy for monitoring, evaluating, and updating the HMP. The 2020 HMP update provides an opportunity for partners to conduct an updated risk assessment, reevaluate recommendations, monitor the impacts of actions that have been completed, and determine if there is a need to adjust the focus of mitigation strategies. The Disaster Mitigation Act of 2000 (DMA) compliance is contingent on meeting the plan update requirement. A jurisdiction covered by a plan that has expired is not able to pursue funding under the Robert T. Stafford Act, which requires a current HMP as a prerequisite.

Snohomish County's Initial Response to the Disaster Mitigation Act

In 2005, Snohomish County and a planning partnership of dozens of local agencies within the county embraced the concept of the DMA and prepared one of the largest multi-jurisdictional HMPs in the western United States. The planning process took over 17 months and generated a plan that identified 216 initiatives to be implemented by 43 partners (13 municipalities and 30 special purpose districts). Snohomish County completed subsequent plans in 2010 and 2015.

The Plan was developed according to the requirements of Chapter 44 of the Code of Federal Regulations (44CFR) and was formally approved by FEMA Region X on April 27, 2005. FEMA's approval qualified the planning partners to pursue implementation funding under the Stafford Act.

The Snohomish County Planning Effort

Local HMPs must be regularly updated to comply with the DMA, and the partnership is responding to this requirement with this plan update. In 2017, the Snohomish County Department of Emergency Management (DEM) and Snohomish County partners teamed together to begin updating a countywide HMP that would best suit the needs and capabilities of all planning partners. The Snohomish County partnership committed to the preparation of its 2020 plan update by securing technical assistance to facilitate a planning process that would comply with all program requirements. The ensuing planning process developed a new plan for the partnership.

Plan Update Process

Phase 1—Organize Resources

The DEM-led Project Team and Snohomish County DEM Advisory Board established a Steering Committee and Planning Team made up of representatives from each of the participating jurisdictions and agencies. The Steering Committee was assembled to guide the planning process, including approving the timeline,

determining key milestones, and developing goals. The Planning Team was tasked with updating the contents of the plan, including supporting the development of objectives and the ranking of hazards. Coordination with other nonparticipating jurisdictions, tribal partners, counties, state, and federal agencies involved in hazard mitigation occurred throughout the plan update process. This phase included a review of the existing HMP, the Washington State Enhanced HMP, and existing programs that may support hazard mitigation actions.

Table ES-1
Planning Partners

#	City/Town	#	Special District
1	Monroe	1	Silver Lake Water and Sewer District
2	Lake Stevens	2	Community Transit
3	Arlington	3	Lake Stevens Sewer District
4	Darrington	4	French Slough Flood Control District
5	Index	5	Snohomish Health District
6	Mukilteo	6	Stanwood-Camino School District
7	Edmonds	7	Alderwood Water & Wastewater District
8	Mill Creek	8	Snohomish Fire District #26
9	Brier	9	Stillaguamish Flood Control District
10	Marysville	10	Snohomish Fire District #5
11	Gold Bar	11	Mukilteo Water & Wastewater District
12	Sultan		
13	Lynnwood		
14	Mountlake Terrace		

Phase 2—Update the Risk Assessment

Risk assessment is the process of measuring the potential loss of life as well as personal injury, economic injury, and property damage resulting from hazards. This process assesses the vulnerability of people, buildings, resources, and infrastructure to hazards. Risk assessment models were enhanced with new data and technologies that have become available since 2015. The risk assessment includes the following:

- Hazard identification and profiling
- Assessment of hazard impacts on physical, social, and economic assets
- Vulnerability identification
- Cost estimates of potential damage

The Steering Committee and Planning Team used the risk assessment to rank hazards facing the county and to gauge the potential impacts of each hazard of concern in the Snohomish County planning area.

Phase 3—Engage the Public

The project team implemented a public involvement strategy developed by the Steering Committee, which included public meetings to present the risk assessment, a hazard mitigation survey, a County-sponsored website, and multiple media releases.

Phase 4—Update the Plan

The HMP planning partners assembled a document to meet federal hazard mitigation planning requirements. A completed local mitigation plan review crosswalk is included in Section 2.3 of Part 1 – Planning Process Overview. This completed crosswalk provides a comparative analysis between the content in the Snohomish County HMP and the federal hazard mitigation planning requirements.

Phase 5—Adopt and Implement the Plan

The final adoption phase takes place after the Washington Military Department, Emergency Management Division and FEMA Region X have granted pre-adoption approval. The plan maintenance process includes a schedule for monitoring and evaluating the plan's progress periodically and producing a revised plan every five years. This plan maintenance strategy also includes processes for continuing public involvement and integrates with other programs that can support or enhance hazard mitigation.

Risk Assessment Results

The Planning Team ranked the below hazards facing the planning area using a range of factors that included severity, frequency, and duration; these were scored based on the most-likely scenario (i.e., greatest potential to occur) and the worst-case scenario (i.e., greatest potential impact).

Most-Likely Scenario	Rank
Winter Storm	1
Earthquake	2
Hazardous Materials Accident	3
Train Accident	4
Windstorm	5
Cyber Security Incident	6
Extreme Weather	7
Aircraft Accident	8
Utility Failure	9
Public Health Emergency	10
Flood	11
Landslide	12
Dam Failure	13
Wildland Fire	14
Active Assailant	15
Drought	16
Volcano/Lahar	17
Avalanche	18

Worst-Case Scenario	Rank
Earthquake	1
Utility Failure	2
Public Health Emergency	3
Hazardous Materials Accident	4
Windstorm	5
Cyber Security Incident	6
Wildland Fire	7
Winter Storm	8
Train Accident	9
Extreme Weather	10
Active Assailant	11
Aircraft Accident	12
Landslide	13
Flood	14
Dam Failure	15
Volcano/Lahar	16
Drought	17
Avalanche	18

The Steering Committee adopted the list of hazards to build out the hazard profiles and mitigation strategies. The Steering Committee identified tsunami as a hazard to be included in the 2020 HMP update after the hazard ranking exercise; therefore, this hazard has not been ranked. Additionally, the Steering Committee and Planning Team elected to remove avalanche due to its low-risk profile and utility failure as it is an outcome of a hazard occurring, not a hazard. The Steering Committee identified active assailant

and aircraft accident as hazards that should be profiled but that could not be mitigated, and to aggregate certain hazards (e.g., mass earth movement includes landslide and mudslide) to streamline analysis.

Rank	Hazard	Hazard Includes
1	Earthquake	
2	Epidemic	
3	Hazardous Materials	Train Accident
4	Weather Events	Windstorm
		Winter Storm
		Drought
5	Flooding	
6	Dam Failure	
7	Wildfire	
8	Cybersecurity Threats	
9	Mass Earth Movement	Landslides and Mudslides
10	Volcano	
11	Active Assailant	
12	Aircraft Accident	
-	Tsunami	

Mitigation Goals and Objectives

The Steering Committee established the goals and the Planning Team established the objectives for the 2020 HMP.

Goal 1: Reduce hazard and threat-related injury and loss of life.	
Item	Objectives
1.1	Develop and implement policies that integrate hazard and risk information into building codes and land use planning that promote resilient and safe development in high-risk areas.
1.2	Strengthen tools to remove threatened uses in hazardous areas and relocate them where risk reduction measures support development to a tolerable level.
1.3	Reduce the adverse impacts from and leverage the beneficial functions of natural hazards.
1.4	Develop continuity of operations plans and community-based continuity plans to mitigate the impacts of hazards becoming disasters, and support disaster preparedness, response, and recovery.
1.5	Develop, implement, and sustain programs that promote reliable, redundant, and resilient lifeline systems.

Goal 2: Promote resilient communities, resilient economy, sustainable growth, and hazard prevention.	
Item	Objectives
2.1	Provide incentives that support the mitigation of impacts to critical business operations, including small businesses and those located in high-risk areas.
2.2	Increase the resilience of critical services, facilities, and infrastructure through applicable retrofits, sustainable funding programs, and zoning and development changes, and reduce exposure/vulnerability to all hazards.
2.3	Promote the ability of communities to mitigate, prepare for, respond to, and recover from an emergency or disaster through the strengthening of community networks and development of community-based emergency planning (e.g., evacuation zones and routes and micro-infrastructure networks).

Goal 3: Consider equity when enhancing public awareness and community members' ability to mitigate, prepare for, respond to, and recover from a disaster.	
Item	Objectives
3.1	Reduce the adverse impacts of disasters on vulnerable communities.
3.2	Create and enhance equitable public information programs and access to hazard information that promotes actionable preparedness and mitigation measures.
3.3	Identify and prioritize opportunities to increase capacity and redundancy for critical services, facilities, and infrastructure to vulnerable communities, with special emphasis on communities that are at risk of isolation.

Goal 4: Make decisions through regional collaboration.	
Item	Objectives
4.1	Support the alignment and integration of the 2020 HMP goals, objectives, and strategies with other planning processes.
4.2	Develop a coordinated incentive program for eligible entities to adapt to risks through structural and nonstructural measures (e.g., acquisition program for homes or other uses located within high-risk hazard areas).
4.3	Use the best available science when developing new or updating existing plans to prepare for and adapt to climate impacts (e.g., update conservation requirements to minimize impacts of drought).
4.4	Support improved data collection, assessment, analysis, and implementation for all hazards.
4.5	Develop a coordinated flood mitigation strategy that leverages sustainable funding sources for flood control improvements and identifies opportunities for multi-agency collaboration.

Mitigation Actions

Mitigation actions presented in this update are activities designed to reduce or eliminate losses resulting from hazards and can be found in each jurisdiction's annex. Through the update process, the Steering Committee and Planning Team determined that the countywide goals and objectives established effective coordination between jurisdictions and agencies for hazard mitigation actions.

Implementation

Full implementation of the recommendations of this plan will require time and resources. The measure of the HMP's success will be its ability to adapt to changing conditions. Each jurisdiction and agency assumes responsibility for adopting the recommendations of this plan and committing resources toward implementation for their actions. However, the most effective mitigation measures will come when multiple agencies identify complimentary projects that support system-level resilience. The framework established by this plan commits all participants to pursue initiatives when the benefits of a project exceed its costs. The HMP partnership developed this plan with public input, and public support of the actions identified in this plan will help ensure its success.

Hazard Two-Pagers

The remainder of the Executive Summary includes hazard-specific two-page documents that are designed for community and stakeholder engagement; more extensive versions of which may be found in Volume 1, Part 2 – Risk Assessment.

Active Assailant

Understanding the Hazard

Active assailant incidents can be well-planned, coordinated attacks with multiple suspects, or the result of a lone individual on a rampage using any type of weapon. The threat of an incident involving an active assailant is increasingly common in the United States. For example, of the 277 active shooter incidents that occurred between 2000 and 2018, 117 (42 percent) occurred between 2014 and 2018.

Active assailant incidents involving other types of weaponry are also increasing. In 2014, a 16-year-old in Pennsylvania stabbed 21 students and a security guard at a high school. In August 2017, a man drove his car into a crowd of protesters in Charlottesville, Virginia, killing one and injuring 28 people. In October 2017, a man rented a pickup truck and drove through a bike path along the Hudson River in New York City, killing eight and injuring 11 people. On May 22, 2017, a suicide bomber entered a concert in Manchester, England, killing 22 and injuring more than 50 attendees.

The locations of active assailant incidents are random and sporadic, challenging the ability of law enforcement to mitigate and prepare for the threat of these incidents. However, assailants do not always choose locations at random; for example, a high percentage of school shootings are carried out by current or former students, and many shootings at businesses are perpetrated by current or former employees or by persons with some grievance against the business. In instances where the assailant has no direct connection to the location, places with a high pedestrian presence are typically chosen (e.g., special events, large gatherings).

DEFINITIONS

Active – Both law enforcement personnel and citizens have the potential to affect the outcome of the event based upon their responses to the situation.

Active Assailant – An individual actively engaged in killing or attempting to kill people in a confined and populated area; in most cases, active assailants use firearms and there is generally no pattern or method to their selection of victims.

Active Shooter – One or more individuals actively engage in killing or attempting to kill people in a populated area using one or more firearms.

Extreme Risk Protection Orders – Designed to prevent individuals at high risk of harming themselves or others from accessing firearms, this type of order allows family, household members, and police to obtain a court order when there is demonstrated evidence that the person poses a significant danger.

Mass killings – Three or more killings in a single incident.

Occurrence and Probability

Between 2000 and 2018, there were 12 active assailant events in the state of Washington, two of them occurring in Snohomish County:

- On October 24, 2014, a 15-year-old armed with a handgun began shooting in the cafeteria of Marysville-Pilchuck High School; four students were killed, three wounded.
- On July 20, 2016, a 19-year-old armed with a rifle began shooting people attending a house party in Mukilteo; three people were killed, one wounded.

Between 2014 and 2019, one mass shooting occurred in Snohomish County every three years.

In Snohomish County, several active assailant attacks were investigated and foiled by law enforcement before they occurred. For example, in February of 2018, a Snohomish County grandmother reported her 18-year-old grandson to the police after finding a journal containing threats to shoot students. After investigation, the threats were considered credible and the would-be assailant was arrested.

Secondary Impacts

An active assailant incident may inundate hospitals and medical centers, resulting in shortages of blood and supplies that put day-to-day patients at risk. Additionally, active assailant incidents put people at an increased risk for depression or other mental health issues resulting from psychological trauma.

Other impacts from active assailant incidents can include loss of business and revenue or loss of labor hours. Property damage can come from the weapon (such as a gun, vehicle, fire, or explosives). Mass shootings have the potential to serve as a catalyst for anti-gun demonstrations, putting additional strain on local law enforcement.

Exposure

As the population grows in Snohomish County, more people are potentially at risk of finding themselves at a location targeted by an active assailant. All critical facilities listed in the Hazard Mitigation Plan could experience an active assailant incident. An active assailant incident can occur at any place throughout the county. Statistically, businesses and malls are the most likely locations, followed by schools and institutions of higher learning.

Prepare: Actions You Can Take

- Sign up for an active shooter training.
- If you see something, say something to an authority right away.
- Be aware of your environment and any possible dangers.
- Make a plan with your family and ensure everyone knows what they would do if confronted with an active shooter.
- Look for the two nearest exits anywhere you are, have an escape path in mind, identify places you could hide.

Aircraft Accident

Understanding the Hazard

Aircraft accidents occur every year in the United States because of mechanical failure or human error. The five most common reasons for aircraft accidents are pilot error (contributing to approximately 50 percent of accidents), mechanical failure, bad weather, intentional crashes, or other forms of human error.

There were 15 fatal aircraft accidents around the world in 2018; with 37.9 million flights worldwide, that is one fatal accident per 2.52 million flights. In general, accident rates are decreasing, and are typically lower in the United States than the rest of the world. In 2018, there was only one major accident with one fatality in the United States, occurring on a commercial airliner. The majority of aircraft accidents occur in general aviation (e.g., personally owned and operated planes or chartered flights), not commercial flights (i.e., major airlines). In 2018, there were 1,257 general aviation accidents in the United States, resulting in 225 fatalities.

DEFINITIONS

Aircraft – A vehicle, such as an airplane or balloon, for traveling through the air.

Aircraft Accident – An occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight and all such persons have disembarked, and in which any person suffers death or serious injury, or in which the aircraft receives substantial damage.

Aircraft Incident – An occurrence other than an accident, associated with the operation of an aircraft, which affects or could affect the safety of operations.

Snohomish County has 24 private and six public airports, the largest being Paine Field in Everett, Washington. Paine Field commercial air service was launched in March of 2019. The terminal accommodates approximately 24 departures per day and supports approximately 10,000 to 15,000 travelers per week. Additionally, Snohomish County is within the flight pattern of multiple flights to and from the Seattle-Tacoma International Airport.

Occurrence and Probability

Although aircraft accidents can happen anywhere in the county, the most likely locations are those close to the 30 airports and along the more populated western portion. Historically, most crashes have happened near Paine Field, the City of Snohomish, and Arlington Municipal Airport.

In Snohomish County, there were three aircraft accidents in 2018. In 2019, one accident occurred: a single engine plane crashed into a field near Marysville, resulting in one fatality. It can be reasonably expected that one or more aircraft accidents will occur each year somewhere in Snohomish County. However, future regulations and safety standards may reduce the amount of aircraft accidents.

Secondary Impacts

After an aircraft accident, areas around the crash are typically closed off and unusable until after an investigation has been completed. Controlled access may negatively impact residents and businesses in the area of the crash by obstructing traffic or preventing income generation.

A crash can also lead to regulation overhaul, potentially affecting passengers on future flights or disrupting business. Fear stemming from the accident can also have a negative financial impact on businesses if people choose a different method of transportation or decide not to travel at all.

Exposure

Residents and businesses across the county are exposed to the occurrence of an aircraft accident, particularly those living closer to airports. Although uncommon, there is a chance for the aircraft to damage property. All critical facilities are potentially exposed to an aircraft accident.

Aircrafts have hazardous materials on board, such as Jet A fuel and hydraulic fluid. The release of these into the soil or water where the aircraft accident occurred can be toxic to the immediate flora and fauna in the vicinity. In general, aircraft accidents have minimal impact on the environment and are typically remediated quickly.

Prepare: Actions You Can Take

- Make a Family Emergency Plan.
- If you see something, say something to an authority right away.
- Be aware of your environment and any possible dangers.
- Have an evacuation strategy.

Cybersecurity Threats

Understanding the Hazard

Cyberattacks are malicious attempts to access or damage a computer system using computers, mobile phones, gaming systems, and other devices to steal identities, block access or delete documents and pictures, target children, or cause problems with business services, transportation, and power. Common types of cyberattacks include denial of service, botnets, distributed denial of service, exploit tools, logic bombs, phishing, sniffers, Trojan horses, viruses, war dialing, war driving, and worms.

Cybersecurity threats are becoming more common, more dangerous, and more sophisticated as more people become increasingly dependent upon the internet. Threats are evolving as nation-states, terrorists, individual criminals, transnational criminal organizations, and other malicious actors move their activities to the digital realm. Motivations for threats include espionage, political and ideological interests, and financial gain.

The broad availability, relatively low cost, and increasing capabilities of cyber tools affect trends and threats; examples include malware and phishing. Institutions commonly attacked are banking, medical, education, military, commerce, communications and infrastructure systems.

Cyberattacks have a significant economic impact on everyone from large corporations to individuals and families. The business sector suffered the most breaches by industry in 2018, followed by medical/healthcare organizations and the banking/credit/financial sector.

In 2014, the Center for Strategic and International Studies estimated that cybercrimes cost the global economy almost $500 billion; in 2018, they estimated that number to be close to $600 billion. In the United States alone, the Internet Crime Complaint Center reported $2.7 billion in losses for 2018; personal data breaches resulted in $149 million in losses and identify theft caused $100 million in losses.

DEFINITIONS

Botnet – A collection of compromised machines under control of an attacker.

Denial of Service – A method of attack from a single source that denies system access to legitimate users by overwhelming the computer with messages and blocking legitimate traffic.

Exploit tools – Publicly available and sophisticated tools that intruders of various skill levels can use to determine vulnerabilities and gain entry to targeted systems.

Logic bombs – A form of sabotage in which a programmer inserts code that causes the program to perform a destructive action when a triggering event occurs.

Phishing – The creation and use of emails and websites designed to deceive Internet users into disclosing their personal data, resulting in identity theft and fraud.

Sniffer – A program that intercepts routed data and examines each packed in search of specified information.

Trojan Horse – A computer program that conceals a harmful code.

Virus – A program that infects computer files by inserting a copy of itself into the file.

Worm – An independent computer program that reproduces by copying itself from one system to another across a network.

Not only do cyberattacks result in economic damage for governments, companies, and individuals, they can also lead to embarrassment, reputation loss, and lack of trust. Attacks are also a risk to critical infrastructure, potentially affecting power grids, transportation systems, and healthcare sectors.

Cyberattacks can occur locally from sources anywhere on the globe. Attackers may be local, wishing harm on county governments, officials, or individuals. People in the county can also be affected by mass breaches elsewhere in the United States or the world, such as a breach at a bank or credit card institution. Often, the source and location of a cyberattack is unknown.

Occurrence and Probability

In May of 2016, The Northshore School District servers were hacked and 9,000 out of 21,000 Gmail accounts were compromised. Thousands of students received spam emails containing inappropriate messages and links to pornography. On Friday, September 20, 2019, the Northshore School District's servers suffered another significant cyberattack, rendering many of the systems inoperable. There were no signs of data being compromised.

In 2016, the Snohomish County Public Utility District enlisted the help of the Washington Air National Guard to identify vulnerabilities in their cybersecurity system, asking them to hack into the system—they were successful. The goal was to identify vulnerabilities before suffering an actual attack to enhance the security of their system to protect customers and employees.

Secondary Impacts

The high risk of impacts from cyberattacks on critical infrastructure systems at a national or local level are only recently being understood and managed, including the cascading impacts that this risk poses. The interconnectedness of major economic systems, utility systems (i.e., smart grids), food and health systems, and transportation systems indicates that these risks are vast and significant.

Exposure

A successful breach of critical public and private networks could severely diminish or destroy basic public utilities, fuel, health care systems, emergency medical services, communications, and governance.

The data stored on public and private networks is property in and of itself and is often the target of a cyberattack or lost during significant cyber outages. The most valuable data (i.e., property) is consumer, financial, medical, intellectual property, and government information. A catastrophic incident or outage from a successful cyberattack or breach can cause physical damage to a property (such as disrupting shutdown procedures, turning off emergency backstops, or taking control of the system itself and overriding safe operating parameters).

Prepare: Actions You Can Take

- Keep software and operating systems up to date.
- Use strong passwords and two-factor authentication.
- Use encrypted internet communications.
- Create backup files.
- Check account statements and credit reports regularly.
- Watch for suspicious activity. When in doubt, don't click.

Dam Failure

Understanding the Hazard

A dam failure is an uncontrolled release of water from a reservoir as a result of structural failures in a dam. Natural hazard events like floods, earthquakes, and landslides can cause dam failures, as well as human activities like deficiencies in maintenance, poor operation, criminal acts, or terrorism. Human error, such as poor construction, lack of maintenance and repair, and deficient operational procedures, is preventable or correctable by a program of regular inspections. Terrorism and vandalism are serious concerns that all operators of public facilities must plan for; these threats are under continuous review by public safety agencies.

Downstream communities can be devastated in the event of a large dam failure, which can result in damage or destruction of buildings and infrastructure, particularly bridges, culverts, and other infrastructure within the floodplain.

There are four regulated dams, and the Washington Department of Ecology regulates 66 dams in Snohomish County. The most likely disaster-related causes of failure in the county are earthquakes, excessive rainfall, and landslides.

Occurrence and Probability

Between 1918 and January 2019, 22 notable dam failures and incidents have occurred in Washington State. Two of these events occurred in Snohomish County, both of which have led to significant economic and environmental impacts.

- In December 1967, in Everett, Washington, the 40-foot-high North Star Sand and Gravel Dam was washed out by overtopping due to the lack of spillway. A 25-foot-high dam was rebuilt, but also failed, washing out Great Northern railroad tracks and derailing a passing train.

In April 2010, at the French Slough Bartelheimer Dairy Waste Pond in Snohomish County, a breached manure lagoon emptied some 27 million gallons onto adjacent

DEFINITIONS

Dam – Any artificial barrier and/or any controlling works, together with appurtenant works, that can or does impound or divert water.

Dam Failure – An uncontrolled release of impounded water due to structural deficiencies in the water barrier.

Emergency Action Plan (EAP) – A formal document that identifies potential emergency conditions at a dam and specifies preplanned actions to be followed to minimize property damage and loss of life. The EAP contains (1) specific actions the dam owner should take to moderate or alleviate the problems at the dam, (2) procedures on issuing early warning and notification messages to responsible downstream emergency management authorities, and (3) inundation maps to show the emergency management authorities the critical areas for action in case of an emergency.

High Hazard Dam – Dams assigned the high hazard potential classification are those where failure or operational issues would probably cause loss of human life.

Inundation Area – The area of land that would be flooded following a dam failure.

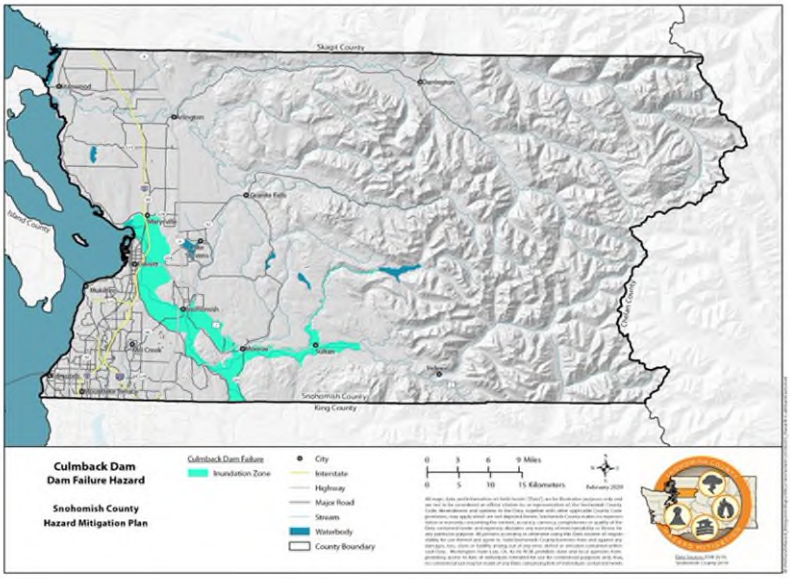
Significant Hazard Dam – Dams where failure or operational issues would not result in probable loss of human life but could cause economic loss, environmental damage, disruption of lifeline facilities, or other impacts.

farmland and into French Slough. The cause of the breach occurred due to the failure to remove a cedar drain field beneath the pond during construction, which allowed internal erosion through the embankment foundation. These types of events and the probability of occurrence of any type of failure are not likely to occur in today's current regulatory and dam safety oversight environment. The frequency of dam failure events is low and typically coincides with other natural hazards, like earthquakes, landslides, and excessive rainfall.

Secondary Impacts

Dam failure can cause severe downstream flooding depending on the magnitude of the failure. Other potential secondary hazards of dam failure include landslides around the reservoir perimeter, bank erosion on the rivers, and destruction of downstream habitat.

Exposure



Culmback Dam Inundation Area

The Snohomish County dam failure exposure analyses focused on the two principal dams of concern for which inundation data are available within the county: Culmback Dam and Tolt Dam. All populations within dam failure inundation zones are exposed to the effects of dam failure. The potential for loss of life is affected by the capacity of the dam, the number of evacuation routes available to populations living in areas of potential inundation, and warning time. For example, the population within the dam-failure inundation areas of the Culmback and Tolt River Dams is approximately 14,926, or 1.9 percent of the total county population. Additionally, 7,315 structures within the inundation areas of the Culmback and Tolt River Dams are exposed.

Transportation routes—including all roads, railroads, and bridges in the path of a dam inundation—are vulnerable and could be washed out, isolating communities and critical infrastructures in the inundation areas. The most vulnerable critical facilities are those not able to withstand a large water surge, which may be due in part to limited maintenance and not being updated to the most current building codes. Utilities such as overhead power lines, cables and phone lines may also be vulnerable, exacerbating isolation within and near inundation areas. The following critical infrastructure and facilities have been identified as within Culmback and Tolt:

- 2 Airports
- 63 Bridges
- 6 Dams
- 2 Fire/EMS
- 5 Government
- 6 Medical
- 3 Police
- 10 Schools
- 24 Wastewater Facilities
- 6 Port Facilities
- 1 Communication Facility
- 13 Other Facilities

Prepare: Actions You Can Take

- Sign up through Smart 911.
- Learn and practice evacuation routes, shelter plans, and flash flood response.
- Gather supplies.
- Purchase or renew a flood insurance policy.
- Keep important documents in waterproof containers.

Earthquake

Understanding the Hazard

The Pacific Northwest is one of North America's most seismically active regions. Hundreds of earthquakes occur here each year, most so small they only can be detected with sensitive instruments. Snohomish County is exposed to several earthquake risks:

The **Cascadia Subduction Zone** lies off the coast and extends from Canada to California. It has produced quakes of great intensity at least five times during the past 2,000 years, drowning coastal forests and unleashing tsunamis. The last occurrence was in 1700. A similar quake today would be a regional catastrophe, causing widespread damage to buildings, roads, and utilities. Even if Snohomish County is spared the worst shaking, the quake would likely bring weeks of hardship because of the crippling impacts on the region's highway and rail systems.

The **South Whidbey Island Fault** runs under much of the county's populated southwest. Computer modeling suggests a strong quake here likely would cause hundreds of human casualties, isolate communities due to road damage and mass earth movement, and destroy or compromise the structural integrity of enough buildings to leave more than 5,000 people in need of short-term shelter. The Puget Sound region is home to numerous similar geologic features, including the Seattle Fault and the Devil's Mountain Fault-North Whidbey Fault Complex. It also is periodically shaken by deep earth movement in a region known as the Benioff zone.

DEFINITIONS

Earthquake – The 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.

Epicenter – The point on the earth's surface directly above the region underground where an earthquake originates. The location of an earthquake is commonly described by the geographic position of its epicenter and by its focal depth.

Fault – A fracture in the earth's crust along which two blocks of the crust have slipped with respect to each other. Most common is a strike-slip, normal, or thrust fault.

Liquefaction – The transformation of water-saturated granular *sediment* into a fluid by some external vibration force, commonly an earthquake.

Occurrence and Probability

At least 20 damaging earthquakes have occurred in Western Washington during the past 125 years. Large earthquakes in 1945, 1949, 1965, and 2001 killed 16 people and caused more than $2 billion in damage; two of which resulted in a disaster declaration.

Between January 2000 and September 2019, Snohomish County experienced 14 earthquakes of a 3.0 magnitude or greater. The most recent, and strongest, was 4.6 magnitude on July 12, 2019 in Monroe.

Geologists say the odds of a large Cascadia Subduction Zone earthquake in the next 50 years are roughly one in three and roughly one in 10 for one that would qualify as a mega quake. The odds of a powerful quake on the South Whidbey Island fault in the next 50 years are one in 10. Meanwhile, there is an 85 percent probability in the next 50 years that people will continue to feel periodic quakes originating from the Benioff zone.

Secondary Impacts

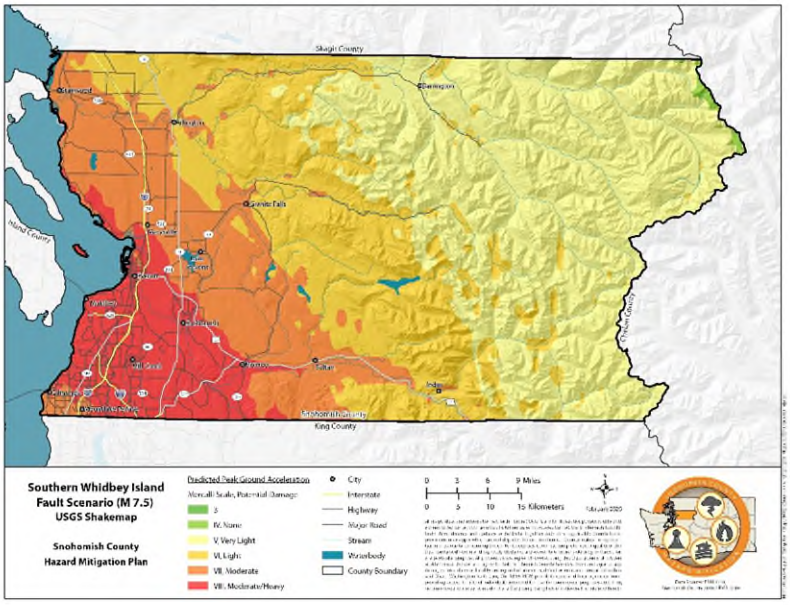
An earthquake may generate secondary hazards or cascading effects, including:

- Fires
- Building damage, collapse
- Liquefaction
- Seiches and tsunamis
- Dam failure
- Mass earth movement
- Release of hazardous materials
- Disruption of utilities
- Limited access to supplies and service

Exposure

Communities across the county have buildings that were constructed prior to the introduction and enforcement of the seismic building codes in the last 30 years, making them particularly vulnerable to damage. The estimated damage potential to structures from a 7.4 magnitude quake on the South Whidbey Island Fault is $13.7 billion and could affect 16,963 households with over 9,673 persons requiring short-term shelter. Many of the oldest communities have many unreinforced brick-and-mortar buildings, some already compromised by prior quake damages.

Some structures have been built on soils known to behave like liquid during hard shaking (i.e., liquefaction), making them vulnerable to greater damage; for example, in some places, past development led to shorelines being filled to support waterfront commerce.



Southern Whidbey Island Fault (SWIF) Peak Ground Acceleration 7.5-Magnitude Scenario Shake Map

The following critical infrastructure and facilities have been identified as exposed to an earthquake level of high to severe, including earthquake shaking hazard and liquefaction potential:

- 9 Airports
- 389 Bridges
- 27 Dams
- 79 Fire/EMS
- 55 Government
- 28 Hazmat
- 32 Medical
- 27 Police
- 248 Schools
- 96 Wastewater facilities
- 34 Water Storage facilities

Prepare: Actions You Can Take

- Maintain a stock of food, water, and medicine to last at least two weeks.
- Secure heavy items such as bookcases, refrigerators, and televisions.
- Create a family emergency communication plan with an out-of-state contact.
- Consider obtaining an earthquake insurance policy.

Epidemic

Understanding the Hazard

Epidemics of infectious diseases are occurring more often, spreading faster and further all over the world. Diseases that are occurring are both newly discovered and reemerging. For example, Severe Acute Respiratory Syndrome (SARS) was unheard of before 2003, and an outbreak of the plague occurred in Madagascar in 2017. Diseases very rarely disappear, and new ones are constantly discovered. Magnifying vulnerability to both newly discovered and reemerging diseases are new strains of pathogens and anti-vaccination movements.

Outbreaks may occur on a periodic basis (e.g., influenza), may be rare but result in a severe disease (e.g., meningococcal meningitis), occur after a disaster (e.g., cholera), or occur due to an intentional release of an agent (e.g., bioterrorism). Agents causing outbreaks can be viruses, bacteria, parasites, fungi, or toxins, and can be spread by people, contaminated food or water, healthcare procedures, animals, insects and other arthropods, or directly from the environment. An individual may be exposed by breathing, eating, drinking, or having direct contact. Some agents have multiple means of spreading, while others are only spread person to person.

DEFINITIONS

Cluster – An aggregation of cases grouped in place and time that are suspected to be greater than the number expected.

Endemic – Refers to the constant presence and/or usual prevalence of a disease or infectious agent in a population within a geographic area.

Epidemic – An increase, often sudden, in the number of cases of a disease above what is normally expected in that population in that area.

Hyperendemic – Persistent, high levels of disease occurrence.

Medical Countermeasures – life-saving medicines and medical supplies that can be used to diagnose, prevent, protect from, or treat conditions associated with chemical, biological, radiological, or nuclear threats, emerging infectious disease, or natural disaster.

Outbreak – The same definition of epidemic but is often used for a more limited geographic area, jurisdiction, or group of people.

Pandemic – An epidemic that has spread over several countries or continents, usually affecting many people.

Sporadic – Refers to a disease that occurs infrequently or irregularly.

Occurrence and Probability

The State of Washington has one of the highest rates of student vaccine exemptions in the nation; data for the 2017 to 2018 school year from the Department of Health shows 75 schools in King, Snohomish, Pierce, and Kitsap counties where at least 10 percent of K–12 students received an exemption for the measles-mumps-rubella (MMR) vaccine. In the Seattle area, Snohomish County has the highest rate of exemptions at 6 percent. These high exemption rates contributing to low immunization coverage rates are below the recommended immunization percentages necessary to allow for herd immunity in the community.

The highly contagious measles virus, which was declared eliminated in 2000, has reemerged throughout the United States with cases confirmed in 31 states, including Washington State. There were over 1,200 new cases of the measles virus in 2019 compared to 375 new cases in 2018. Clark County, Washington,

experienced 71 cases of measles in 2019, which resulted in roughly 19,000 response hours and costing $864,679.

In 2009, Snohomish County residents were exposed to the H1N1 virus, also known as swine flu, which resulted in more than 1,650 hospitalizations and deaths across the State of Washington; H1N1 was the first influenza pandemic of the 21st century.

The 2019 National Health Security Preparedness Index showed Washington State operating below the national average for health security and preparedness. According to the report, the State showed significantly below the national average scores in the domains Healthcare Delivery and Incident & Information Management, although there were gains to the Countermeasures Management domain.

During the time of the HMP update, the county was experiencing the worst pandemic of the 21st century, the novel coronavirus disease 2019 (COVID-19). Implications and lessons learned from this hazard will be included in detail during the next HMP update.

Secondary Impacts

The largest secondary impact caused by an epidemic or outbreak would be economic. The reduction in workforce and labor hours would cause businesses and agencies to be greatly impacted. With a reduced workforce, there may be transportation route closures or supply chain disruptions, resulting in a lack of food, water, or medical resources. Another large and costly secondary impact would be fear or stigmatization, which may result in isolation or social unrest. Hospitals and public health facilities may be inundated with individuals, including those with the disease and concerned about having contracted it. Finally, the disease may mutate, rendering cures and research unusable and contributing to the previously identified secondary impacts.

Exposure

All residents and visitors in the county could be susceptible to the effects and exposed to infectious disease. A large outbreak or epidemic could have devastating effects on the population. Those with compromised immune systems, children, individuals who are socioeconomic or health disadvantaged, and individuals with access and functional needs are considered some of the most vulnerable to diseases.

Health care facilities may reach capacity and become inundated with people. Early identification of shelters, alternate treatment facilities, isolation capacity, and methods to expand resources can help health care facilities and governments cope with an epidemic. However, epidemics and diseases would not have significant measurable impact on the critical facilities or infrastructure of the county.

Prepare: Actions You Can Take

- Store additional supplies of food and water.
- Have health supplies on hand.
- Get copies and maintain electronic versions of health records.
- Talk to family about what would be needed to care for them at home if they become sick.
- Ensure a continuous supply of prescriptions drugs are in supply at home.

Flood

Understanding the Hazard

Floods are one of the most common hazards in the United States, developing over a period of days or occurring rapidly without warning. The effects of floods can be local (impacting a neighborhood or community) to regional (impacting counties or states). While flooding often occurs in a floodplain, the extent to which a floodplain becomes inundated during a flood depends partly on the magnitude of the flood and partly on the surrounding landscape.

The headwaters and middle reaches of rivers in Snohomish County are typically steep and dominated by bedrock and boulders. In these areas, floodplains are often narrow or absent. When these rivers eventually reach the Puget Sound lowlands, they flatten out, deposit sediments, and form floodplains that are often broad, ecologically complex, and biologically productive.

In the relatively brief time since Euro-American settlement began in the Puget Sound basin, development has extensively altered the region's floodplains. Initially, these changes were caused by land clearing and installation of drainage systems that supported land uses such as farming, mining, and railroad transportation. More recently, intensive residential, commercial, and industrial land uses have come to occupy the downstream portions of some of Snohomish County's river valleys, increasing floodplain management conflicts and costs. It is in these flat, lowland floodplain areas that human development and flooding coincide, posing some of the greatest management challenges.

DEFINITIONS

Flood —Inundation of normally dry land resulting from rising and overflowing of a body of water.

Floodplain —The land adjoining a channel of a river, stream, ocean, lake, or other watercourse or waterbody that becomes inundated with water during a flood.

100-Year Floodplain—The area flooded by the flood 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.

500-year Floodplain —Also known as the 0.2-percent annual chance flood. The area inundated by floodwaters that has a 0.2-percent chance of being equaled or exceeded each year.

Return Period—The average period in years between occurrences of a particular hazard (equal to the inverse of the annual frequency of occurrence).

Occurrence and Probability

Flooding in Snohomish County has and continues to be documented by gage records, high water marks, damage surveys, and personal accounts. Since 1964, there have been 16 flood events that have resulted in property damage, FEMA disaster declarations, or deaths and injuries; ten floods resulted in a Disaster Declaration. Snohomish County experiences episodes of riverine flooding nearly every winter. Large, damaging floods have typically occurred every two to ten years. Urban portions of the county annually experience nuisance flooding related to drainage issues.

Principal flooding sources for Snohomish County include the following waterbodies:

- Sauk River
- Stillaguamish River
- Ebey Slough
- Snohomish River
- Skykomish River
- Snoqualmie River
- Pilchuck River

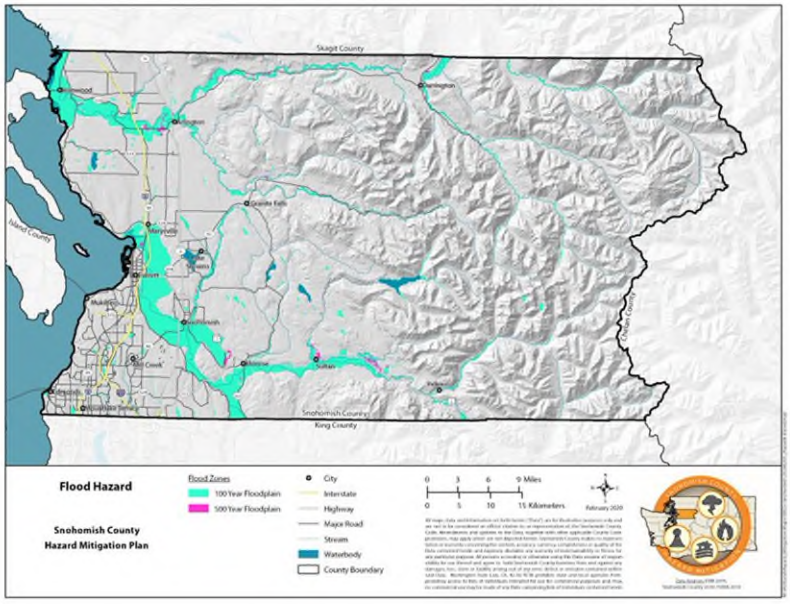
Secondary Impacts

The most problematic secondary hazard for flooding is bank erosion and rapid channel migration. In many cases, the threat and effects of bank erosion are more harmful than actual flooding. Flooding is also responsible for hazards such as landslides when high flows oversaturate soils on steep slopes, causing them the fail. Hazardous material spills can also occur if storage tanks rupture or sewage/manure lagoons overtop and spill into streams, rivers, or drainage sewers.

Flooding can cause increased mold growth within a home. People with asthma, allergies, or other breathing conditions may be more susceptible to mold. Sensitive persons may experience a stuffy nose, irritated eyes, wheezing, or skin irritation. There is also a possibility of power outages after a flood event.

Exposure

Population counts of those living in the floodplain is estimated to be 10,417 within the entire county. Spatial analysis indicates that there are 8,545 structures within the 100-year floodplain and 2,347 additional structures within the 500-year floodplain across the county; over 67 percent of these structures are in unincorporated areas. It is estimated that there would be up to $2.12 billion of flood loss from a 100-year flood event and $3.3 billion of flood loss from a 500-year flood event.



County Flood Hazard, 100- and 500- Year Floodplains

The following critical infrastructure and facilities have been identified as within a 100-year or 500-year floodplain:

- 1 Airport
- 128 Bridges
- 2 Dams
- 6 Fire/EMS
- 10 Government
- 2 Hazmat/Oil Facility
- 1 Medical
- 4 Police
- 7 Schools
- 20 Wastewater Facilities
- 2 Communication Facilities
- 8 Port Facilities

Prepare: Actions You Can Take

- Learn and practice evacuation routes, shelter plans, and flash flood response.
- Gather supplies in case of immediate evacuation.
- Purchase or renew a flood insurance policy.
- Keep important documents in a waterproof container.
- Move valuables to higher levels.
- Declutter drains and gutters.

Hazardous Materials

Understanding the Hazard

Hazardous materials are substances or materials that pose an unreasonable risk to health, safety, and property, and include hazardous substances, hazardous wastes, marine pollutants, elevated temperature materials, and others. Products are shipped daily on highways, railroads, waterways, and pipelines. A hazardous material may cause damage to people, property, or the environment when released to soil, water, or air.

Damage from hazardous materials can occur from the material's flammability, toxicity, corrosiveness, chemical instability, and/or combustibility. Material releases can seep through the soil and eventually into the groundwater, making water supplies unsafe to drink. Vapors from released materials can collect in houses and businesses, sometimes in low-lying areas, creating fire, explosion, and toxic inhalation hazards. Public health impacts of a release can vary from temporary skin irritation to death. Exposure can pose short- and long-term toxicological threats to humans, terrestrial and aquatic plants, and to land and marine wildlife.

Small releases can have the potential to endanger public health and contaminate groundwater, surface water, and soils. Environmental damage from such releases depends on the material spilled and the extent of contamination. Many are releases of small quantities that are contained and cleaned up quickly with little damage to the environment. While small releases can incur thousands of dollars of cleanup costs and damages, large releases can cost communities and companies millions of dollars.

DEFINITIONS

Hazardous Substance – Those substances listed in Appendix A of 49 CFR §172.101; does not include petroleum, natural gas, liquefied natural gas, or fuel.

Hazardous waste – Materials subject to 40 CFR §262.

Marine pollutant – Materials listed in Appendix B of 49 CFR §172.101.

Elevated temperature material – Materials which are in a liquid phase at a temperature at or above 212°F, or are in a liquid phase with a flash point at or above 100°F, or are in a solid phase at a temperature at or above 464°F.

Navigable waters – Waters of the United States, including territorial seas.

Accidental releases of petroleum, toxic chemicals, gases, and other hazardous materials occur frequently throughout Snohomish County. They occur on transportation corridors that include highways, railroads, air/flight paths, pipelines, and navigable waterways. Major transportation routes through Snohomish County include Interstate 5 (I-5), I-405, U.S. Route 2, State Route (SR-) 104, SR-99, SR-524, SR-527, SR-525, SR-522, SR-203, SR-9, SR-529, SR-92, SR-528, SR-530, SR-531, and SR-532. Potential for a release also exists on routes used for business and industrial purposes. BNSF railroad also runs along the West Coast and southern portion of the county.

Occurrence and Probability

Snohomish County experienced 150 oil spills between July 1, 2015 to September 30, 2019, 97 percent of which were under 100 gallons; five were 100 gallons and over. According to the Pipeline and Hazardous Materials Safety Administration, Snohomish County has experienced 189 hazardous materials incidents along transportation corridors since 1975.

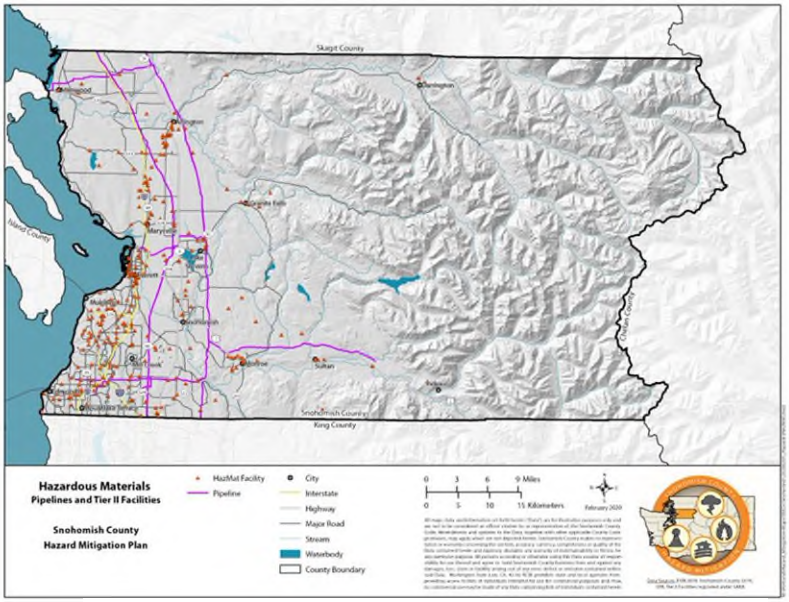
Hazardous material releases are more likely to occur in areas surrounding fixed site facilities and along major transportation routes in the county. There are 287 Tier II facilities listed in Snohomish County. Additionally, the EPA identifies 92 facilities under the Toxic Release Inventory.

Secondary Impacts

Hazardous material incidents can result in the contamination of air, water, and soils, leaving lasting long-term exposure and negative impacts on plants, animals, and even humans. Large-scale incidents can require long-term health and environmental monitoring costs to monitor impacts on humans and the environment. With certain materials, there is a chance for fire, which can result in an urban fire or wildfire. Long-term environmental impacts can in turn cause negative economic impacts to tourism or fishing.

Exposure

The entire population of Snohomish County is vulnerable to a hazardous material incident due to widespread use and storage throughout communities. Although the vulnerability is low, populations are more at risk due to higher utilization and transportation of hazardous materials. Communities along major transportation highway and rail transportation routes are at a higher risk for an incident. The general population may be exposed to a hazardous material release through inhalation, ingestion, or dermal exposure.



Hazardous Material Facilities – Pipelines and Tier II

Some hazardous materials pose a reactivity, fire, or explosion risk. Materials improperly stored in buildings have the potential to mix with incompatible substances which can result in polymerization, the production of heat, combustion or fire, and even an explosion.

Environmental damage resulting from a hazardous material incident can be on a scale from limited to disastrous. Released materials can end up in the air, soil, and water. Some materials contribute to the destruction of the ozone. As materials soak into the soil, they can kill microorganisms and nutrients that contribute to the livelihood of plants and animals. Hazardous materials can eventually reach the groundwater, potentially toxifying community drinking water systems. Materials that end up in bodies of water can kill off aquatic plants and animals and strain an ecosystem.

Prepare: Actions You Can Take

- Build an emergency supply kit with the addition of plastic sheeting and duct tape.
- Make a Family Emergency Plan.
- Know how to operate your home's ventilation system.
- Identify an above-ground shelter room with as few openings as possible.
- Read more about Sheltering in Place at https://www.ready.gov/shelter
- Learn and practice evacuation routes.

Mass Earth Movement

Understanding the Hazard

Mass earth movements can be a debris flow, mudslide, rock fall, sinkhole, or landslide; they denote any down-slope movement of soil, rock, or debris under the direct influence of gravity. There are five modes of slope movement: falls, topples, slides, spreads, and flows. Slope movement occurs when forces acting down-slope exceed the strength of the earth materials that compose the slope. Landslides can be initiated in slopes already on the verge of movement by rainfall, snowmelt, changes in water level, stream erosion, changes in ground water, earthquakes, volcanic activity, disturbance by human activities, or any combination of these factors.

A debris flow is a moving mass of loose mud, sand, soil, rock, water, and air that travels down a slope under the influence of gravity. To be considered a debris flow, more than half of the solids must be larger than sand grains. A mud flow is a mass of water and fine-grained earth materials that flow down a stream, ravine, canyon, arroyo, or gulch.

In general, landslide hazard areas are where the land has characteristics that contribute to the risk of the downhill movement of material, such as:

- A slope greater than 33 percent
- A history of landslide activity or movement in the past 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 of an alluvial fan, indicating vulnerability to the flow or debris or sediments
- The presence of impermeable soils, such as silt or clay, which are mixed with granular soils, like sand and gravel

The most common slide is the shallow colluvial slide, occurring in response to intense, short-duration storms. Less common, the largest and most destructive slides are deep-seated slides. The county's shoreline contains many large, deep-seated dormant landslides. Most landslides occur in January after the water table has risen during the wet months of November and December. In addition to the coastal bluffs, landslides are most prevalent around the slopes of the county's steep, linear hills. Water is involved in nearly all cases, and human influence has been identified in more than 80 percent of reported slides.

DEFINITIONS

Debris Flow – A form of rapid mass movement in which loose soil, rock, and sometimes organic matter combine with water to form a slurry that flows downslope.

Landslide—The sliding movement of masses of loosened rock and soil down a hillside or slope.

Mass Movement—A collective term for landslides, debris flows, falls and sinkholes.

Mudslide (or Mudflow)—A river of rock, earth, organic matter, and other materials saturated with water.

Sinkhole—A collapse depression in the ground with no visible outlet. Its drainage is subterranean. Commonly vertical-sided or funnel-shaped.

Occurrence and Probability

There are two FEMA disaster declarations for landslides/mudslides in Snohomish County and six events listed in the National Oceanic and Atmospheric Administration Storm Events Database. In 1997, a large slide occurred in Woodway, just north of the Richmond Beach neighborhood. It cut 50 feet into the

property above, passed over the railroad tracks, and knocked a freight train into the Puget Sound. The 2014 Oso landslide is the only known slide known to have caused fatalities in the county.

The recognition of ancient dormant mass movement sites is vital in the identification of areas susceptible to flows and slides. These sites can be reactivated by earthquakes, exceptionally wet weather, natural weathering, and strength-reduction processes, and are vulnerable to construction-triggered sliding.

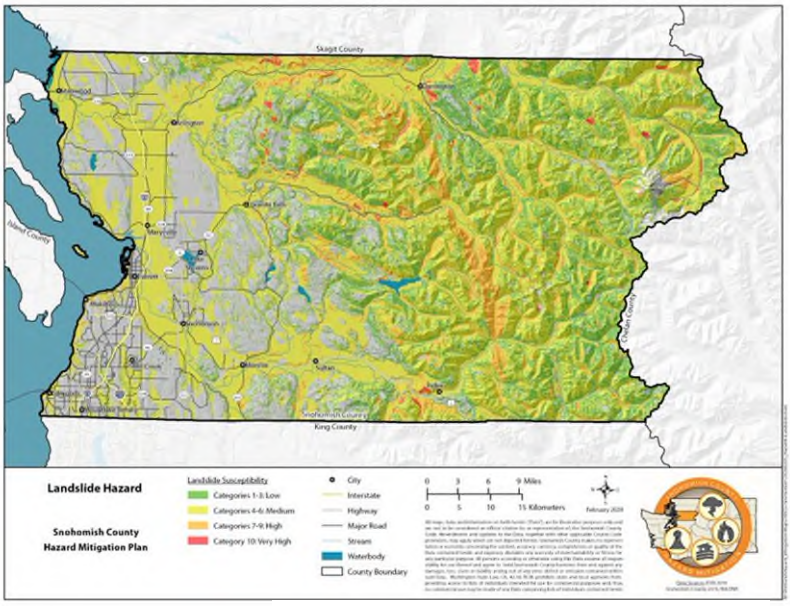
In Snohomish County, movements typically occur during and after major storms. Mass earth movements are typically unpredictable and can occur any month of the year. Slope failures cause an estimated 25 to 50 deaths and $3.5 billion in damage each year in the United States.

Secondary Impacts

Roads can become blocked or destroyed, isolating residents, communities, and businesses and delaying commercial, public, and private transportation. Poles can be knocked over resulting in loss of power and communication. There is also a risk of destabilizing the foundations of structures, resulting in property and monetary losses for businesses and homeowners. Earth movements can also block waterways, resulting in flooding, reduced water quality, and potential harm to fisheries and spawning habitat.

Exposure

The estimated county population living in earth movement risk areas is 233,967. Nearly 12,000 buildings worth an assessed value of approximately $32.3 billion are exposed to landslides. Landslides can impact the topography/morphology of both subaerial and submarine surfaces, rivers, streams, forests, and grasslands, and the habitats of native fauna, both on land and in water.



Landslide Hazard – Low to Very High Susceptibility

The following critical infrastructure and facilities are exposed to the mass earth movement hazard:

- 6 Airports
- 299 Bridges
- 3 Communication
- 15 Dams
- 37 Fire/EMS
- 4 Ferry
- 44 Government
- 12 Hazmat/Oil
- 24 Medical
- 17 Police
- 6 Power facilities
- 102 Schools
- 74 Wastewater facilities
- 6 Water Storage facilities
- 8 Port Facilities

Prepare: Actions You Can Take

- Build an emergency kit and make a family communications plan.
- Get insurance.
- Become familiar with the land around you, learn whether landslides have occurred in your area, and recognize warning signs.
- Get an assessment of your property by a qualified geotechnical professional if you live in the hazard area.
- Consider flexible pipe fittings, which can better resist breakage and avoid gas and water leaks.
- Recognize warning signs.

Tsunami

Understanding the Hazard

Tsunamis are waves caused by earthquakes, volcanic eruptions, or landslides under the sea. As waves travel inland, they build to higher heights as the depth of the ocean decreases. Waves can reach heights of over 100 feet and can travel at speeds over 500 miles per hour, the same speed as a commercial plane. Major tsunamis occur about once per decade; 59 percent of the world's tsunamis occurred in the Pacific Ocean, 25 percent in the Mediterranean Sea, 12 percent in the Atlantic Ocean, and 4 percent in the Indian Ocean. The time before a tsunami hits can vary from minutes to hours; higher ground should be sought out immediately.

Natural warning signs for tsunamis include severe ground shaking from local earthquakes, water receding from the coast and exposing the ocean floor, reefs, and fish, and abnormal ocean activity (a wall of water) creating a loud roaring sound similar to that of a train or jet aircraft. A tsunami's height and impacts are influenced by local bathymetry and topography and the direction from which the tsunami arrives.

Tsunamis typically cause the most severe damage and casualties near their source. Tsunamis with runups over one meter are particularly dangerous to people and property, but smaller tsunamis can also be dangerous. Strong currents can injure and drown swimmers, destroy boats, and destroy infrastructure in harbors. Low-lying areas such as beaches, bays, lagoons, harbors, river mouths, and areas along rivers and streams leading to the ocean are most vulnerable.

Most tsunami damage and destruction are caused by flooding, wave impacts, erosion, strong currents, and floating debris. As water returns to the sea, it takes debris and people with it. In addition to loss of life and mass injuries, other potential impacts include damage to and destruction of homes and businesses, ports and harbors, cultural resources, utilities, and critical infrastructure and facilities. Utilities, such as power, sewer, water, and communications, may be lost or disrupted and transportation, health, and public safety services may be delayed. Tsunamis can also cause hazardous material releases, contaminating water supplies and threatening public health.

DEFINITIONS

Runup – A measurement of the height of the water onshore observed above a reference sea level.

Tsunami – Comes from the Japanese words for *harbor* ("tsu") and *wave* ("nami"); a long high sea wave caused by an earthquake, submarine landslide, or other disturbance.

Tsunami from a large undersea earthquake – The earthquake must cause significant vertical deformation on the seafloor for a tsunami to occur.

Tsunami Advisory – Issued when strong currents and dangerous waves of 1-3 feet are expected.

Tsunami Warning – Issued by NTWC when a potential tsunami with significant widespread inundation is imminent or expected.

Tsunami Watch – Issued when an event may later impact the watch area; may be upgraded to tsunami warning.

Occurrence and Probability

There has been one tsunami to strike Snohomish County since 1800. In 1820, a large landslide from Camano Head created a tsunami that hit Hat Island, drowning an Indian village.

The Southern Whidbey Island Fault and Seattle fault pose the greatest danger from a tsunami. An earthquake along the SWIF or Seattle fault could produce a tsunami with the ability to reach shores in 30 minutes, giving emergency management officials little time to warn and evacuate people.

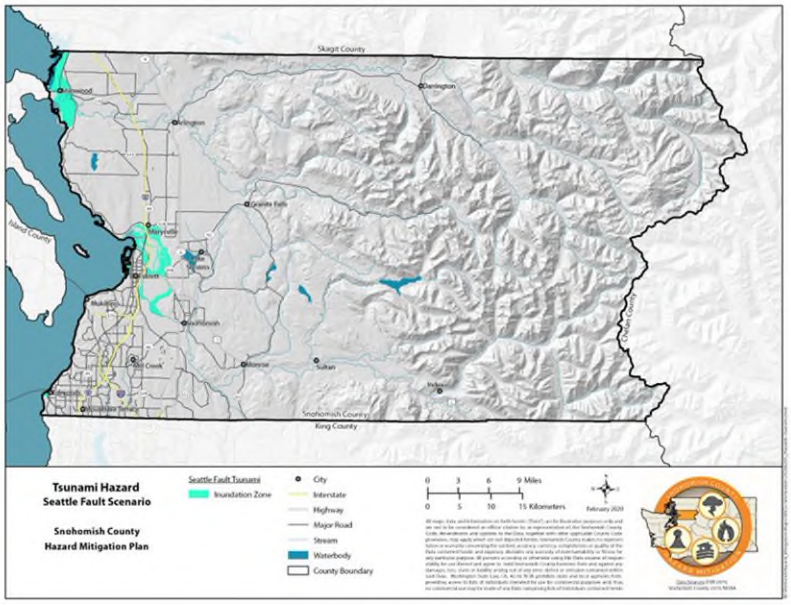
The SWIF can generate a tsunami that would affect the county. Earthquakes that occur throughout the region can trigger landslides, which may create or amplify tsunamis. The locations most susceptible to the tsunami hazard are the western coast of the county, the rivers inland from the bay, and the inland lakes.

Secondary Impacts

Tsunamis may bring in and produce tons of floating debris, endangering human lives and property. Ships moored in marinas or harbors may be destroyed or washed up onto shore. As vessels are broken up, they release oil and other hazardous materials into the environment; if any facilities on shore store hazardous substances those may also be released, contaminating the floodwater. Coastal structures such as breakwaters, piers, port facilities, and public utilities may be swept away from the force of the water or the erosion of the foundation below. The destruction of this property can hurt the economy of the area, affecting food, employment, and fuel. Utilities such as water, sewage, communications, and power may be disrupted or damaged.

Exposure

The estimated resident population living in tsunami hazard areas is 3,599 and an estimated 2,688 structures. The estimated worth of building-and-contents exposed to the tsunami hazard is $821 million.



Tsunami Hazard – Seattle Fault Scenario

The following critical infrastructure and facilities have been identified as exposed to a tsunami in the event of an earthquake on the Seattle Fault:

- 23 Bridges
- 1 Communication
- 2 Dams
- 8 Government
- 1 Medical
- 1 Oil Facility
- 2 Police
- 5 Port Facilities
- 4 Schools
- 23 Wastewater facilities
- 1 Water facility

Prepare: Actions You Can Take

- Learn about the risk of tsunami and learn and practice evacuation zones and routes.
- Learn the signs of a potential tsunami.
- Identify shelters 100 feet or more above sea level or at least one mile inland.
- Sign up through Smart 911.
- Create a family emergency communication plan with an out-of-state contact.
- Consider earthquake and flood insurance.

Volcanic Hazards

Understanding the Hazard

A volcano is a vent in the earth's crust through which magma, rock fragments, gases, or ash are ejected from its interior. Volcanoes may lie dormant for centuries between eruptions; therefore, the risk posed by volcanic activity is not always apparent. 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 different types of eruptive events include pyroclastic explosions, hot ash releases, lava flows, and gas emissions. Secondary hazards include flooding and lahars (i.e., mudflows), due to the melting of ice/snow and rainfall, and wildfires due to pyroclastic flows. Vulnerability factors to volcanic hazards include topographic characteristics (e.g., river channels), proximity of a population, non-load bearing roof structures for ash accumulations, and the lack of warning systems or evacuation plans.

Volcanoes can generate destructive lahars, ash fall, lava and pyroclastic flows, and debris avalanches. Acid rain, gases and fumes, and ash can negatively impact human and animal health. Ash can contaminate food and water, damage infrastructures and water systems, cause building collapses under accumulated weight, and interfere with communication systems and transportation. The impacts on transportation (e.g., air travel) can cause high economic losses.

DEFINITIONS

Lahar—A rapidly flowing mixture of water and rock debris that originates from a volcano. While lahars are most commonly associated with eruptions, heavy rains, and debris accumulation, earthquakes may also trigger them.

Lava Flow— Slow-moving stream of molten rock.

Lava Dome—A pile of viscous lava that forms a steep-sided mound over an erupting vent.

Pyroclastic Flow—A ground-hugging current of hot ash and gas that travels outward at high speed away from a volcano.

Stratovolcano— Typically a large, steep-sided, symmetrical cone built of alternating layers of lava flows and tephra layers.

Tephra—Ash and fragmented rock material ejected by a volcanic explosion.

Volcanic ash—Fine-grained rock fragments less than 0.08" (2 mm) in diameter.

Occurrence and Probability

The 1980 eruption of Mount St. Helens buried 23 square miles of the North Fork Toutle and generated a pyroclastic flow that covered 230 square miles north of the volcano, causing 57 fatalities. Glacier Peak in eastern Snohomish County is a major Cascade stratovolcano thought to have erupted as recently as the eighteenth century. Except for Mount St. Helens, Glacier Peak has produced larger and more explosive eruptions than any other Washington volcano.

United States Geological Survey scientists have described evidence of large prehistoric lahars from Glacier Peak for most of these eruptive episodes. During the eruptions 13,600 and 5,000 to 7,000 years ago, heavy-flow lahars caused the Sauk Valley at Darrington to fill up with material. This filling of the valley forced the river to switch course into the North Fork of the Stillaguamish River. The Mount St. Helens volcanic eruption is the only event to result in a federal disaster declaration for this hazard.

Glacier Peak is the only volcano capable of producing a lahar that travels into the county. Only the eastern border of the county is at higher risk of ashfall from a Glacier Peak eruption, due to prevailing winds blowing toward the east. However, it is worth noting that surface-level winds do blow westward about 10 percent of the time; it would be possible for a significant eruption of Glacier Peak to deliver heavy ashfall to Snohomish County under these weather conditions.

Most of the county falls within the ashfall hazard zone of Mount St. Helens, which is over 110 miles to the south. Mount St. Helens has wide-reaching impacts here for two reasons: (1) it has much more frequent volcanic activity than any other Cascade Range volcano, and (2) there is a greater likelihood of winds blowing the ash northward toward Snohomish County.

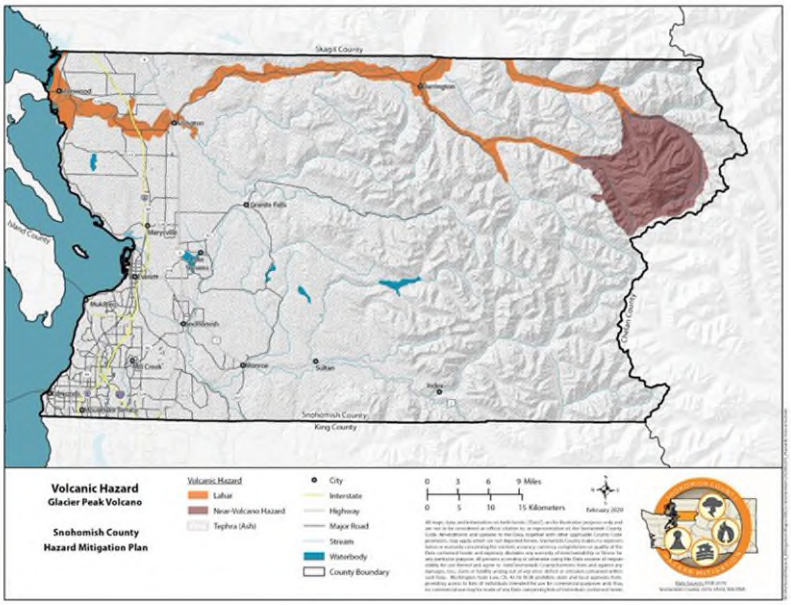
Secondary Impacts

Ashfall can contaminate food and water, causing health issues. Persons with preexisting respiratory issues may face medical difficulties with fine ash in the air. Although unlikely in Snohomish County, weight of ash accumulation may cause problems for buildings. Interference for communication systems, poor visibility, and slippery roads are all issues that may arise from ash. In addition, lahars, landslides, and mudslides may occur, and wildfires may spread from the heat of a pyroclastic flow.

Exposure

It is estimated that the population exposed in the lahar zone is 7,696 and the entire population of the county is vulnerable to volcanic ash. There are approximately 7,632 buildings worth $1.2 billion located in the lahar zone.

The following critical infrastructure and facilities have been identified as exposed in the lahar zone:



Glacier Peak Volcanic Hazard – Lahar and Near-Volcano Hazard

- 1 Airport
- 66 Bridges
- 2 Dams
- 6 Fire/EMS
- 5 Government
- 1 Hazmat
- 1 Medical
- 2 Police
- 1 Power Facility
- 8 Schools
- 3 Wastewater facilities
- 1 Water facilities

Prepare: Actions You Can Take

- Know your area's risk from volcanic eruption and learn shelter and evacuation plans.
- Sign up for the Volcano Notification Service.
- Gather supplies in case of immediate evacuation.
- Consult your doctor if you have existing respiratory difficulties.
- Have a shelter-in-place plan if there is risk from ash.
- Find out what your homeowner's insurance policy will cover should a volcano erupt.

Wildfire

Understanding the Hazard

A reportable wildland fire is any fire involving vegetative fuels, including a prescribed fire, that occurs in the wildland or wildland-urban interface (WUI) areas, including those fires that threaten or consume structures. Most natural fires are caused by lightning; however, a small percentage of fires are caused by spontaneous combustion or other natural means. A majority of wildland fires are caused by human activity such as smoking, campfires, equipment use, and arson. Wildfires can happen every month of the year; drought, snowpack, and local weather conditions such as high winds can expand the length of the fire season. How a fire behaves depends on the following:

- Fuel – Fuel load plays a factor along with mixed fuel types (e.g., vegetative underbrush under the canopy). Lighter fuels such as grasses, leaves, and needles quickly expel moisture and burn rapidly, while heavier fuels such as tree branches, logs, and trunks take longer to warm and ignite. Dead, dying, and diseased trees present a higher hazard.
- Weather – Strong, dry winds and relative humidity plays a large part in determining fire conditions.
- Terrain – The topography of a region influences the amount and moisture of fuel, the impact of weather conditions (such as temperature and wind), potential barriers to fire spread (such as highways and lakes), and elevation and slope of landforms (uphill vs. downhill). South facing slopes, box canyons, and saddles can intensify fire spread.

The potential for significant damage to life and property exists in areas designated as WUI areas, where development is adjacent or among lands prone to wildland fire.

DEFINITIONS

Conflagration—A fire that grows beyond its original source area to engulf adjoining regions. Wind, extremely dry or hazardous weather conditions, excessive fuel buildup, and explosions are usually the elements behind a wildfire conflagration.

Firestorm—A fire that expands to cover a large area, often more than a square mile. A firestorm usually occurs when many individual fires grow together into one. The area involved becomes so hot that all combustible materials ignite, even if they are not exposed to direct flame. Temperatures may exceed 1,000°C. Superheated air and hot gases of combustion rise over the fire zone, drawing surface winds in from all sides, often at velocities approaching 50 miles per hour. Although firestorms seldom spread because of the inward direction of the winds, once started, there is no known way of stopping them.

Interface Area—An area susceptible to wildfires and where wildland vegetation and urban or suburban development occur together. An example would be smaller urban areas and dispersed rural housing in forested areas.

Wildfire—Fires that result in uncontrolled destruction of forests, brush, field crops, grasslands, and real and personal property in non-urban areas. Because of their distance from firefighting resources, they can be difficult to contain and cause a great deal of destruction.

Occurrence and Probability

The greatest potential danger zones are the WUI areas. There is no record of any large wildland fire (greater than 1,500 acres) in the county since 1900. The Washington Department of Natural Resources (DNR) has records of 977 wildland fire starts dating back to 1970.

WUIs tend to be in the foothills and valleys east of Puget Sound stretching into the lower reaches of the Cascades, where people are present in semi-urban densities. Wildland fire analysis has been done using WUI data created by DNR, which analyzed areas with population densities of at least 20 people per square mile, defensible space, access and ingress, water capabilities, fuel supply, weather and topography, and speed of response.

Secondary Impacts

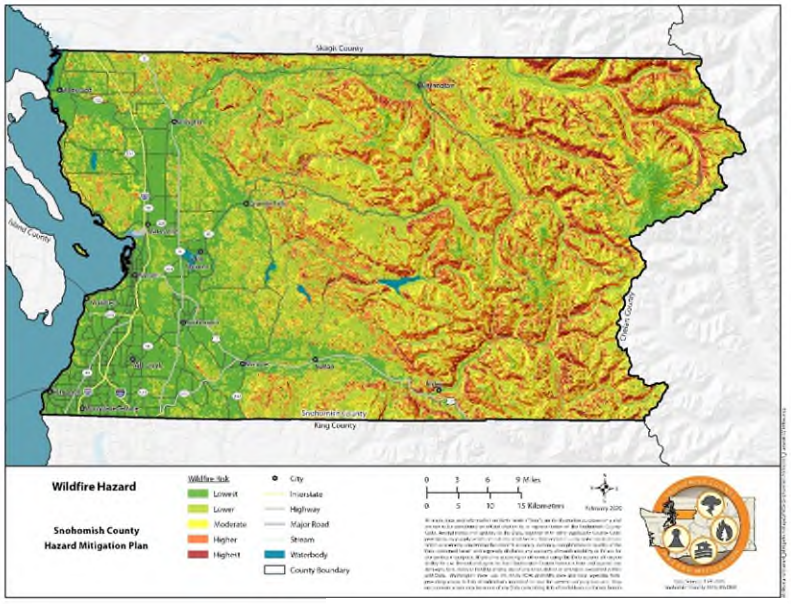
A wildfire may generate secondary hazards or cascading effects, including:

- Reduction of harvestable timber
- Indirect economic losses (e.g., reduced tourism)
- Mass earth movement
- Contamination of reservoirs and drinking water
- Disruption of utilities
- Contribution to increase flooding
- Release of hazardous materials
- Limited access to supplies and services

Exposure

It is estimated that the population living with WUIs is 16,406. Smoke and air pollution from surrounding wildfires can be a health hazard to residents, especially for sensitive populations. There are 6,589 buildings that are exposed to at least moderate wildland fire hazards, worth an estimated $1.3 billion.

The following critical infrastructure and facilities have been identified as exposed to at least moderate wildland fire hazards:



Wildfire Hazard – Lowest to Highest

- 39 Bridges
- 1 Communication
- 1 Dam
- 3 Fire/EMS
- 2 Government
- 27 Hazmat
- 1 Police
- 1 School
- 1 Natural Gas Facility

Prepare: Actions You Can Take

- Sign up through Smart 911.
- Know your community's evacuation plans and find several ways to leave the area. Drive the routes and find shelter locations.
- Have a plan for pets and livestock.
- Make an emergency kit, including N95 respirator masks. Don't forget the needs of pets.
- Designate a room that can be closed off from outside air.
- Keep important documents in a fireproof, safe place.
- Review your insurance coverage.

Weather Events

Understanding the Hazard

Severe weather can be defined as dangerous meteorological or hydro-meteorological phenomena of varying duration with risk of causing major damage, serious social disruption, and loss of human life, and requiring measures for minimizing loss, mitigation, and avoidance. This can include severe thunderstorms, flash floods, damaging winds, extreme heat, large hail, and winter storms.

Severe weather can be categorized into two types: systems that form over wide geographic areas are classified as general severe weather; those with a more limited geographic area are classified as localized severe weather. Severe weather events are not the same as extreme weather; extreme weather refers to phenomena that are at the extremes of the historical distribution and are rare for a particular place and/or time.

Damage from severe and extreme weather events varies. Examples can include destruction of structures and infrastructure, multiple injuries and deaths, hazardous material releases or oil discharges, and utility failure. Severe weather can also lead to mass earth movements. Damage from storms themselves and cascading impacts/secondary hazards can cost millions of dollars.

DEFINITIONS

Severe Local Storm – Small atmospheric systems including tornadoes, thunderstorms, and windstorms. 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.

Windstorm—A storm featuring violent winds. Southwesterly winds are associated with strong storms moving onto the coast from the Pacific Ocean. Southern winds are the strongest and most destructive winds.

Winter Storm – A storm having significant snowfall, ice, and/or freezing rain.

Occurrence and Probability

Western Washington has a predominantly marine climate. 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 190 days in the mountains and along the coast. Thunderstorms occur approximately 10 days each year over the lower elevations and around 15 days over the mountains. Damaging hailstorms are rare.

During the summer months of July and August, weeks can pass with few showers. December and January bring precipitation, frequently recorded on 25 days or more each month. Snowfall is light in the lower elevations and heavier 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. The strongest winds are generally from the south or southwest and occur during fall and winter.

The National Oceanic and Atmospheric Administration has recorded a total of 112 weather events in Snohomish County, which have resulted in approximately $40.65 million in property damage and six deaths. There are 13 severe weather events that resulted in presidentially declared disaster declarations.

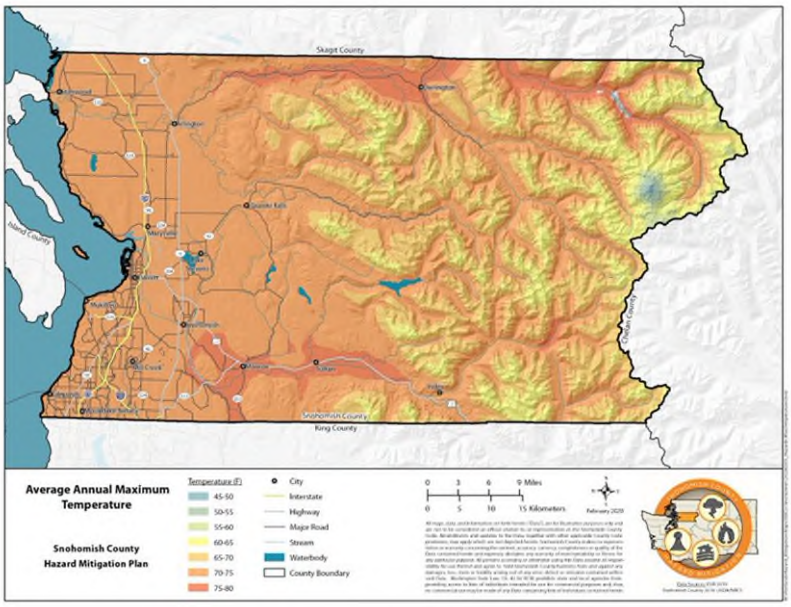
Severe and extreme weather events have the potential to happen anywhere in the county. Communities in low-lying areas next to stream, lakes, or shorelines are more susceptible to flooding. Wind events are most damaging to areas that are heavily wooded. Predicting the frequency of severe weather events in a constantly changing climate is a difficult task. It can be assumed that the county can expect to experience exposure to and adverse impacts from some type of severe or extreme weather event at least annually.

Secondary Impacts

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 and stormwater from heavy rains 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. Fires, both structural and wild, along with power outages, can occur as a result of lightning strikes.

Exposure

A lack of data separating severe weather damage from flooding and landslide damage prevented a detailed analysis for exposure and vulnerability. It can be assumed that the entire county is exposed, to some extent, to severe and extreme weather events. Populations living in heavily wooded areas may be more susceptible to wind damage and utility loss, while populations living in low-lying areas are at an increased risk for flooding. There are approximately 285,819 buildings that are exposed to weather events. All critical facilities vulnerable to flooding are also likely exposed to severe and extreme weather.



Average Annual Maximum Temperatures

Prepare: Actions You Can Take

- Understand the type of hazardous weather that affects you and your family where you live.
- Sign up through Smart 911.
- Identify nearby sturdy buildings close to where you live, work, study, and play.
- Cut down or trim trees that may be in danger of falling on your home.
- Consider buying surge protectors.
- Gather supplies in case you need to stay home for several days without power.

Snohomish County 2020 Hazard Mitigation Plan

Part 1: Planning Process Overview and Community Profile

PART 1
Planning Process Overview

1 Introduction to Hazard Mitigation Planning

1.1 The Big Picture

Hazard mitigation is the use of long- and short-term strategies to reduce or alleviate the loss of life, personal injury, and property damage that can result from a disaster. It involves strategies such as planning, policy changes, programs, projects, and other activities that can mitigate the impacts of hazards. The responsibility for hazard mitigation lies with many, including private property owners, business and industry, and local, state, and federal government. Mitigation plans are key to breaking the cycle of disaster damage, reconstruction, and repeated damage (FEMA 2019a).

Prior to 2000, federal disaster funding in the United States focused on relief and recovery, with limited funding for hazard mitigation planning. In 2000, the federal Disaster Mitigation Act required state and local governments to develop hazard mitigation plans (HMPs) as a condition for receiving disaster-related federal grant assistance (Public Law 106-390, approved by Congress on October 10, 2000). Commonly known as the DMA or the 2000 Stafford Act amendments, the act emphasizes the importance of community hazard mitigation planning before disasters occur.

The DMA encourages state and local authorities to work together on pre-disaster planning, and it promotes "sustainable hazard mitigation," which includes the sound management of natural resources, local economic and social resiliency, and the recognition that hazards and mitigation must be understood in the largest possible social and economic context. The enhanced planning network called for by the DMA helps local governments articulate precise needs for mitigation, resulting in faster allocation of funding and more cost-effective risk reduction projects.

1.2 Local Concerns

Snohomish County residents live in an environment with natural and human-caused hazards. Hazards like extreme weather and flooding may occur relatively often, arising multiple times within a person's life, while other hazards, like volcanic eruptions and large earthquakes, are less frequent, occurring once or not at all in a person's life. Whether hazard events occur frequently or infrequently, hazards potentially present risks to human life, health, property, and wellbeing. All hazards may impact the economy, supply of basic goods and services, employment, ecosystem services, and general quality of life.

1.3 Purposes for Planning

Snohomish County continues to update its HMP to better identify and prioritize
actions to reduce or alleviate risks from all hazards, which reduces loss of life, personal injury, and property damage to residents and businesses within the county. The HMP also enables Snohomish County, partnering jurisdictions, and special purpose districts to maintain eligibility for disaster-related federal grant assistance, in accordance with the DMA (2000). In addition, the HMP helps meet the planning requirements of the Federal Emergency Management Agency's (FEMA) Community Rating

System (CRS), which allows partners that participate in the CRS program to maintain or enhance their CRS classifications.

1.4 Who Will Benefit from This Plan

The residents and businesses of the entire Snohomish County planning area are the ultimate beneficiaries of this HMP. The plan strives to reduce risk for those who live in, work in, and visit Snohomish County. Participation in development of the plan by key stakeholders in the county will help ensure mutually beneficial outcomes. The resources and background information in the plan are applicable countywide, and the plan's goals and recommendations can lay groundwork for the development and implementation of local mitigation activities and partnerships.

1.5 Contents of This Plan

The plan uses four goals and 16 objectives to guide plan development and mitigation-strategy identification and prioritization.

The tables below identify the goals and objectives adopted by the Steering Committee. The Steering Committee established the goals and the Planning Team established the objectives. Achievement of these goals defines the effectiveness of a mitigation strategy, which are also used to help establish mitigation strategy priorities for each of the jurisdictions. Each goal has a distinct set of objectives, and each objective will help to measure the effectiveness of mitigation initiatives and plan.

Goal 1 Reduce Hazard and Threat-related Injury and Loss of Life.	
Item	Objectives
1.1	Develop and implement policies that integrate hazard and risk information into building codes and land use planning that promote resilient and safe development in high-risk areas.
1.2	Strengthen tools to remove threatened uses in hazardous areas and relocate them where risk reduction measures support development to a tolerable level.
1.3	Reduce the adverse impacts from and leverage the beneficial functions of natural hazards.
1.4	Develop continuity of operations plans and community-based continuity plans to mitigate the impacts of hazards becoming disasters, and support disaster preparedness, response, and recovery.
1.5	Develop, implement, and sustain programs that promote reliable, redundant, and resilient lifeline systems.

Goal 2 Promote Resilient Communities, Resilient Economy, Sustainable Growth, and Hazard Prevention.	
Item	Objectives
2.1	Provide incentives that support the mitigation of impacts to critical business operations including small businesses and those located in high risk areas.
2.2	Increase the resilience of critical services, facilities, and infrastructure through applicable retrofits, sustainable funding programs, and zoning and development changes, and reduce exposure/vulnerability to all hazards.

Goal 2 Promote Resilient Communities, Resilient Economy, Sustainable Growth, and Hazard Prevention.	
Item	Objectives
2.3	Promote the ability of communities to mitigate, prepare for, respond to, and recover from an emergency or disaster through the strengthening of community networks and development of community-based emergency planning (e.g., evacuation zones and routes, and micro-infrastructure networks).

Goal 3 Consider Equity When Enhancing Public Awareness and Community Members' Ability to Mitigate, Prepare for, Respond to And Recover from a Disaster.	
Item	Objectives
3.1	Reduce the adverse impacts of disasters on vulnerable communities.
3.2	Create and enhance equitable public information programs and access to hazard information that promotes actionable preparedness and mitigation measures.
3.3	Identify and prioritize opportunities to increase capacity and redundancy for critical services, facilities, and infrastructure to vulnerable communities with special emphasis on communities that are at risk of isolation.

Goal 4 Make Decisions through Regional Collaboration.	
Item	Objectives
4.1	Support the alignment and integration of the 2020 HMP goals, objectives, and strategies with other planning processes.
4.2	Develop a coordinated incentive program for eligible entities to adapt to risks through structural and nonstructural measures (e.g., acquisition program for homes or other uses located within high-risk hazard areas).
4.3	Use the best available science when developing new or updating existing plans to prepare for and adapt to climate impacts (e.g., update conservation requirements to minimize impacts of drought).
4.4	Support improved data collection, assessment, analysis, and implementation for all-hazards.
4.5	Develop a coordinated flood mitigation strategy that leverages sustainable funding sources for flood control improvements and identifies opportunities for multiagency collaboration.

The hazards covered in the plan are listed in the table below:

Rank	Hazard	Hazard Includes
1	Earthquake	
2	Epidemic	
3	Hazardous Materials	Train Accident
4	Weather Events	Windstorm
		Winter Storm
		Drought
5	Flooding	
6	Dam Failure	
7	Wildfire	
8	Cybersecurity Threats	
9	Mass Earth Movement	Landslides and Mudslides
10	Volcano	
11	Active Assailant	
12	Aircraft Accident	
-	Tsunami	

The Steering Committee adopted the above aggregated list of hazards for the building out of hazard profiles and mitigation strategies, which is discussed at length in Part 2 – Risk Assessment. The Steering Committee identified tsunami as a hazard to be included in the 2020 HMP update following the hazard ranking exercise; therefore, this hazard has not been ranked. Additionally, the Steering Committee and the Planning Team elected to remove avalanche due to its low-risk profile and utility failure as it is an outcome of a hazard occurring, not a hazard. The Steering Committee identified active assailant and aircraft accident as hazards that should be profiled but that could not be mitigated, and to aggregate certain hazards (e.g., mass earth movement includes landslide and mudslide) to streamline analysis.

2 Plan Update

2.1 The Previous Plans

In 2005, Snohomish County and a planning partnership of dozens of local agencies within the county embraced the concept of the DMA and prepared one of the largest multi-jurisdictional HMPs in the western U.S. The planning process took over 17 months and generated a plan that identified 261 initiatives to be implemented by 43 partners (13 municipalities and 30 special purpose districts).

In 2009, the County applied for and secured federal Pre-Disaster Mitigation Grant Program (PDM) funding to update the 2005 HMP. Due to the success of the initial plan, the same structure was used for the 2010 update. The 2010 HMP identified 330 mitigation initiatives and involved 35 partner organizations. The plan received formal approval by FEMA on September 14, 2010 for the updated HMP.

In 2013, Snohomish County was awarded a PDM to update prepare the 2015 update to the Snohomish County HMP. The County hired a consultant to prepare the plan with oversight from the Planning Committee. The committee acted as the principal vehicle for public involvement during the plan update

process. The process covered five principal phases: organization, risk assessment, public involvement, plan development, and adoption. The plan received formal approval by FEMA on September 8, 2015.

The 2015 HMP included a single guiding principle, five goals, nine objectives, and 38 mitigation strategies. Each initiative was prioritized based on the benefits of the project versus the cost, whether the project met multiple objectives, and whether the project could be implemented within the capabilities of the jurisdiction. The action plan was reviewed annually via a prescribed plan maintenance process that involved progress reports reviewed and prepared by the same Planning Committee that oversaw the plan's development.

2.2 Why Update?

The Code of Federal Regulations (CFR) Title 44 (44CFR) stipulates that HMPs must describe the method and schedule for monitoring, evaluating, and updating the plan. Prescribing an update schedule establishes an opportunity to reevaluate recommendations, monitor the impacts of actions that have been accomplished, and determine if there is a need to change the focus of mitigation strategies. DMA compliance is contingent on meeting the plan update requirement. A jurisdiction covered by a plan that has expired is not able to pursue elements of federal funding under the Stafford Act, which requires a current HMP for eligibility.

2.3 The Updated Plan—What is Different

The plan has been significantly enhanced using recently updated best available data and technology, especially in the risk assessment portion of this update. This plan update followed the same basic planning process as was followed under the initial effort. The Steering Committee and Planning Team were critical components in the process. Table 2-1 indicates the major changes between the 2015 and 2020 plans as they relate to 44CFR planning requirements.

Table 2-1
Major Changes

44CFR Requirement	2015 Hazard Mitigation Plan	2020 Hazard Mitigation Plan
44CFR 201.6(b): An open public involvement process is essential to the development of an effective plan. In order to develop a more comprehensive approach to reducing the effects of natural disasters, the planning process shall include: (1) An opportunity for the public to comment on the plan during the drafting stage and prior to plan approval; (2) An opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, and agencies that have the authority to regulate development, as well	Volume 1, Chapters 3, 4, and 5 describe the planning process this updated plan went through, including description of the planning process, organizing resources, and public involvement.	Part 1, Sections 3.6 and 3.7 describe the public involvement process and the opportunities presented for comments on the plan during drafting stages and prior to plan approval. Part 1, Section 3.4 describes the opportunity for other communities and agencies to be involved in the plan update process. Part 1, Section 3.5 provides an overview of the review and incorporation of plans, studies, reports, and technical information.

Table 2-1 Major Changes		
44CFR Requirement	2015 Hazard Mitigation Plan	2020 Hazard Mitigation Plan
as businesses, academia and other private and non-profit interests to be involved in the planning process; and (3) Review and incorporation, if appropriate, of existing plans, studies, reports, and technical information.		
44CFR 201.6(c)(2): A risk assessment that provides the factual basis for activities proposed in the strategy to reduce losses from identified hazards. Local risk assessments must provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards.	Part 2 of Volume 1 presents a comprehensive risk assessment for the planning area that looks at ten hazards of concern: climate change, avalanche, dam /levee failure, earthquake, flood, landslide, severe weather, volcano, and wildland fire. All data from 2010 plan was updated with best available data. Hazards, United States-Multi Hazard (HAZUS-MH) was used for dam failure, earthquake, flood, and tsunami. Appendix B presents preliminary risk assessment information for hazardous materials and pipelines. Because of limitation in modeling capability during this update, the tsunami hazard information was moved to the secondary impacts subsection of the earthquake risk assessment.	Part 2, Chapter 5 details the methodology and tools utilized in the comprehensive risk assessment. The 13 hazards of concern looked at in the risk assessment were (1) active assailant, (2) aircraft accident, (3) earthquake, (4) epidemic, (5) hazardous materials, (6) weather events, (7) flooding, (8) dam failure, (9) wildfire, (10) cybersecurity threats, (11) mass earth movement, (12) volcano, and (13) tsunami. The latest data available in HAZUS-MH was used for dam failure, earthquake, flood, and tsunami.
44CFR 201.6(c)(2)(i): [The risk assessment shall include] a description of the type, location, and extent of all natural hazards that can affect the jurisdiction. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.	Chapters 11–19 present a comprehensive risk assessment of each hazard of concern. Each chapter is broken down into the following components: • hazard profile, including maps of extent and location, historical occurrences, frequency, severity, and warning time • secondary hazards • climate change impacts	Part 2, Chapters 6–18 outline a comprehensive risk assessment for each hazard of concern, not just natural hazards. The updated hazard profile incudes a more general overview of the hazard and updated historical occurrences. Future probability was updated based on the latest data and studies. Scenarios were removed. Hazard maps were updated with the

Table 2-1 Major Changes		
44CFR Requirement	2015 Hazard Mitigation Plan	2020 Hazard Mitigation Plan
	• exposure of people, property, critical facilities, and environment • vulnerability of people, property, critical facilities, and environment • future trends in development • scenarios • issues	latest data and added to the end of the profiles.
44CFR 201.6(c)(2)(ii): [The risk assessment shall include a] description of the jurisdiction's vulnerability to the hazards described in paragraph (c)(2)(i) of this section. This description shall include an overall summary of each hazard and its impact on the community.	Vulnerability was assessed for all hazards of concern, with the exception of levee failure. The HAZUS-MH computer model was used for the dam failure, earthquake, and flood hazards. These were Level 2 analyses using planning partner and county data. "User defined" analysis techniques were applied to the flood and dam failure hazards. Additionally, site-specific data on county identified critical facilities was entered into the HAZUS model. Qualitative assessments were developed for other hazards. The asset inventory was based on County Assessor's "user defined facilities" data. Best available data was used for all analyses.	Vulnerability was assessed for all hazards of concern. The HAZUS-MH computer model was used for the earthquake and flood hazards. These were Level 2 analyses using updated planning partner and county data. "User defined" analysis techniques were applied to the flood and earthquake hazards. Additionally, updated site-specific data on county identified critical facilities was entered into the HAZUS model. The vulnerability assessment for all other hazards determined the total assessed value of all buildings exposed to the hazard. The updated asset inventory was based on County Assessor's "user defined facilities" data. Best available data was used for all analyses.
44CFR 201.6(c)(2)(ii): All plans approved after October 1, 2008 must also address [the National Flood Insurance Program] (NFIP) insured structures that have	The repetitive loss section meets DMA and CRS planning requirements. The update includes a comprehensive analysis of repetitive loss areas that includes	The repetitive loss section meets DMA and CRS planning requirements. The update includes a comprehensive analysis of

Table 2-1 Major Changes		
44CFR Requirement	2015 Hazard Mitigation Plan	2020 Hazard Mitigation Plan
been repetitively damaged by floods.	an inventory of the number and types of structures in the repetitive loss area. Repetitive loss areas were delineated, causes of repetitive flooding were cited, and these areas were reflected on maps.	repetitive loss areas. Repetitive loss areas were delineated, and these areas were reflected on maps.
44CFR 201.6(c)(2)(ii)(A): The plan should describe vulnerability in terms of the types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard area.	A complete inventory of the numbers and types of buildings exposed was generated for each hazard of concern. The Planning Committee defined "critical facilities" as they pertained to the planning area, and these facilities were inventoried by exposure. Each hazard chapter provides a discussion on future development trends as they pertain to each hazard.	A complete inventory of the numbers and types of buildings exposed was generated for each hazard of concern. This included County Assessor's "user defined facilities" data for existing buildings. Critical facilities were compiled using updated planning partner and county data. Each hazard profile includes a section on the updated future development trends in the county.
44CFR 201.6(c)(2)(ii)(B): The plan should describe an estimate of the potential dollar losses to vulnerable structures identified in paragraph (c)(2)(ii)(A) of this section and a description of the methodology used to prepare the estimate.	Loss estimations in terms of dollar loss were generated for all hazards of concern with the exception of avalanche, climate change, and levee failure hazards. The estimates were generated by HAZUS-MH for the dam failure, earthquake, and flood hazards. The asset inventory was the same for all hazards and based on County Assessor's "user defined facilities" data.	Loss estimations in terms of dollar losses were generated for all hazards of concern except epidemic, cybersecurity incident, active assailant, and aircraft accident hazards. Loss estimates for Earthquake and Flood came directly from the HAZUS-MH model. The loss estimates for all other hazards was determined by the assessed value of all buildings exposed to the hazard. The asset inventory was the same for all hazards and based on County Assessor's "user defined facilities" data.

Table 2-1 Major Changes		
44CFR Requirement	2015 Hazard Mitigation Plan	2020 Hazard Mitigation Plan
44CFR 201.6(c)(2)(ii)(C): The plan should provide a general description of land uses and development trends within the community so that mitigation options can be considered in future land use decisions.	Using data from the Snohomish County buildable lands analysis required by the Washington Growth Management Act, the plan includes discussion on future development trends for each identified hazard of concern.	This update utilized the most current available analysis of Snohomish County buildable lands. The plan includes discussion on future development trends for each identified hazard of concern.
44CFR 201.6(c)(3): The plan should include a mitigation strategy that provides the jurisdiction's blueprint for reducing the potential losses identified in the risk assessment, based on existing authorities, policies, programs and resources, and its ability to expand on and improve these existing tools.	The update includes both countywide initiatives and jurisdiction specific initiatives. A crosswalk to actions identified in the initial plan has been provided in the plan update to identify the status of actions identified in the 2010 plan.	Countywide actions were removed. Each jurisdiction reviewed and provided the status of their 2015 strategies. Each jurisdiction then provided a new, prioritized list of updated and original strategies.
44CFR 201.6(c)(3)(i): [The mitigation strategy shall include] a description of mitigation goals to reduce or avoid long-term vulnerabilities to the identified hazards.	The Planning Committee determined that the original guiding principle and goals and are still relevant for the updated plan. The objectives were updated and are found in Chapter 5.	The Steering Committee adapted the 2015 countywide actions items and turned them into objectives assigned to the new goals of this plan.
44CFR 201.6(c)(3)(ii): [The mitigation strategy shall include] a section that identifies and analyzes a comprehensive range of specific mitigation actions and projects being considered to reduce the effects of each hazard, with particular emphasis on new and existing buildings and infrastructure.	A mitigation strategy list was used by the partners during the update process. The list supported each planning partner as the mitigation catalog did during the 2010 plan development process. The mitigation list was included in the body of the plan of the update, and not as an appendix. The mitigation catalog from the 2010 Plan was included as an appendix in this update. An analysis of mitigation initiatives matrix was added to each jurisdictional annex to identify which of mitigation categories each initiative meets. This helps to illustrate the comprehensive range of actions identified.	With the removal of the previous Countywide action items, each jurisdiction was given the opportunity to add and create new mitigation strategies to their 2020 strategy matrix. For each strategy identified for 2020, jurisdictions were asked to complete a prioritization workbook, stating which goals the strategy met, current status, hazards it addressed, primary and supporting agencies, cost, timeline, funding source, and priority.

Table 2-1 Major Changes		
44CFR Requirement	2015 Hazard Mitigation Plan	2020 Hazard Mitigation Plan
44CFR 201.6(c)(3)(ii): [The mitigation strategy shall] address the jurisdiction's participation in the NFIP, and continued compliance with NFIP requirements, as appropriate.	All municipal planning partners that participate in the NFIP have identified an action stating their commitment to maintain compliance and good standing under the NFIP. Additionally, communities that participate in the CRS have identified actions to maintain or enhance their standing under the CRS program.	All jurisdiction annexes contain information about repetitive loss properties and NFIP policy numbers, dates, and claims. All annexes also state the municipal codes in place for municipalities to continue compliance with the NFIP requirements.
44CFR 201.6(c)(3)(iii): [The mitigation strategy shall include] an action plan describing how the actions identified in paragraph (c)(3)(ii) of this section will be prioritized, implemented, and administered by the local jurisdiction. Prioritization shall include a special emphasis on the extent to which benefits are maximized according to a cost benefit review of the proposed projects and their associated costs.	The same prioritization scheme from 2010 was carried over to the 2015 plan. This scheme is described in Chapter 1 of Volume 2 of the 2015 plan.	In Section 5 of every jurisdiction annex, planning partners reviewed mitigation initiatives for the 2020 plan. Included in the matrix are the goals supported, hazards addressed, lead entity, support entity, implementation timeline, cost, funding, and a STAPLEE and mitigation effectiveness score to assist the partners with prioritization.
44CFR 201.6(c)(3)(iv): For multi-jurisdictional plans, there must be identifiable action items specific to the jurisdiction requesting FEMA approval or credit of the plan.	Chapter 22 of Volume 1 includes a countywide initiative for all participating jurisdictions to provide documentation of adoption to FEMA with a formal request for approval. This will be coordinated by Snohomish County Department of Emergency Management (DEM).	All countywide initiatives were removed in this plan update. All jurisdictions that participated in the update reviewed prior initiatives and adopted new ones for the 2020–2025 plan period.
44CFR 201.6(c)(4)(i): [The plan maintenance process must include] a section describing the method and schedule of monitoring, evaluating, and updating the mitigation plan within a five-year cycle.	Chapter 7 of Volume 1 details a plan maintenance strategy that includes maintaining a planning committee, annual progress reporting, a five-year update protocol, a strategy for continuing public involvement, and methods for incorporation into other planning mechanisms.	Part 3, Sections 22.3 through 22.7 describe a maintenance process that includes maintaining a planning committee, annual progress reports, supporting forms and their distribution, a five-year update cycle protocol with minimum elements to update, continuing public involvement, and methods

Table 2-1 Major Changes		
44CFR Requirement	2015 Hazard Mitigation Plan	2020 Hazard Mitigation Plan
		for incorporation into other planning mechanisms in the planning area.
44CFR 201.6(c)(4)(ii): [The plan maintenance process must include] a process by which local governments incorporate the requirements of the mitigation plan into other planning mechanisms such as comprehensive or capital improvement plans, when appropriate.	Chapter 7 details recommendations for incorporating the plan into other planning components, including: • critical areas regulations • shorelines master programs • growth management plans • capital improvement plans • Water Resource Inventory Area planning • basin planning	Part 3, Section 21.7 details different programs to integrate information from this plan: • Land use planning • Critical areas regulation • Growth management • Capital improvements • Water Resource Inventory Area planning • Basin planning
44CFR 201.6(c)(4)(iii): [The plan maintenance process must include] a discussion on how the community will continue public participation in the plan maintenance process.	Chapter 7 details a strategy for continuing public involvement, including: • website • libraries • publication of annual progress report	Part 3, Section 22.6 details a strategy for continuing public involvement through • DEM Website • Annual Progress Reports distributed to stakeholders and media • Copies of plan in Sno-Isle Library System
44CFR 201.6(c)(5): Documentation that the plan has been formally adopted by the governing body of the jurisdiction requesting approval of the plan. For multi-jurisdictional plans, each jurisdiction requesting approval of the plan must document that it has been formally adopted.	All resolutions from adopting jurisdictions are included in Appendix D of Volume 1.	All resolutions from adopting jurisdictions are included in Annex J.

3 Plan Methodology

3.1 Formation of the Project Team

County staff resources were not sufficient to achieve all the desired objectives of the plan. Following County procurement procedures, Ecology and Environment, Inc. (E & E) was hired to assist with development and implementation of the plan update. The County retained roles of lead planner, risk assessment development, and stakeholder/public outreach. E & E facilitated stakeholder/public meetings and drafted the document, reporting directly to a County-designated project manager from the DEM. A Project Team was formed to lead the planning effort, made up of the following members from DEM, the City of Monroe, and E & E:

- John Holdsworth (DEM)—Lead planner, project oversight
- Jason Biermann (DEM)—Director, project oversight
- Brad Feilberg (Monroe)—Director of Public Works
- Trevor Clifford (E & E)—Project Manager, Lead Planner
- Samantha Fisher (E & E)—Emergency Planner
- Manique Talaia-Murray (E & E)—Emergency Planner
- Nicole Hurley (E & E)—Geographic Information System (GIS) Analyst
- Brennah McVey (E & E)—GIS Analyst

3.2 Defining the Planning Area

The planning area boundary is the Snohomish County boundary. The City of Bothell, the City of Everett, the Sauk-Suiattle Tribe, the Stillaguamish Tribe, and the Tulalip Tribes have their own HMPs and are not included in this update; however, many of the same hazards are observed in each of these jurisdictions.

3.3 The Steering Committee and the Planning Team

Hazard mitigation planning is one of the best ways to enhance collaboration and gain support among parties whose interests can be affected by hazard losses. By working together, a broad range of stakeholders can identify and create partnerships that pool resources to achieve a common vision for the community. The Steering Committee was assembled to oversee the plan update and guide the planning process, including approving the project timeline, determining key milestones, and developing goals. Agencies on the Steering Committee included:

- City of Everett Public Works
- Darrington School District
- City of Lake Stevens
- City of Mukilteo
- City of Monroe
- Snohomish County Human Services
- City of Stanwood
- Snohomish County DEM
- Snohomish Health District
- Snohomish County Public Works

The Planning Team included County staff, residents, and other stakeholders from within the planning area. The Planning Team was tasked with updating the contents of the plan, including the ranking of hazards, supporting the development of objectives, reviewing the 2015 mitigation initiatives, and establishing new 2020 mitigation initiatives.

The Steering Committee would receive input from the Planning Team after meetings and exercises. The Steering Committee would then review that information collectively and hold an open discussion. Topics included hazard ranking and identification, wording of goals and objectives, and implementation of the plan. The Steering Committee sought input from the Project Team when needed to keep the plan aligned with best practices. Finally, the Steering Committee would cast a vote for changes and updates to ensure all members had a part in the decision-making process.

3.4 Coordination with Other Agencies

44CFR requires that opportunities for involvement in the planning process be provided to neighboring communities, local and regional agencies involved in hazard mitigation, agencies with authority to regulate development, as well as businesses, academics, and other private and nonprofit interests (Section 201.6(b)(2)). This task was accomplished by providing information on the update process, sharing risk assessment data, and providing an opportunity to review and provide comments on the plan to agencies who complete their own plan, including FEMA Region X, the Washington Emergency Management Division (WAEMD) , neighboring counties, tribal partners, and local jurisdictions.

Snohomish County partnered with the City of Everett to conduct a crosswalk of their objectives with the County goals and objectives.

3.4.1 Pre-Adoption Review

All the agencies listed above were provided an opportunity and the means to review and comment on this plan update. The predominant means for this review was through HMP website, which was hosted by DEM. Each agency was sent an email informing them that draft portions of the plan were available for review. In addition, the complete draft plan was sent to FEMA Region X and WAEMD for a pre-adoption review to ensure program compliance.

3.5 Review of Existing Programs

44CFR states that hazard mitigation planning must include review and incorporation, if appropriate, of existing plans, studies, reports, and technical information (Section 201.6(b)(3)). Part 4 of this plan provides a review of laws and ordinances in effect within the planning area that can affect hazard mitigation initiatives. In addition, the following programs can affect mitigation within the planning area:

- Snohomish County Comprehensive Plan (2015)
- Washington State Enhanced HMP (October 2018)
- Snohomish County Shoreline Master Program (2019)
- Snohomish County Unified Development Code 30.62A Critical Area Regulation
- Stillaguamish River Comprehensive Flood HMP (2004)
- Snohomish River Comprehensive Flood Control Management Plan
- Sauk River Erosion/Flood HMP (2010)
- Snohomish River Basin Salmon Conservation Plan (2005)

- Stillaguamish Watershed Chinook Recovery Plan (2005)
- Sustainable Lands Strategy

An assessment of all planning partners' regulatory, technical, and financial capabilities to implement hazard mitigation initiatives is presented in the individual jurisdiction-specific annexes in Part 4. Many of these relevant plans, studies, and regulations are cited in the capability assessment.

3.5.1 National Flood Insurance Program Participation

In addition to the Federally administered NFIP, the county's comprehensive flood hazard management planning program incorporates a selection of planning, engineering, and environmental protection measures. The county's floodplain management actions include:

- Participation in the NFIP
- Adoption of floodplain development regulations that meet NFIP requirements
- Participation in an NFIP Inventive Program and CRS
- Preparation of emergency preparedness plans
- Preparation of comprehensive flood hazard management plans for the main rivers, which propose actions to minimize future flood damage.

Snohomish County's flood hazard regulations are found in the following sections of Title 30 (Unified Development Code) of the Snohomish County Code (SCC):

- SCC 30.65 - Flood Hazard Areas
- SCC 30.43C - Flood Hazard Permits
- SCC 30.91S.745 - Definition: Substantial Damage
- SCC 30.91S.750 - Definition: Substantial Improvement

Frequently flooded areas in unincorporated Snohomish County are regulated through County Code, Chapter 30 – Unified Development Code. The chapter states that the County has adopted the 2015 International Building Code, International Residential Code, and the International Existing Building Code. Each of these codes contain provisions for construction in flood-prone areas. FEMA states that the "floodplain provisions of the I-Codes (2009 edition and later) are consistent with the NFIP minimum requirements for buildings and structures in flood hazard areas."

These county statutes/regulations establish policies, standards, and permitting requirements to guide, limit, and regulate new development within floodplains and floodways as required by the State Growth Management Act, State Shoreline Management Act, and NFIP.

More specifically, the Snohomish County Critical Areas Regulation (Chapter 30) identifies and protects critical areas, including wetlands and fish and wildlife conservation areas, geologically hazardous areas, aquifer recharge areas, and special flood hazard areas.

3.6 Public Involvement

Broad public participation in the planning process helps to ensure a diverse range of community members voices concerning risks, capabilities, and actions will be heard and addressed throughout the planning process. 44CFR requires that the public have opportunities to comment on disaster mitigation plans during the drafting stages and prior to plan approval (Section 201.6(b)(1)). The CRS expands on these

requirements by making CRS credits available for optional public involvement activities. While providing an opportunity for public comment on the draft plan is one way to engage with the public around hazard concerns, the Steering Committee also wanted to ensure the public had a meaningful way to participate in the process.

3.6.1 Online Outreach

Public engagement was initiated soon after the first Steering Committee meeting. An online survey was developed to learn more about the public's initial concerns prior to plan development. The initial online survey was distributed through social media (e.g., Facebook, Twitter, etc.) beginning on June 13th, 2019. Over the course of three months, 115 individuals responded to the survey and provided their feedback. Full survey questions and results are located in Appendix B.

3.6.2 Public Meetings

The Project Team hosted a series of public meetings to ensure that additional stakeholders were reached who may not routinely respond to online surveys. In an effort to avoid the issues associated with traditional public meetings (e.g., low attendance, one-way communication), the Project Team embraced an open house meeting concept that allowed the public to learn and discuss different HMP components in an interactive setting. One example included the use of a computer and projector to allow for interactive mapping/GIS, enabling participants to zoom in on their home's location and see what hazards directly affected them.

The following table provides a summary of public meetings held during the course of the HMP update process:

Outreach Event	Date	Objectives	Attendance
Public Meeting #1	August 5, 2019	Provide an opportunity for residents to share their concerns and ideas.	3 people
Public Meeting #2	September 25, 2019	Provide an opportunity for residents to share their concerns and ideas.	4 people

3.6.3 Public Comments

Community members were provided with the draft HMP from March 17th to April 17th, 2020 on the county's website (https://snohomishcountywa.gov/180/Emergency-Management) and informed of the availability of the plan through a press release and announcements on the county's social media accounts, including Twitter and Facebook. No comments were received during the public comment period.

3.7 Plan Development Chronology and Milestones

Table 3-1 summarizes important milestones in the development of the plan update:

Table 3-1 Milestones			
Date	Event	Milestone	Attendance
June 18, 2019	Steering Committee Meeting #1	• Introduce members to the planning process • Review and collect feedback on 2015 HMP process • Review and revise 2015 goals and objectives • Identify key hazards of concern.	14 Steering Committee members
July 25, 2019	Planning Team Meeting #1	• Discuss community events for public engagement • Rank hazards in ranking exercise • Complete hazard consequence exercise • Discuss previous mitigation actions and changes in capabilities • Discuss updated goals • Request data	18 Planning Team and two Steering Committee members
August 5, 2019	Steering Committee Meeting #2	• Report out from Planning Team meeting • Discuss risk assessment methodology • Discuss online survey to county residents	14 Steering Committee members
August 5, 2019	Public Meeting #1	• Public open house at the Snohomish County campus from 3:00 p.m. to 7:00 p.m. • Display initial hazard maps	Two Project Team and three Community members
September 25, 2019	Steering Committee Meeting #3	• Present updated goals • Adopt 11 identified hazards • Complete hazard mitigation strategies exercise	10 Steering Committee members
September 25, 2019	Public Meeting #2	• Public open house in City Hall in the City of Monroe from 5:00 p.m. to 7:00 p.m. • Display hazard maps and an interactive Environmental Systems Research Institute map (ESRI)	Three Project Team members and four Community members

Table 3-1 Milestones			
Date	Event	Milestone	Attendance
September 26, 2019	Planning Team Meeting #2	• Provide update on the project and updated goals • Discuss hazards, objectives, and countywide action items for 2020 plan • Develop hazard mitigation strategies	22 Planning Team and three Steering Committee members
October 17, 2019	Planning Team Webinar	• Provide update on project, hazards, goals, and objectives • Discuss draft countywide action items for 2020 plan • Complete capability assessment exercise • Prioritize jurisdiction-specific action items	20 Planning Team and one Steering Committee member
January 7, 2020	Steering Committee Meeting #4	• Provide update on project and draft plan • Discuss assignment of objectives to 2020 goals • Review major changes of the draft plan from 2015 • Discuss improvement for annual progress reporting	Eight Steering Committee members

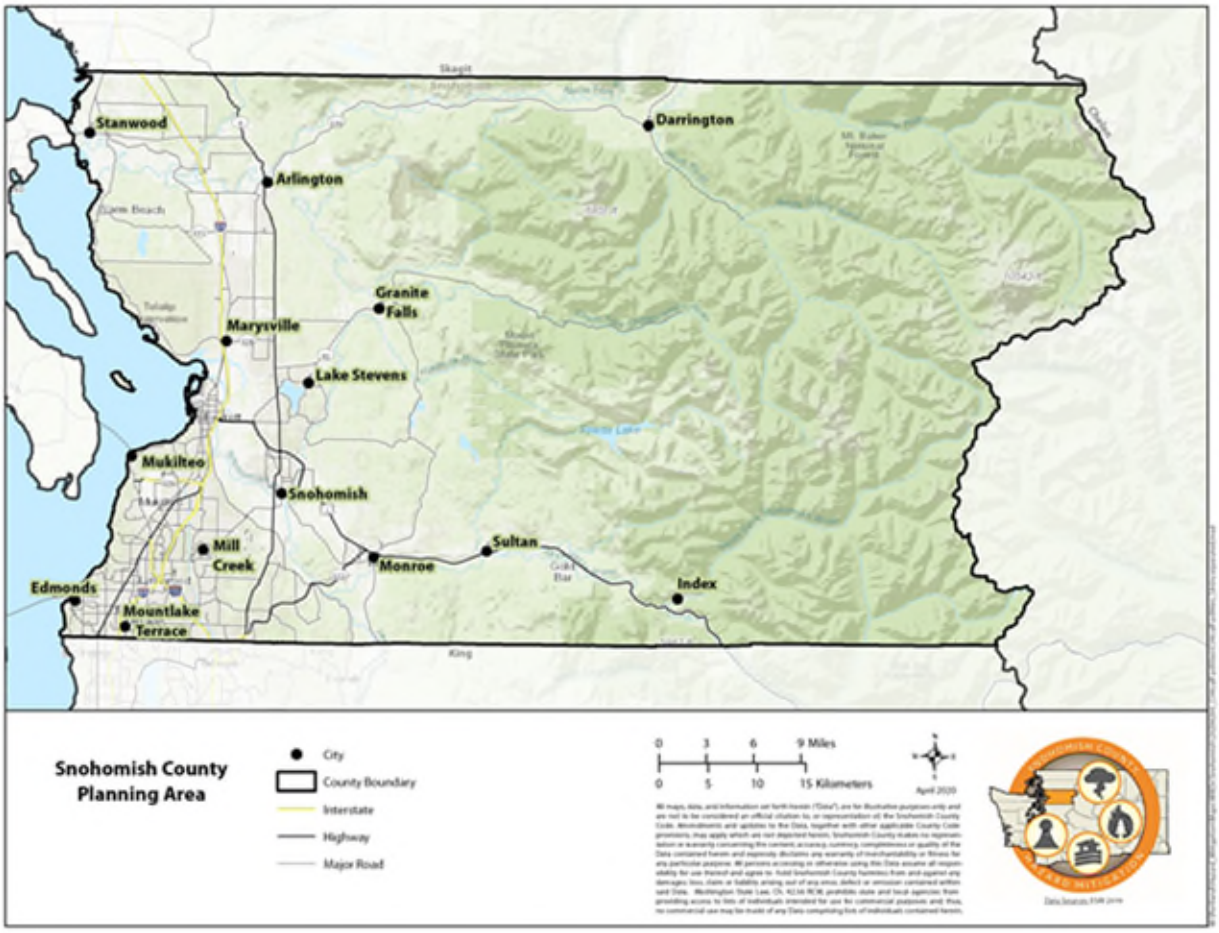
4 Snohomish County Profile

4.1 Introduction

Snohomish County is located on Puget Sound in Western Washington. It lies between Skagit County to the north and King County to the south, borders Chelan County to the east, and Island and Kitsap counties to the West. Covering 2,087.27 square miles of land and an additional 107 square miles of water, it is the 13th largest county in total land area in Washington. Sixty-eight percent of the land is forest, 18 percent is rural, 9 percent is urban/city, and 5 percent is agricultural. The county's varied topography ranges from saltwater beaches, rolling hills, and rich river bottom farmlands in the west to dense forest and alpine wilderness in the mountainous east. Due to the mountainous geography in the eastern portion of the county, much of the development and population resides along the narrow, westernmost Puget Sound lowlands.

The U.S. Census Bureau July 1, 2018 estimate for population is 814,901 people; of which almost 44 percent live in unincorporated areas. Washington's Growth Management Act (GMA) concentrates population and development which, combined with the natural terrain, allows for the development of population centers and efficient delivery of services while maintaining opportunities for recreation, agriculture, and open space; 713,335 residents lived in the GMA as of 2010, which is projected to grow to between 905,000 and

1.25 million by 2040. The formation of valleys, lowlands, waterfront, and buildable lands is the result of natural geological process that make Snohomish County a desirable place to live. However, these same processes (floods, earth movements, tectonic plates, volcanoes) when paired with population density create risk.



Snohomish County contains the third largest population in the state. Its major cities include Everett, Marysville, Edmonds, and Lynnwood. Other cities include Arlington, Bothell, Brier, Gold Bar, Granite Falls, Lake Stevens, Mill Creek, Monroe, Mountlake Terrace, Mukilteo, Snohomish, Stanwood, and Sultan. Snohomish County is also home to the incorporated Towns of Index, Darrington, and Woodway. The Tribal Nations of Tulalip Tribes, Stillaguamish Tribe of Indians, and Sauk-Suiattle Tribe also have land within Snohomish County. Much of the population is located along transportation corridors like Interstate 5 and State Highways 9 and 99, which are also interspersed with commercial and industrial operations. Management and professional occupations, sales, and manufacturing are important base industries in the county. Snohomish County is the home of the Boeing Company's largest aerospace assembly plant.

Since a considerable portion of the land in Snohomish County consists of forestland, there is an abundance of recreational opportunity and access to natural resources. Snohomish County is a destination for those seeking golfing, boating, hiking, camping, fishing, and hunting activities.

4.2 Climate

The Cascade Mountain Range in the east and ocean currents along Washington State's west coast significantly influence Snohomish County's climate. Mild temperatures with heavier rain in the winter and occasional snow characterize the lowland climate, while lower temperatures and higher precipitation are normal at higher elevations. Daily coastal temperatures in the City of Everett average 63°F during August and 39°F in January. In the mountain valley town of Darrington, August temperatures average 63.7°F and January temperatures are typically around 34.5°F.

Most precipitation in the county occurs during the fall and winter seasons. Moisture from Pacific storms falls on the windward (western) side of the Cascade Range. The moisture in the air condenses and precipitates as it travels up and over the mountains. Normal precipitation varies significantly based on location in the county. The average annual precipitation in Everett is 36 inches, which contrasts with 81.25 inches in Darrington.

4.2.1 Climate Change and Hazard Mitigation Planning

Although no modeling is currently available to develop quantitative estimates of the effect of climate change on natural hazard risks, an understanding of the basic features of climate change allows for the following qualitative assessments of impacts on hazards of concern addressed in this hazard mitigation plan. Each hazard profile contains an overview that serves as a basis for evaluating how risk will change as a result of future climate change impacts. The vulnerabilities identified in this plan update will ultimately be used to inform other aspects of emergency management planning, such as the Comprehensive Emergency Management Plan.

4.3 Economy

The economy of Snohomish County employs 414,000 people and is primarily consisted of manufacturing, educational services, health care and social assistance, and retail trade. The largest employers are the Boeing Company (35,000), Providence Regional Medical Center (4,906), Edmonds School District (3,616), and The Tulalip Tribes (3,500). Almost 63 percent of Snohomish County workers work in Snohomish County; 12.4 percent workers travel to King County, 3.7 percent to Kitsap County, and 2.8 percent to Pierce County. Over 20 percent of employees in Snohomish County transit from King County, 4.2 percent from Pierce County, 2.4 percent from Skagit, and 2.0 percent from Island County.

Snohomish County's economy is strongly based in the biotech industry, clean technology, and aerospace engineering and production. The county's highly technical-skilled workforce produces products ranging from airplanes to sustainable/green technology and conducts research for the cure of diseases. The Port of Everett provides direct deep-water access for shipping containers. The county's largest communities are located along Interstate 5, the state's major north-south corridor, which links numerous truck and transportation routes throughout the Puget Sound. The BNSF Railway provides valuable rail service, for both freight and passengers to many locations in the country.

Understanding the major employers and economic sectors in Snohomish County whose losses or inoperability would affect the community and its ability to recover from a disaster is essential. As indicated in the FEMA Local Mitigation Handbook, economic resiliency is a major driver of recovery efforts after a hazard event.

The chart below shows number of employees by industry in Snohomish County. Understanding the distribution of employees by industry helps to identify the potential impacts that a given hazard may have on the economy. For example, the impacts of a hazard event on those industries that provide goods and services for the local economy (e.g., accommodation and food) may vary when compared to those that provide them through a regional-global supply chain (e.g., manufacturing). The occurrence of any hazard that impacts a given industry, whether directly or indirectly, will likely impact their employees.

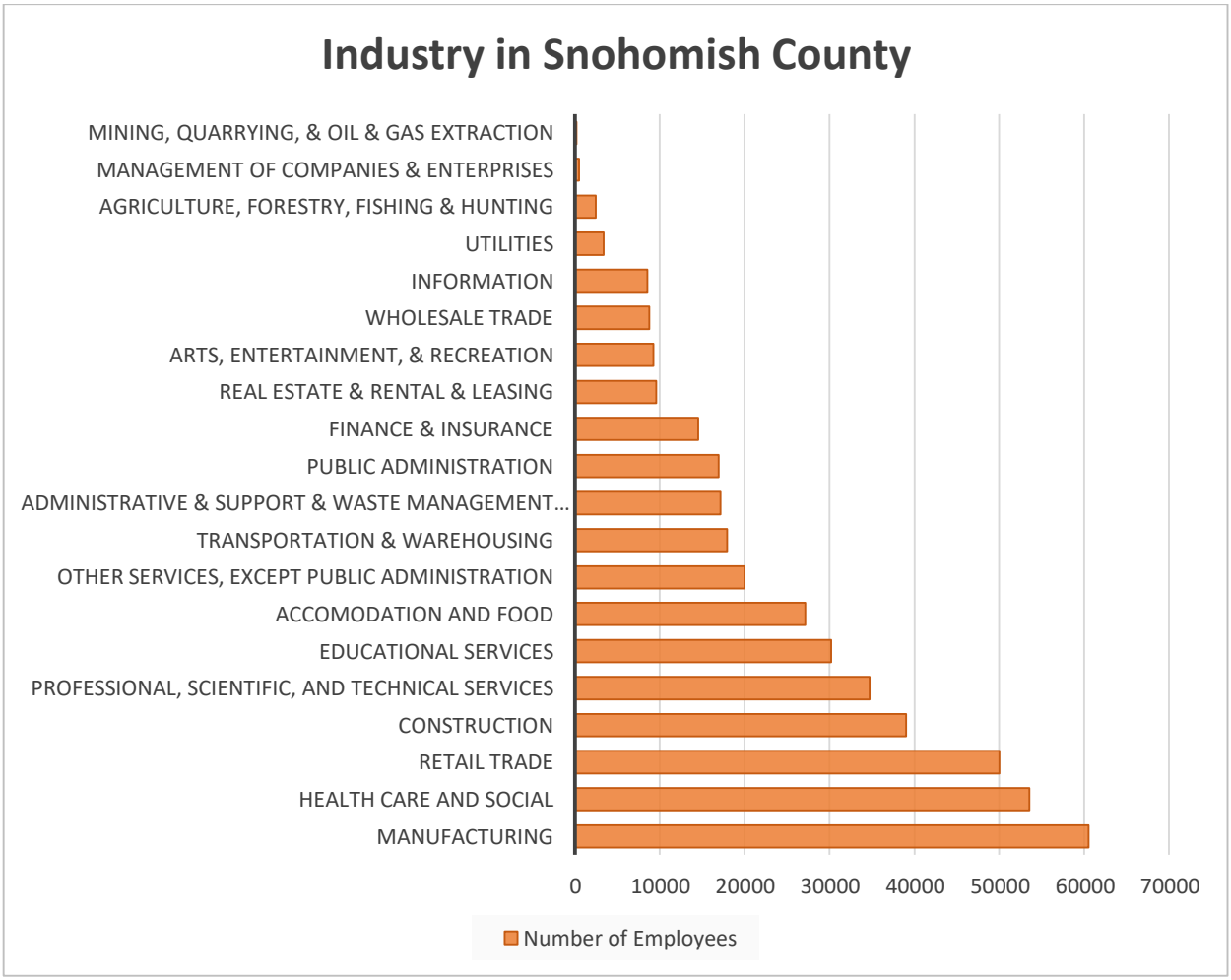


Figure 4-1 Industry in Snohomish County

4.4 Population

The population of Snohomish County is growing, with an annual average population growth of 1.2-1.8 percent. Between 2010 and 2018, the percent change in population was 14.2 percent. The county's largest city is Everett, with an estimated 111,262 people. Next largest cities include Marysville, Bothell, and Edmonds. The county's smallest census-designated place is Hat Island, with a population of 48 people.

The median age in the county is 38.1 years, and 49.8 percent of people are females. The highest race percentages in the county are people identified as white alone at 77.6 percent, Asian at 11.6 percent, and Hispanic or Latino at 10.4 percent. Black or African American alone is 3.7 percent, American Indian and Alaska Native alone is 1.6 percent, Native Hawaiian and Other Pacific Islander alone is 0.7 percent, and

two or more races is 4.8 percent. There are approximately 52,413 veterans living in the county. On average, there are 2.68 people per household, and 66.8 percent of housing units are owner-occupied.

4.4.1 Vulnerable Populations

People living near or below the poverty line, the elderly, the disabled, women, children, ethnic minorities, and renters tend to be more vulnerable to the effects from disaster and are considered "vulnerable populations." These populations may vary in living conditions, access to information, capabilities during a disaster event, and access to resources for post-disaster recovery.

In the United States and Snohomish County, individual households are expected to use private resources to prepare for, respond to, and recover from disasters to some extent. Approximately 8 percent of all Snohomish county residents live below the poverty line and may occupy poorly built and maintained housing, such as older houses, prefabricated homes, trailer homes and apartment complexes, that are more vulnerable to the effects of hazards (e.g., structural damage from earthquakes or built in flood prone areas). Furthermore, these residents are less likely to have insurance to compensate for losses incurred from a disaster.

Households without internet, a computer, or those that speak a language other than English at home may be disadvantaged by delayed or inadequate access to important information. Twenty-one percent of households in Snohomish County speak a language other than English at home. Foreign born persons make up 15.7 percent of the county. Ninety-five percent of households have a computer, but only 89 percent of households have broadband internet.

Elderly residents (65+) make up 13.5 percent of the population in Snohomish County and 25 percent of those over 65 have a disability. The vulnerability of elderly and disabled residents can vary significantly based on health, age, and economic security. Overall, the elderly and disabled are more likely to lack the physical and economic resources necessary for preparation, response, and recovery from a disaster event and are more likely to suffer health-related consequences. Evacuation from assisted-living facilities and private homes may be more difficult because of physical mobility, transportation, or economic resources. These vulnerable populations are more likely to need special medical attention, which may not be readily available during a disaster.

In contrast, children and persons under 18 are vulnerable to disaster events due to their young age and dependence on others for necessities. This vulnerability can be worsened during a natural disaster because they may not understand the measures that need to be taken to protect themselves from hazards. In the county, 22.6 percent of the population is younger than 18. Very young children may be especially vulnerable to injury or sickness.

4.5 Critical Facilities and Infrastructures

Critical facilities and infrastructure are those that are essential to the health and welfare of the population. These become especially important after any hazard event. Critical facilities are typically defined to include police and fire stations, schools, and emergency operations centers; and can include the roads and bridges that provide access and egress for residents and emergency responders. Utilities that provide water, electricity, and communication services to the community are also included in this definition. Additionally, "Tier II" facilities and railroads, which hold or carry significant amounts of hazardous materials with a potential to impact public health and welfare in a hazard event are also contained in this

definition; see Appendix A for a definition of Tier II facilities. The definition of critical facilities for this updated plan is as follows:

Critical Facilities: Facilities and infrastructure essential to the health and welfare of the population. These become especially important after any hazard event occurs. For the purposes of this plan, critical facilities include all of the following:

- Structures or facilities that produce, use, or store highly volatile, flammable, explosive, toxic and/or water reactive materials
- Hospitals, nursing homes, and housing likely to serve people who may not be sufficiently mobile to avoid death or injury during a hazard event
- Police stations, fire stations, vehicle and equipment storage facilities, and emergency operations centers that are needed for disaster response before, during, and after hazard events
- Public and private utilities, facilities and infrastructure that are vital to maintaining or restoring normal services to areas damaged by hazard events
- Government facilities (city hall, judicial, emergency management)

A database of critical facilities within the planning area was created to identify vulnerabilities to each hazard addressed by this plan. The risk assessment for each hazard profile discusses the intersection of that hazard with critical facilities, which is discussed more in-depth in each jurisdiction annex.

Snohomish County 2020 Hazard Mitigation Plan

Part 2: Risk Assessment

PART 2
Risk Assessment

5 Risk Assessment Methodology and Hazards of Concern

5.1 Introduction

Risk assessment is the process of measuring the potential loss of life, personal injury, economic injury, and property damage resulting from hazards. It allows emergency management personnel to establish early response priorities by identifying potential hazards and vulnerable assets. The process focuses on the following elements:

- **Hazard Identification** – Use all available information to determine what types of hazards may affect a jurisdiction, how often they can occur, and their potential severity.
- **Exposure identification** – Estimate the total number of people and properties in the jurisdiction that are likely to experience a hazard event.
- **Vulnerability identification and cost evaluation** – Assess the impact of hazards on the people, property, environment, economy, and lands of the region, with estimates of the cost of potential damage and losses, or cost that can be avoided by mitigation.

44 CFR Section 201.6(c)(2) requires a risk assessment that provides factual basis for activities proposed in the strategy to reduce losses from identified hazards. To protect privacy and security, information on properties assessed is presented in aggregate, without details about specific properties.

5.2 Methodology

Chapters 6 through 18 describe the risks associated with each hazard of concern identified for Snohomish County. Each chapter elaborates on the hazard, the planning area's vulnerabilities, and probable event scenarios. The following steps were used to define the risk of each hazard:

- Identify and profile each hazard—The following information is given for each hazard:
    - Geographic areas most affected by the hazard;
    - Event frequency estimates;
    - Severity estimates; and
    - Warning time likely to be available for response.
- Determine exposure to each hazard—Exposure was determined by overlaying hazards with an inventory of potentially vulnerable structures, facilities, and systems to determine which of them would be exposed to each hazard. The Snohomish County geographical information system (GIS) database contains extensive coverage of the inventory.
- Assess the vulnerability of exposed facilities—Vulnerability of the exposed structures and
- infrastructure was determined by interpreting the probability of occurrence of each event and assessing structures, facilities, and systems that are exposed to each hazard. Tools such as GIS and Federal Emergency Management Agency's (FEMA's) hazard-modeling program called Hazards U.S. (HAZUS) were used to perform this assessment for the flood, dam failure, and earthquake

hazards. Outputs similar to those from HAZUS were generated for other hazards, using maps generated by the HAZUS program.

5.3 Identified Hazards of Concern

For this update, the Steering Committee considered the full range of hazards that could impact the planning area and then ranked the hazards that present the greatest concern. The process incorporated review of the *Washington State Enhanced Hazard Mitigation Plan* and the *2015 Snohomish County Hazard Mitigation Plan*, and the annual progress reports for the initial county plan. Also considered were local, state, and federal information on the frequency, magnitude, and costs associated with hazards that have impacted or could impact the planning area. Additionally, relevant qualitative or anecdotal information regarding hazards and the perceived vulnerability of the planning area's assets to them was used. Based on the review, this plan update addresses the following hazards of concern:

- Earthquake
- Epidemic
- Hazardous Materials
- Weather Events
- Flooding
- Dam Failure
- Active Assailant
- Wildfire
- Cybersecurity Threats
- Mass Earth Movement
- Volcano
- Tsunami
- Aircraft Accident

5.4 Risk Assessment Tools

5.4.1 Mapping

National, state, county, and city databases were reviewed to locate available spatially based data relevant to this planning effort. Maps were produced using GIS software to show the spatial extent and location of hazards when such datasets were available. Data used for this plan update represents the best science currently available. These maps are included in the Hazard Profile component of this section.

5.4.2 HAZUS-MH

In 1997, FEMA developed the standardized Hazards U.S., or HAZUS, model to estimate losses caused by earthquakes and identify areas that face the highest risk and potential for loss. HAZUS was later expanded into a multi-hazard methodology, Hazards United States – Multi-Hazards (HAZUS-MH), with new models for estimating potential losses from wind (hurricanes) and flood (riverine and coastal) hazards.

HAZUS-MH is a GIS-based software program used to support risk assessments, mitigation planning, and emergency planning and response. It provides a wide range of inventory data, such as demographics, building stock, critical facilities, transportation, and utility lifeline; this data can be used in multiple models to estimate potential losses from natural disasters. The program maps and displays hazard data and the results of damage and economic loss estimates for buildings and infrastructure. Its advantages include the following:

- Provides a consistent methodology for assessing risk across geographic and political entities;
- Provides a way to save data so that it can readily be updated as population, inventory, and other factors change, and mitigation planning efforts evolve;
- Facilitates the review of mitigation plans, ensuring that FEMA methodologies are incorporated;
- Supports grant applications by calculating benefits using FEMA definitions;
- Produces hazard data and loss estimates that can be used in communication and interaction with local stakeholders; and
- Is administered by the local government and can be used to manage and update a hazard mitigation plan throughout its implementation

The version used for this plan was HAZUS-MH 4.2, released by FEMA in January 2018. Analyses included all available service packs (SP1, SP2, and SP 3).

5.5 Overall Risk Assessment Approach

5.5.1 GIS Assessed Hazards

All hazards with available geospatial data were analyzed using GIS to identify the level of risk and exposure to the community. The risk assessment included total and vulnerable population exposure, critical infrastructure vulnerability, and economic exposure of structures within the county. For hazards with no geographic information, a qualitative analysis was conducted using the best available data and professional judgment.

Population exposure: To estimate population exposure, the total and vulnerable populations in each census tract were distributed to the residential buildings within each tract. The population within any exposed residential buildings is summed to find the number of people at risk of a hazard. We report the populations susceptible to each hazard by jurisdiction, considering only the 267,036 residential buildings and 651,014 people within the jurisdictions discussed in this HMP. Vulnerable population categories considered include language, race, age, poverty, and disability. Population exposure is included in the hazard profile sections of this document.

Structural economic exposure: The economic exposure to each hazard considers 285,819 structures within the jurisdictions discussed in this HMP. The assessed total economic value of the structure is reported, including the structural value and assessed value of contents within. The total economic value of all exposed structures is summed to find the value of structures at risk of a hazard. The economic exposure of buildings within each jurisdiction is reported in the hazard profile sections of this document.

Critical facility exposure: Critical facilities and infrastructure are those that are essential to the health and welfare of the population. These become especially important after any hazard event. Critical facilities are typically defined to include police and fire stations, schools, and emergency operations centers. Critical infrastructure can include the roads and bridges that provide access and egress and allow emergency vehicles to reach those in need, and the utilities that provide water, electricity, and communication services to the community. Also included are “Tier II” facilities and railroads, which hold or carry significant amounts of hazardous materials with a potential to impact public health and welfare in a hazard event. The definition of critical facilities for this updated plan is as follows:

Critical facilities: Facilities and infrastructure essential to the health and welfare of the population. These become especially important after any hazard event occurs. For the purposes of this plan, critical facilities include all of the following:

- Structures or facilities that produce, use, or store highly volatile, flammable, explosive, toxic and/or water reactive materials;
- Hospitals, nursing homes, and housing likely to serve people who may not be sufficiently mobile to avoid death or injury during a hazard event;
- Police stations, fire stations, vehicle and equipment storage facilities, and emergency operations centers that are needed for disaster response before, during, and after hazard events;
- Public and private utilities, facilities and infrastructure that are vital to maintaining or restoring normal services to areas damaged by hazard events; and
- Government facilities (city hall, judicial, emergency management).

A database of critical facilities within the planning area was created to identify vulnerabilities to each hazard addressed by this plan. Due to the sensitivity of this information, a detailed list of facilities is not provided in this plan. The list is on file with each planning partner.

Critical Infrastructure within the jurisdictions discussed in this HMP include 1,098 facilities in the following categories: Airport, Bridge, Communication, Dam, Emergency Center, Ferry, Fire/EMS, Government, Hazmat, Medical, Natural Gas, Oil, Other, Police, Port, Power, School, Wastewater, and Water. These facilities were compiled using a combination of federal, county, and city databases. Critical infrastructure exposure is reported by jurisdiction and is included in the planning partner sections of this document.

Vulnerability definitions: Hazard specific information for the GIS-based risk assessment is included below:

- Earthquake: The buildings and critical infrastructure that will experience at least a moderate amount of shaking during the South Whidbey Island Fault Earthquake scenario are considered vulnerable.
- Liquefaction: The buildings and critical infrastructure with at least a moderate risk of liquefaction are considered vulnerable.
- Weather Events: All buildings and critical facilities are considered vulnerable to an extreme weather event.
- Flooding, Dam Failure, Tsunami: The buildings and critical infrastructure within the 100yr floodplain, 500yr floodplain, tsunami inundation zone, or dam failure inundation zone are considered vulnerable.
- Wildfire: The buildings and critical infrastructure that are with at least a moderate wildfire hazard zone are considered vulnerable.
- Mass Earth Movement: The buildings and critical infrastructure that are within at least a moderate landslide hazard zone are considered vulnerable.
- Soils: The buildings and critical infrastructure built on soils classified as D, E, or F are considered vulnerable.
- Volcano: The buildings and critical infrastructure within a lahar zone are considered vulnerable.

5.5.1.1 Data Sources

County-relevant information was gathered from a variety of sources. The primary data source was the Snohomish County GIS database, augmented with state and federal data sets as shown in Table 5-1.

Table 5-1 Geographic Information System Data Sources	
Data	Source
Critical Facilities	ESRI, Snohomish County, jurisdictions and special districts
Structures	Snohomish County
Population	ESRI, U. S. Census
Earthquake	U.S. Geological Survey (USGS)
Hazardous Materials	Snohomish County, Environmental Protection Agency (EPA)
Weather Events	U.S. Department of Agriculture Natural Resources Conservation Service, National Oceanic and Atmospheric Administration (NOAA): National Climatic Data Center
Flooding	Snohomish County Digital Flood Insurance Rate Maps, FEMA
Dam Failure	Snohomish County Public Utility District, City of Seattle City Light Department
Wildfire	Snohomish County, Washington State Department of Natural Resources
Mass Earth Movement	Washington State Department of Natural Resources
Volcano	USGS Cascade Volcano Observatory
Tsunami	NOAA, Washington State Department of Natural Resources

5.5.2 HAZUS-MH Assessed Hazards

HAZUS-MH provides default data for inventory, vulnerability, and hazards; this default data can be supplemented with local data to provide a more refined analysis (see Table 5-2). The model can carry out three levels of analysis, depending on the format and level of detail of information about the planning area:

- Level 1—All of the information needed to produce an estimate of losses is included in the software's default data. This data is derived from national databases and describes in general terms the characteristic parameters of the planning area.
- Level 2—More accurate estimates of losses require more detailed information about the planning area. To produce Level 2 estimates of losses, detailed information is required about local geology, hydrology, hydraulics, and building inventory, as well as data about utilities and critical facilities. This information is needed in a GIS format.
- Level 3—This level of analysis generates the most accurate estimate of losses. It involves adjusting the built-in loss estimation models used for the earthquake, flood, and hurricane loss analyses. This typically is done in concert with the use of level 2 analysis. It is only pursued by advanced

users with knowledge of the hazard models developed for HAZUS-MH and when the users need more accurate results or need to solve specific problems.

Earthquake: A Level 2 HAZUS-MH analysis was performed to analyze the earthquake hazard. Updated general building stock and critical facilities data was used in place of the HAZUS-MH defaults. Earthquake shake maps and probabilistic data prepared by the USGS were used for the analysis.

Flood: A Level 2 analysis was performed. Updated building and assessor data (replacement cost values and detailed structure information) were loaded into HAZUS-MH. An updated inventory was used in place of the HAZUS-MH defaults for essential facilities, transportation, and utilities. Snohomish County Preliminary Digital Flood Insurance Rate Maps (DFIRMs) (expected to be adopted in 2020) were used to delineate flood hazard areas and estimate potential losses from the 100- and 500-year flood events. Using the DFIRM floodplain boundaries and Light Detection and Ranging (LIDAR) digital elevation grids, a flood depth grid was generated and integrated into the model.

Table 5-2
HAZUS Data Sources

Data	Source
Critical Facilities	HAZUS defaults, Snohomish County*
Structures	HAZUS defaults, Snohomish County
Earthquake	USGS
- Liquefaction	USGS
- Soils	Washington State Department of Natural Resources
- Landslide	Washington State Department of Natural Resources
Flood	Snohomish County, FEMA

*Critical Facility Inventory is not as robust within HAZUS as the GIS Assessed Hazards

5.6 Limitations

Loss estimates, exposure assessments, and hazard-specific vulnerability evaluations rely on the best available data and methodologies. Uncertainties are inherent in any loss estimation methodology and arise in part from incomplete scientific knowledge concerning natural hazards and their effects on the built environment. Uncertainties also result from all of the following:

- Approximations and simplifications necessary to conduct a study;
- Incomplete or outdated inventory, demographic, or economic parameter data;
- The unique nature, geographic extent and severity of each hazard;
- Mitigation measures already employed; and
- The amount of advance notice residents have to prepare for a specific hazard event.

These factors can affect loss estimates by a factor of two or more. Therefore, potential exposure and loss estimates are approximate. The results do not predict precise results and should be used only to understand relative risk. Over the long term, Snohomish County and its planning partners will collect additional data to assist in estimating potential losses associated with other hazards.

HAZUS Facility Limitations: HAZUS provides a default inventory of critical facilities. These facilities can be augmented with additional inventory. However, the program requires detailed information about the structure so it can predict how the facility will behave during a hazard event. The dataset considered for HAZUS analysis is not as comprehensive as the critical facilities dataset used for GIS Assessed Hazards (Section 5.5.1) because detailed structural information was not available for all facilities in the county. Between 2020 and 2025, the county will be updating and aligning the HAZUS dataset with the comprehensive set of critical facilities used for GIS Assessed Hazards.

5.7 Hazard Profiles

The remainder of Part 2 – Risk Assessment is comprised of comprehensive hazard profiles for each of the adopted hazards. Each hazard profile begins with a general overview of the hazard before looking at the hazard in the context of Snohomish County. Hazards were ranked by the Steering Committee and Planning Team informed by a range of hazard-related factors based on worst-case and most likely scenarios, which are included and discussed in each profile where available. Hazard profiles also include a discussion of previous hazard events that have occurred in the county, the location that these events have or may occur, the frequency with which they occur, severity, warning time, and cascading or secondary impacts. Finally, there is a discussion of how climate change may exacerbate each hazard, the exposure and vulnerability of communities, property, critical infrastructure and the environment, development trends and potential issues. Each hazard profile includes a map showing the geographic distribution of the hazard, if data is available.

Two-page versions of the hazard profiles are available in the Executive Summary of this volume, which are abbreviated versions of the comprehensive hazard profiles that follow; they are intended for community and stakeholder engagement.

6 Active Assailant

6.1 General Background

The threat from an active assailant is becoming more common in the United States. Active assailant incidents can be well-planned, coordinated attacks with multiple suspects, or the result of a lone individual on a rampage (DHS 2017). Most incidents have occurred in places of commerce, followed by education, open space, and government properties (FBI 2019a).

Analyses over the previous 18 years show an increasing trend in the number of active assailant incidents. Between 2000 and 2018, there were 277 active shooter incidents in the United States. Of those 277 incidents, 42 percent (117) occurred between 2014 and 2018. In 2018, the FBI designated 27 shootings as active shooter incidents, 10 of which met the criteria in the federal definition of mass killings (FBI 2019a).

Active assailant attacks can also come in the form of a car, knives, or explosives. In Pennsylvania during 2014, a 16-year-old student with two knives went on a rampage at a high school, stabbing 21 students and a security guard. In August 2017, a man drove his car into a crowd of protesters in Charlottesville, Virginia, killing one and injuring 28. In October 2017, a man rented a pickup truck and drove through a bike path along the Hudson River in New York City, killing 8 and injuring 11 others. On May 22, 2017, a suicide bomber entered a concert in Manchester, England, killing 22 people and injuring over 50 (Gibson 2019).

DEFINITIONS

Active Assailant – An individual actively engaged in killing or attempting to kill people in a confined and populated area…in most cases, active assailants use firearm(s) and there is generally no pattern or method to their selection of victims.

Active Situation – Both law enforcement personnel and bystanders have the potential to affect the outcome of the event based upon their responses to the situation.

Active Shooter – One or more individuals actively engage in killing or attempting to kill people in a populated area using one or more firearms.

Extreme Risk Protection Orders – Designed to prevent individuals at high risk of harming themselves or others from accessing firearms, it allows family, household members, and police to obtain a court order when there is demonstrated evidence that the person poses a significant danger.

Mass killings – Three or more killings in a single incident.

6.1.1 Potential Damage from Active Assailants

The most immediate damage from active assailants is the loss of human life and the wounding of people. Although sometimes there is a particular victim in mind, most people involved in an incident are innocent bystanders. After the incident, fear can be present not only in the community but in similar locations across the nation. Lasting trauma can affect individuals and their families involved in the attacks.

6.2 Snohomish County Hazard Profile

An active assailant incident can occur throughout the entire county. Statistically, businesses and malls are the most likely locations, followed by schools and institutions of higher learning (FBI 2014).

6.2.1 Hazard Ranking

The Steering Committee and Planning Team completed a hazard ranking survey during the Snohomish County 2020 HMP update process for a range of hazard-related factors based on worst-case and most likely scenarios; definitions of the hazard ranking factors may be found in Table K-1 in Appendix K. The results of the survey were averaged together for each factor to generate a total average score and rank, enabling the prioritization of hazards by type. When compared against the other hazards included in the 2020 hazard ranking survey, active assailants were ranked as the eleventh worst-case scenario and the fifteenth most likely scenario (see Table 6-1).

Table 6-1
Hazard Ranking Output

Severity (1=lowest, 5=highest)	Magnitude (1=lowest, 5=highest)	Frequency (1=lowest, 5=highest)	Onset (1=slowest, 5=fastest)	Duration (1=shortest, 5=longest)	Perceived Change in Risk	Average	Rank
Worst-case Scenario							
4.63	3.00	3.13	4.75	2.31	0.8	3.56	11
Most Likely Scenario							
1.69	1.44	1.75	4.38	1.56	0.8	2.16	15

6.2.2 Past Events

Between 2000 and 2018, there were 12 events in the State of Washington, and 2 in Snohomish County (FBI 2019b):

- On October 24, 2014, a 15-year-old armed with a handgun began shooting in the cafeteria of Marysville-Pilchuck High School; four students were killed, three wounded; and
- On July 20, 2016, a 19-year-old armed with a rifle, began shooting people attending a house party in Mukilteo; three people were killed, one wounded.

In Snohomish County, multiple potential mass shooting/active assailant attacks were investigated and foiled by law enforcement before they occurred. For example, in February of 2018, a Snohomish County grandmother reported her 18-year-old grandson to the police after finding a journal with threats to shoot students (Berhard 2018). After investigation, the threats were considered credible and the man was arrested.

6.2.3 Location

Locations of active assailant incidents are random and sporadic for the purposes of planning for law enforcement. Locations are not typically random for the assailant; a high percentage of school shootings are carried out by current or former students, and many shootings at businesses are carried out by current or former employees, or by persons with some known grievance with the business. In instances with no direct connection to the location, places with a high-pedestrian presence are typically chosen (i.e., special events, large gatherings). According to the FBI, between 2000 and 2018, the most targeted locations were

businesses open to pedestrian traffic. Following close behind are schools (Pre-K to 12), businesses closed to pedestrian traffic, and government properties not classified as military. Places of worship, residences, and military installations are low on the list of targeted locations (FBI 2019a).

6.2.4 Frequency

In Washington State, the average for shootings meeting the mass killing definition is under one per year. Snohomish County's frequency, looking at the 2014 to 2019 data, is one mass shooting every 3 years; however, there is an increasing trend of mass killings in the United States and the frequency is expected to increase.

6.2.5 Severity

Active assailant incidents can range from no deaths and very few injuries, to potentially dozens of casualties and even more wounded. Active assailant instances involving cars or explosives can be over in seconds or last minutes. Active shooter situations are often over within 10 to 15 minutes, but the damage from this time can vary greatly (DHS 2008). Some of the most severe aftereffects are the trauma to victims and families, as well as the fear that is instilled in the public.

6.2.6 Warning Time

In the weeks and months before an attack, many active assailants engage in behaviors that may signal impending violence. Some of these behaviors are intentionally concealed, but others are observable and reportable. Most assailants take time to plan and prepare for the attack, sometimes spending a week or more (Silver, Simons, and Craun 2018). Once an incident has started, when the active assailant arrives on scene and begins the act of violence, there is virtually no warning time; those further away from the assailant have more time to implement action-based response options to increase survivability and save lives.

Due to many active assailant events being planned, law enforcement agencies can stifle incidents before they happen. Three foiled mass shooting examples from August 2019 include a 22-year old male in Connecticut who expressed on Facebook his interest in committing the crime, a 25-year old male from Florida who sent his ex-girlfriend texts threatened to commit a mass shooting, and a 20-year old male in Ohio that threatened to carry out a mass shooting at a religious center (Andone, Kaur, and Halcombe 2019).

6.3 Cascading Impacts/Secondary Hazards

Cascading impacts from active assailant incidents can include loss of business and revenue or loss of labor hours. Physical damage can come from the weapon (e.g., gun, vehicle, fire, or explosives), resulting in property damage. Mass shootings have the potential to serve as a catalyst for anti-gun demonstrations, putting additional strain on local law enforcement. Inundation of hospitals and medical centers after a mass killing can result in shortages in blood and supplies, potentially putting other victims more at risk. Active assailant incidents put people at an increased risk for depression or other mental health issues resulting from psychological trauma.

6.4 Potential Impacts from Future Climate Conditions

There is no evidence to show that future climate conditions would increase active assailant threats.

6.5 Exposure and Vulnerability

6.5.1 Population

As the population grows in Snohomish County, more people are potentially at risk for finding themselves at a location targeted by an active assailant.

6.5.2 Property

Property exposure and vulnerability to damage is not typically considered in active assailant incidents. Property can be damaged by the weapon and/or assailant, but damage is typically minimal. Any building near the active assailant is vulnerable to damage.

6.5.3 Critical Facilities

All critical facilities listed in the plan could experience an active assailant incident.

6.5.4 Environment

Active assailant incidents have minimal impact on the environment.

6.6 Development Trends

The potential for active assailant threats in Snohomish County is not likely to lessen or prohibit future community development.

6.7 Issues

Important issues associated with active assailants and active shooters include (Washington Association of Sheriffs and Police Chiefs 2018):

- An absence of legislative requirements to address active assailant threats and issues;
- Future changes in gun control laws from a federal, state, or county level;
- Availability and funding for technology, mitigation equipment, and/or structural upgrades and safety retrofitting;
- Availability and funding for police and security at government buildings or large public events;
- Availability and funding for properly trained school resources officers;
- Training for school staff and increased awareness for students, including drills;
- Sufficient and effective school counselors, psychologists, mental health professionals, family engagement coordinators, school social workers;
- Accessible and effective mental health services with improvements to the mental health system;
- Encouragement to report suspicious or threatening behavior;
- Suicide and bullying prevention outreach and education efforts; and
- Extreme Risk Protection Orders (Seattle Police Department, n.d.).

6.8 Hazard Map

No geospatial data are available for this hazard.

7 Aircraft Accident

7.1 General Background

Aircraft accidents occur every year in the United States. Accidents occur from either mechanical failure or human error. The five most common reasons for airliner disasters are pilot error, contributing to around 50 percent of accidents, mechanical failure, bad weather, intentional crashes or other forms of human error (Kiger, n.d.).

Throughout the world in 2018, there were 15 fatal airliner accidents; with 37.9 million flights worldwide, the rate is one fatal accident per 2.52 million flights (Kiger, n.d.). In general, accident rates are decreasing, and are typically lower in the United States when compared to the rest of the world. In 2018, there was only one major accident with one fatality in the United States; it was on a commercial airliner. The majority of aircraft accidents occur in general aviation, not commercial flights. In 2018, there were 1,257 general aviation accidents in the United States, resulting in 225 fatalities (National Transportation Safety Board 2019).

DEFINITIONS

Aircraft – A vehicle, such as an airplane or balloon, for traveling through the air.

Aircraft Accident – An occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight and all such persons have disembarked, and in which any person suffers death or serious injury, or in which the aircraft receives substantial damage.

Aircraft Incident – An occurrence other than an accident, associated with the operation of an aircraft, which affects or could affect the safety of operations.

7.1.1 Potential Damage from Aircraft Accidents

The two main ways an aircraft accident could cause damage indirectly by the impact, or indirectly via explosion, fire, and vibration. Aircraft landing in residential areas have the potential to damage property and injure people. Some aircrafts have skidded off runways, hitting cars in streets. The most potential for loss of human life comes from a high-impact crash.

7.2 Snohomish County Hazard Profile

Snohomish County is home to 6 public and 24 private airports, the largest public airport being Paine Field in Everett, Washington ("Snohomish County Public and Private Airports, Washington," n.d.). The County is also within the flight pattern of multiple flights flying to and from Seattle-Tacoma International Airport. Paine Field commercial air service was launched in March of 2019. The terminal accommodates approximately 24 departures per day and supports approximately 10,000 to 15,000 travelers per week (Paine Field Snohomish County Airport 2019).

7.2.1 Hazard Ranking

The Steering Committee and Planning Team completed a hazard ranking survey during the Snohomish County 2020 HMP update process for a range of hazard-related factors based on worst-case and most likely scenarios; definitions of the hazard ranking factors may be found in Table K-1 in Appendix K. The results of the survey were averaged together for each factor to generate a total average score and rank, enabling the prioritization of hazards by type. When compared against the other hazards included in the

2020 hazard ranking survey, aircraft accidents were ranked as the number twelfth worst-case scenario and the eighth most likely scenario (see Table 7-1).

Table 7-1
Hazard Ranking Output

Severity (1=lowest, 5=highest)	Magnitude (1=lowest, 5=highest)	Frequency (1=lowest, 5=highest)	Onset (1=slowest, 5=fastest)	Duration (1=shortest, 5=longest)	Perceived Change in Risk	Average	Rank
Worst-case Scenario							
4.56	3.00	2.13	5.00	2.88	0.5	3.51	12
Most Likely Scenario							
2.00	1.75	1.44	5.00	2.06	0.5	2.45	8

7.2.2 Past Events

Aircraft accidents tend to happen annually in Snohomish County. There were three accidents in 2018. In 2019, one accident occurred. A single engine plane crashed into a field near Marysville, resulting in one fatality (Skagit Breaking Staff 2019).

7.2.3 Location

Although aircraft accidents can happen anywhere in the county, the most likely locations are those close to the 30 airports and along the more populated western portion of the county. Historically, most crashes have happened near Paine Field, Snohomish, and Arlington Municipal Airport (Plane Crash Map 2019).

7.2.4 Frequency

It can be reasonably expected that one or more aircraft accidents will occur each year somewhere in Snohomish County. However, future regulations and safety standards may reduce the amount of aircraft accidents.

7.2.5 Severity

All aircraft accidents should be considered severe. Severity can vary depending on where the aircraft landed or crashed (e.g., population, property), how fast it was going, how heavy it was, and how much fuel was on board.

7.2.6 Warning Time

In almost all cases, there is little to no warning time for aircraft accidents for people on the ground.

7.3 Cascading Impacts/Secondary Hazards

After an aircraft accident, areas around the crash are typically closed off and unusable until after an investigation has been completed. This can lead to negative financial impacts for affected businesses, such as airlines or the airport terminal. A crash can also lead to regulation overhaul, potentially affecting passengers on future flights or disrupting business. Fear stemming from the accident can also have a negative financial impact on businesses if people choose a different method of transportation or not to travel at all.

7.4 Potential Impacts from Future Climate Conditions

There is no linkage between future climate conditions and aircraft accidents. Although bad weather plays a role in some accidents, technology and government agencies can typically compensate for and forecast potentially dangerous conditions.

7.5 Exposure and Vulnerability

7.5.1 Population

Residents across the county could be susceptible to an aircraft accident, particularly those living closer to airports.

7.5.2 Property

Although uncommon during an aircraft accident, there is a chance for the aircraft to damage property.

7.5.3 Critical Facilities

All critical facilities are potentially exposed to an aircraft accident.

7.5.4 Environment

Aircrafts have hazardous materials on board, such as Jet A fuel and hydraulic fluid. The release of these into the soil or water where the aircraft accident occurred can be toxic to the immediate flora and fauna in the vicinity. In general, aircraft accidents have minimal impact on the environment and are typically remediated quickly.

7.6 Development Trends

The potential for aircraft accidents in Snohomish County is not likely to lessen or prohibit future development.

7.7 Issues

Important issues associated with aircraft accidents and incidents include:

- Drones – Many pilots are reporting drones that are flying too high and too close (Kiernan 2019).

7.8 Hazard Map

No geospatial data are available for this hazard.

8 Cybersecurity Threats

8.1 General Background

Cybersecurity threats are becoming more common, more dangerous, and more sophisticated as more people become increasingly dependent upon the internet (FEMA 2019b). Threats are evolving as nation-states, terrorists, individual criminals, transnational criminal organizations, and other malicious actors move their activities to the digital realm (DHS 2018). Motivations include espionage, political and ideological interests, and financial gain (DHS 2018).

The broad availability, relatively low cost, and increasing capabilities of cyber tools affect trends and threats; examples include malware and phishing (DHS 2018). Cybersecurity threats can affect institutions such as banking, medical, education, military, commerce, and communications and infrastructure systems.

Cyberattacks are malicious attempts to access or damage a computer system using computers, mobile phones, gaming systems, and other devices to steal identities, block access or delete documents and pictures, target children, or cause problems with business services, transportation and power (DHS, n.d. [a]). Common types of cyberattacks include denial of service, botnets, distributed denial of service[1], exploit tools, logic bombs, phishing, sniffers, Trojan horses, viruses, war dialing[2], war driving[3], and worms (United States Government Accountability Office 2005).

8.1.1 Potential Damage from Cybersecurity Attacks

Cyberattacks have a significant economic impact on everyone from large corporations to individuals and families. In 2014, the Center for Strategic and

DEFINITIONS

Botnet – A collection of compromised machines under control of an attacker.

Denial of Service – A method of attack from a single source that denies system access to legitimate users by overwhelming the computer with messages and blocking legitimate traffic.

Exploit tools – Publicly available and sophisticated tools that intruders of various skill levels can use to determine vulnerabilities and gain entry into targeted systems.

Logic bombs – A form of sabotage in which a programmer inserts code that causes the program to perform a destructive action when a triggering event occurs.

Phishing – The creation and use of e-mails and websites designed to deceive Internet users into disclosing their personal data, resulting in identity theft and fraud.

Sniffer – A program that intercepts routed data and examines each packed in search of specified information.

Trojan Horse – A computer program that conceals a harmful code.

Virus – A program that infects computer files by inserting a copy of itself into the file.

Worm – An independent computer program that reproduces by copying itself from one system to another across a network.

[1] A variant of the denial of service attack that uses a coordinated attack from a distributed system of computers rather than a single source.
[2] Simple programs that dial consecutive telephone numbers looking for modems.
[3] A method of gaining entry into wireless computer networks using a laptop, antennas, and a wireless network adaptor that involves patrolling locations to gain unauthorized access.

International Studies (CSIS) estimated that cybercrimes cost the global economy almost $500 billion; in 2018, they estimate that number to be close to $600 billion (CSIS 2018). The business sector suffered the most breaches by industry in 2018, followed by medical/healthcare organizations and the banking/credit/financial sector (Insurance Information Institute 2019). In 2018, the Internet Crime Complaint Center stated $2.7 billion in losses in 2018 in the United States; personal data breaches resulted in $149 million in losses and identify theft caused $100 million in losses (Insurance Information Institute 2019).

Cyberattacks can not only damage governments, companies, and individuals economically, but can also lead to embarrassment, reputation loss, and lack of trust. Attacks are also a risk to critical infrastructure, potentially affecting power grids, transportation systems, and healthcare sectors.

8.2 Snohomish County Hazard Profile

Washington State ranks sixth in reported incidents of cybercrime in 2018; total losses by victims in Washington was $60,513,117 (FBI 2019c). Individuals, businesses, utilities, and governments in Snohomish County are all potential targets for cyberattacks.

8.2.1 Hazard Ranking

The Steering Committee and Planning Team completed a hazard ranking survey during the Snohomish County 2020 HMP update process for a range of hazard-related factors based on worst-case and most likely scenarios; definitions of the hazard ranking factors may be found in Table K-1 in Appendix K. The results of the survey were averaged together for each factor to generate a total average score and rank, enabling the prioritization of hazards by type. When compared against the other hazards included in the 2020 hazard ranking survey, cybersecurity threats were ranked as the sixth worst-case scenario and the fifth most likely scenario (see Table 8-1).

Table 8-1
Hazard Ranking Output

Severity (1=lowest, 5=highest)	Magnitude (1=lowest, 5=highest)	Frequency (1=lowest, 5=highest)	Onset (1=slowest, 5=fastest)	Duration (1=shortest, 5=longest)	Perceived Change in Risk	Average	Rank
Worst-case Scenario							
2.94	4.25	3.00	5.00	3.88	1	3.81	6
Most Likely Scenario							
1.25	1.94	2.50	4.63	2.19	1	2.50	5

8.2.2 Past Events

In May of 2016, The Northshore School District servers were hacked and 9,000 out of 21,000 Gmail accounts were compromised (KOMO Staff 2016). Thousands of students received spam emails containing inappropriate messages and links to pornography (KOMO Staff 2016). On Friday, September 20, 2019, the Northshore School District's servers suffered another significant cyberattack, rendering many of the systems inoperable (Hozan 2019). There were no signs of data being compromised (Hozan 2019).

In 2016, the Snohomish County Public Utility District enlisted the help of the Washington Air National Guard to identify vulnerabilities in their cybersecurity system, asking them to hack into the system–they

were successful (Farley 2016). The goal was to identify vulnerabilities before suffering an actual attack to enhance the security of their system to protect customers and employees.

8.2.3 Location

Cyberattacks can occur locally from sources anywhere on the globe. Attackers may be local, wishing harm on county governments, officials, or individuals. People in the county can also be affected by mass breaches elsewhere in the United States or the world, such as a breach at a bank or credit card institution. It is frequent that the source and location of the cyberattack is unknown.

8.2.4 Frequency

One major internet service provider reports seeing 80 billion malicious scans a day, showing automated efforts by cybercriminals to identify vulnerable targets (CSIS 2018). Many researchers track the quantity of new malware released, estimating a range from 300,000 to a million viruses or other malicious software products being created every day. Every day people, governments, and companies are targeted and may be vulnerable to cyberattacks. The frequency of these attempted attacks and incidents will continue to increase, especially as the county population increases.

8.2.5 Severity

Severity of a cyberattack can vary greatly. An attack against an individual can cost a few hundred dollars or can cost much more in the event of identity fraud, affecting livelihoods years or decades later. Attacks against governments or government officials can cause a lack of trust and a loss of reputation, changing public perception and harming individuals and whole communities. Small businesses can go out of business paying off cybercriminals; hacked medical information, credit card data, bank account information can affect individuals to the biggest companies worldwide. Hacking of businesses can cost shareholders and consumers, loss of transportation systems can cause delays in goods and services. Every person and sector are affected in some severity by cybersecurity threats.

8.2.6 Warning Time

Attacks are instantaneous; there is virtually no warning time for cybersecurity threats once they occur. Once intrusions to systems are recognized, steps can be taken to mitigate the severity of consequences, but this is after a problem has already been identified or made present. Identifying vulnerabilities in systems and increasing cybersecurity are ways to prevent attacks.

8.3 Cascading Impacts/Secondary Hazards

The high risk of impacts from cyber-attacks on critical infrastructure systems at a national or local level are only recently being understood and managed, including the cascading impacts that this risk poses. The interconnectedness of major economic systems, utility systems (i.e., smart grids) food and health systems, and transportation systems indicates that these risks are vast and significant (Toregas and Santos 2019).

8.4 Potential Impacts from Future Climate Conditions

Cyber-attacks may impact the functionality of smart technology that could disrupt the availability of water or energy during heat waves or droughts, which are occurring with greater frequency due to climate change, negatively impacting public health or destroying an entire seasons crop (Toregas and Santos 2019).

8.5 Exposure

8.5.1 Population

As population grows in Snohomish County, more people depend on network connectivity for daily use. More businesses are dependent on networked systems. A successful breach of critical public and private networks could severely diminish or destroy basic public utilities, fuel, health care systems, emergency medical services, communications, and governance (Washington Military Department 2015).

8.5.1.1 Vulnerability

Every person, business, and government entity connected to the grid in Snohomish County is vulnerable to cybersecurity threats.

8.5.2 Property

The data stored on public and private networks are property in and of themselves and often the target of a cyberattack, or lost during significant cyber outages (Washington Military Department 2015). The most valuable data (i.e., property) are consumer, financial, medical, intellectual property, and government information (Washington Military Department 2015). A catastrophic incident or outage from a successful cyberattack or breach can cause physical damage to a property (such as disrupting shutdown procedures, turning off emergency backstops, or taking control of the system itself and overriding safe operating parameters).

8.5.2.1 Vulnerability

Public utilities, private companies, government institutions, and medical sectors are just some of the sectors vulnerable to property damage, both physical and virtual.

8.5.3 Critical Facilities

All critical facilities listed in the plan can experience a cyberattack.

8.5.3.1 Vulnerability

All critical facilities in the county are vulnerable to cyberattacks.

8.5.4 Environment

A cyberattack impacting industrial control systems such as supervisory control and data acquisition systems (those that control public utilities like waste water treatment or sewage processing) could cause immediate environmental damage and health concerns in higher populations areas (Washington Military Department 2015). A fuel or chemical spill resulting from disruption to railway or traffic control systems could negatively impact land, groundwater, and waterways, costing potentially millions of dollars in cleanup and restoration.

8.6 Developing Trends

The threat of cybersecurity incidents and the availability of Homeland Security Funds will influence future development of the county's critical facilities. However, the potential for these threats in Snohomish County is not likely to lessen or prohibit future development.

8.7 Issues

Important issues associated with cybersecurity threats that support future mitigation actions include but are not limited to:

- Participate in regional, state, and federal efforts to gather terrorism information at all levels and keep public safety officials briefed at all times regarding any local threats. Staff will then further develop response capabilities based on emerging threats.
- Enhance awareness training for all public employees to recognize threats or suspicious activity to prevent an incident from occurring.
- Work with the private sector to enhance and create Business Continuity Plans in the event of an emergency.
- Encourage local businesses to adopt information technology and telecommunications recovery plans.

8.8 Hazard Map

No geospatial data are available for this hazard.

9 Dam Failure

9.1 General Background

A dam failure is an uncontrolled release of water from a reservoir as a result of structural failures in a dam. Dam failures can range from minor to catastrophic and can result in deaths, injuries, and damage to property in areas downstream from the reservoir. Natural hazard events like floods, earthquakes, and landslides can cause dam failures, as well as human activities like deficiencies in maintenance, poor operation, criminal acts, or terrorism.

Dam failures in the United States often occur as the result of other hazards, such as earthquakes, landslides, storms, snowmelt or sabotage. Human error, such as poor construction, lack of maintenance and repair, and deficient operational procedures are preventable or correctable by a program of regular inspections. Terrorism and vandalism are serious concerns that all operators of public facilities must plan for; these threats are under continuous review by public safety agencies.

Two federal agencies play significant roles in ensuring the safe operation and maintenance of dams identified under the National Dam Safety Program: the U.S. Army Corps of Engineers and the Federal Energy Regulatory Commission (FERC).

9.1.1 Potential Damage from Dam Failure

A dam failure has the potential to cause damage similar to a flash flood. Downstream communities can be devastated in the event of a large dam failure, which can result in damage or destruction of buildings and infrastructure, particularly bridges, culverts, and other infrastructure within the floodplain. Large dam failures can also result in injuries and deaths and damage to agriculture and natural ecosystems.

9.2 Snohomish County Hazard Profile

There are 66 dams in Snohomish County regulated by the Washington Department of Ecology (Washington Department of Ecology 2019). The most likely disaster-

DEFINITIONS

Dam – Any artificial barrier and/or any controlling works, together with appurtenant works that can or do impound or divert water.

Dam Failure – An uncontrolled release of impounded water due to structural deficiencies in the water barrier.

Emergency Action Plan (EAP) – A formal document that identifies potential emergency conditions at a dam and specifies preplanned actions to be followed to minimize property damage and loss of life. The EAP contains specifies actions the dam owner should take to moderate or alleviate the problems at the dam, procedures on issuing early warning and notification messages to responsible downstream emergency management authorities, and inundation maps to show the emergency management authorities the critical areas for action in case of an emergency.

High Hazard Dam – Dams assigned the high hazard potential classification are those where failure or operational issues will probably cause loss of human life.

Inundation Area – The area of land that would be flooded following a dam failure

Significant Hazard Dam – Those dams where failure or operational issues result in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns.

related causes of dam failure in Snohomish County are earthquakes, excessive rainfall, and landslides.

9.2.1 Hazard Ranking

The Steering Committee and Planning Team completed a hazard ranking survey during the Snohomish County 2020 HMP update process for a range of hazard-related factors based on worst-case and most likely scenarios; definitions of the hazard ranking factors may be found in Table K-1 in Appendix K. The results of the survey were averaged together for each factor to generate a total average score and rank, enabling the prioritization of hazards by type. When compared against the other hazards included in the 2020 hazard ranking survey, dam failures were ranked as the fifteenth worst-case scenario and the thirteenth most likely scenario (see Table 9-1).

Table 9-1
Hazard Ranking Output

Severity (1=lowest, 5=highest)	Magnitude (1=lowest, 5=highest)	Frequency (1=lowest, 5=highest)	Onset (1=slowest, 5=fastest)	Duration (1=shortest, 5=longest)	Perceived Change in Risk	Average	Rank
Worst-case Scenario							
3.44	3.31	1.88	4.38	3.81	0.1	3.36	15
Most Likely Scenario							
2.06	1.94	1.00	3.19	3.25	0.1	2.29	13

9.2.2 Past Events

The Washington Department of Ecology Dam Safety Office maintains records of dam accidents in Washington. Between 1918 and January 2019, 22 notable dam failures and incidents occurred in Washington State[d]. Two of these events occurred in Snohomish County (see Table 9-2).

Table 9-2
Dam Failure Events Snohomish County

Project Name	Location	Date	Lives Lost	Nature of Failure
North Star Sand & Gravel Dams	Everett	December 1967	0	40-foot-high dam washed out by overtopping due to lack of spillway. 25-foot-high dam rebuilt, also failed, washed out GN railroad tracks, derailed passing train.
French Slough Bartelheimer Dairy Waste Pond	Snohomish County	April 2010	0	Breached manure lagoon emptied some 27 million gallons on to adjacent farmland and into French Slough. Cause of Breach: Failure to remove cedar drain field beneath the pond during construction allowed internal erosion through the embankment foundation.

[d] Washing Department of Ecology. (2019, January). *Washington State Notable Dam Failures and Incidents.* Retrieved from https://fortress.wa.gov/ecy/wrdocs/WaterRights/wrwebpdf/damfailure-ws.pdf.

9.2.3 Location

There are 66 regulated dams in Snohomish County. Of these, 13 are categorized as a high-downstream hazard (Hazard Class 1A, 1B, & 1C; see Table 9-3).

Table 9-3
High Downstream Hazard Dams in Snohomish County

Name	Hazard Class [a]	Water Course	Year Built	Dam Type	Crest Length (ft)	Height (ft)	Storage Capacity (acre-ft)	Drainage Area (sq. mi.)
Cedar Way Stormwater Detention Dam	1B	Lyons Creek	1985	Earth Fill	175	30	25	1.63
Chaplain Lake North Dam	1B	Woods Creek	1940	Earth Fill	800	35	2,200	2.6
Chaplain Lake South Dam	1A	Chaplain Creek	1930	Earth Fill	900	75	16,200	2.6
Everett Reservoir #3	1B	Pigeon Creek	1923	Earth Fill	1500	22	61	0
George Culmback Dam	1A	Sultan River	1965	Rock fill	480	270	154,900	74.5
N. Marysville Regional Stormwater Pond	1B	Quilceda Creek	2004	Earth Fill	2600	8	10	.13
Silver Firs Detention Pond No. 3	1B	Little Bear Creek	1999	Earth Fill	1000	14	1	.63
Hilltop Waterski Pond	1C	Quilceda Creek	1995	Earth Fill	4200	26	100	.04
Kayak Lake Dam	1C	Cherry Creek	1965	Earth Fill	1170	24	130	.42
N Marysville Regional Stormwater Pond No. 2	1C	Quilceda Creek	2015	Earth Fill	2060	7	14	.02
Nielsen Dam B	1C	North Creek	1973	Earth Fill	150	10	10	.08
Nielsen Dam C	1C	North Creek	1973	Earth Fill	250	9	12	.15
Rainbow Springs Dam	1C	South Fork Stillaguamish	1969	Earth Fill	900	14	43	.56

a. Downstream Hazard Class 1A: >300 lives at risk, 1B: 31 to 300 lives at risk, 1C: 7 to 30 lives at risk
Source: Washington Department of Ecology – Water Resources Program – Dam Safety Office

9.2.4 Frequency

Dam failure events are infrequent; their frequency coincides with that of the events that may cause them, including earthquakes, landslides, and excessive rainfall and snowmelt. Dams pose "residual risk"; risk remaining after implementation of safeguards. Residual risk is associated with events beyond those the dam was designed to withstand. Two notable dam failure incidents have occurred in Snohomish County since 1918. These types of events and the probability of occurrence of any type of failure are not likely to occur in today's current regulatory and dam safety oversight environment.

9.2.5 Severity

Dam failure can be catastrophic to all life and property downstream. Past dam failure events in Snohomish County and Washington State have led to significant economic and environmental impacts. Measure of extent or severity of a dam failure is through the classification of the dam. The U.S. Army Corps of Engineers hazard classification is shown in Table 9-4.

Table 9-4
U.S. Army Corps of Engineers Dam Hazard Classification

Hazard Category [a]	Direct Loss of Life [b]	Lifeline Losses [c]	Property Losses [d]	Environmental Losses [e]
Low	None (rural location, no permanent structures for human habitation)	No disruption of services (cosmetic or rapidly repairable damage)	Private agricultural lands, equipment, and isolated buildings	Minimal incremental damage
Significant	Rural location, only transient or day-use facilities	Disruption of essential facilities and access	Major public and private facilities	Major mitigation required
High	Certain (one or more) extensive residential, commercial, or industrial development	Disruption of essential facilities and access	Extensive public and private facilities	Extensive mitigation cost or impossible to mitigate

a. Categories are assigned to overall projects, not individual structures at a project.
b. Loss of life potential based on inundation mapping of area downstream of the project. Analyses of loss of life potential should take into account the population at risk, time of flood, wave travel, and warning time.
c. Indirect threats to life caused by the interruption of lifeline services due to project failure or operational disruption; for example, loss of critical medical facilities or access to them.
d. Damage to project facilities and downstream property and indirect impact due to loss of project services, such as impact due to loss of a dam and navigation pool, or impact due to loss of water or power supply.
e. Environmental impact downstream caused by the incremental flood wave produced by the project failure, beyond what would normally be expected for the magnitude flood event under which the failure occurs.
Source: U.S. Army Corps of Engineers 1995[e]

[e] U.S. Army Corps of Engineers. (1995, July). Earthquake Design and Evaluation for Civil Works Projects. *U.S. Army Corp of Engineers Publication EM 1110-2-1806*. Retrieved from www.usace.army.mil/publications/eng-regs/er1110-2-1806/a-b.pdf.

9.2.6 Warning Time

Warning time for dam failure varies depending on the cause of the failure. Evacuations prior to events of extreme precipitation or massive snowmelt can be planned given enough time. A structural failure due to earthquake could possibly allow no warning time. A dam's structural type also affects warning time. Earthen dams do not tend to fail completely or instantaneously. Once a breach is initiated, discharging water erodes the breach until either the reservoir water is depleted, or the breach resists further erosion. Concrete gravity dams also tend to have a partial breach as one or more monolith sections formed during dam construction are forced apart by the escaping water. The time for breach formation ranges from a few minutes to a few hours (U.S. Army Corps of Engineers 1997)[f].

9.3 Cascading Impacts/Secondary Hazards

Dam failure can cause severe downstream flooding depending on the magnitude of the failure. Other potential secondary hazards of dam failure include landslides around the reservoir perimeter, bank erosion on the rivers, and destruction of downstream habitat.

9.4 Potential Impacts from Future Climate Conditions

Dams are designed partly based on assumptions about a river's flow behavior, expressed as hydrographs. Changes in weather patterns can have significant effects on the hydrograph used for the design of a dam. If the hydrograph changes, it is conceivable that the dam could lose some, or all, of its designed margin of safety, also known as freeboard. If freeboard is reduced, dam operators may be forced to release increased volumes earlier in a storm cycle to maintain the required margins of safety. These earlier releases of increased volumes of water can increase flood potential downstream (University of Washington 2015a).

Future climate conditions are unlikely to increase the occurrences of structural dam failure. However, spillway overflow events, often referred to as "design failures," may increase. This would result in increased discharges downstream and flooding potential. Climate change would also increase the occurrence of floodwaters exceeding levee capacity and the risk for structural levee failure.

9.5 Exposure

An exposure overlay analysis was used for the assessment of dam failure risk and vulnerability in Snohomish County for facilities with sufficient data to support modeling. The exposure and vulnerability analyses focused on the two principal dams of concern for which inundation data are available: Culmback Dam and Tolt Dam. Although the following discussions on exposure and vulnerability evaluate the data for each facility separately, it should be noted that there is an overlap in data between the two inundation areas.

9.5.1 Population

All populations within dam failure inundation zones would be exposed to the effects of a dam failure. The potential for loss of life is affected by the capacity of the dam, the number of evacuation routes available to populations living in areas of potential inundation, and warning time. For example, the population

[f] U.S. Army Corps of Engineers. (1997, October). Engineering and Design - Hydrologic Engineering Requirements for Reservoirs. *U.S. Army Corp of Engineers Publication EM 1110-2-1420*. Retrieved from www.usace.army.mil/publications/eng-manuals/em1110-2-1420/c-16.pdf

within the dam-failure inundation areas of the Culmback and Tolt River dams is approximately 14,926 or 1.9 percent of the total county population. Table 9-5 summarizes the at-risk population information.

Table 9-5
Population at Risk from Dam Failure

River System	Affected Population	% of County
Tolt	4724	0.6 %
Culmback	14549	1.8 %
Total[i]	14926	1.9 %

i. Represents the total population in the combined inundation areas for both dams.

9.5.1.1 Vulnerability

Vulnerable populations are all populations downstream from dam failures that are incapable of escaping the area within the allowable time frame. This population includes the economically disadvantaged, elderly and young, those who may be unable to get themselves out of the inundation area, and those who may not have adequate warning.

9.5.2 Property

Based on Snohomish County Assessor parcel data, the HAZUS-MH model estimated that there are 7,315 structures within the combined inundation areas of the Culmback and Tolt River Dams. The value of exposed buildings in the planning area was generated using HAZUS-MH and is summarized in Table 9-6. This methodology estimated $2.54 billion worth of building-and-contents exposure to dam failure inundation in these areas, representing 5 percent of the total assessed value of the planning area. Since the Culmback and Tolt dam failure inundation areas overlie the mapped floodplain areas, the land use in these areas is the same as described for the flood risk assessment in Chapter 12.

Table 9-6
Value of Property Exposed to Dam Failure

Jurisdiction	Buildings Exposed	Assessed Value			% Of Total
		Structure	Contents	Total	
Marysville	82	$22,654,532	$24,225,474	$46,880,006	1%
Monroe	2737	$883,416,339	$809,679,681	$1,693,096,020	61%
Snohomish	218	$29,199,189	$20,155,582	$49,354,771	4%
Sultan	1644	$191,492,288	$126,418,303	$317,910,591	68%
Unincorporated	2634	$244,640,942	$190,270,148	$434,911,090	1%
Grand Total	7315	$1,371,403,289	$1,170,749,188	$2,542,152,477	5%

9.5.2.1 Vulnerability

Vulnerable properties are those closest to the dam inundation area. These properties would undergo the largest, most destructive surge of water. Low-lying areas are also vulnerable because dam waters would collect there.

The initial vulnerability analysis for property requires details mapping that illustrates depth of flooding. The property initial vulnerability analyses are summarized in Table 9-7 and 9-8:

Table 9-7 Value of Property Vulnerable to Culmback Dam Failure					
Jurisdiction	Buildings Exposed	Assessed Value			% Of Total
		Structure	Contents	Total	
Marysville	78	$22,506,761.91	$24,041,353.66	$46,548,115.57	1%
Monroe	2643	$871,113,059.13	$802,688,231.05	$1,673,801,290.18	60%
Snohomish	218	$29,199,188.83	$20,155,582.22	$49,354,771.05	4%
Sultan	1644	$191,492,287.76	$126,418,303.08	$317,910,590.85	68%
Unincorporated	2587	$239,731,970.68	$186,009,083.58	$425,741,054.26	1%
Grand Total	7170	$1,354,043,268.31	$1,159,312,553.59	$2,513,355,821.90	5%

Table 9-8 Value of Property Vulnerable to South Fork Tolt River Dam Failure					
Jurisdiction	Buildings Exposed	Assessed Value			% Of Total
		Structure	Contents	Total	
Marysville	29	$11,164,851	$14,100,720	$25,265,571	0.4%
Monroe	1211	$554,718,281	$577,866,883	$1,132,585,164	41%
Snohomish	60	$6,652,807	$5,325,228	$11,978,035	1%
Unincorporated	1166	$111,916,771	$101,213,788	$213,130,559	1%
Grand Total	2466	$684,452,709	$698,506,619	$1,382,959,328	3%

9.5.3 Critical Facilities

GIS analysis was applied to determine the number of critical facilities within the mapped dam inundation areas. As Table 9-9 indicates, 141 of Snohomish County's critical facilities are within the inundation areas.

Table 9-9 Critical Facilities Within Snohomish County's Culmback and Tolt Dam Inundation Zones	
Airport	2
Bridge	63
Communication	1
Dam	6
Fire/EMS	2
Government	5
Medical	6
Other	13
Police	3
Port Facility	6
School	10
Wastewater Facility	24
Total	141

9.5.3.1 Vulnerability

All critical facilities within dam inundation areas are vulnerable to the dam failure hazard. Transportation routes—including all roads, railroads, and bridges in the path of a dam inundation—are vulnerable and could be wiped out, creating isolation issues. Critical facilities most vulnerable are those already in poor condition and thus not able to withstand a large water surge. Utilities such as overhead power lines, cable, and phone lines could also be vulnerable. Loss of these utilities could create additional isolation issues within the inundation areas.

9.5.4 Environment

Reservoirs held behind dams affect many ecological aspects of a river. River topography and dynamics depend on a wide range of flows, but rivers below dams often undergo long periods of very stable flow conditions or saw-tooth flow patterns caused by releases followed by no releases. Water releases from a reservoir, including those exiting a turbine, usually contain very little suspended sediment; this can lead to scouring of riverbeds and loss of riverbanks.

9.5.4.1 Vulnerability

The environment would be exposed to a number of risks in the event of dam failure. The inundation could introduce many foreign elements into local waterways, possibly destroying downstream habitat and exerting detrimental effects on many species of animals. Any facilities that house or process hazardous materials within the inundation are may also threaten the environment. The extent of vulnerability of the environment is the same as the extent of exposure.

9.6 Development Trends

Since the dam failure inundation areas overlie the mapped floodplain areas, the future trends for development in these areas are the same as described for the flood risk assessment in Chapter 12.

9.7 Issues

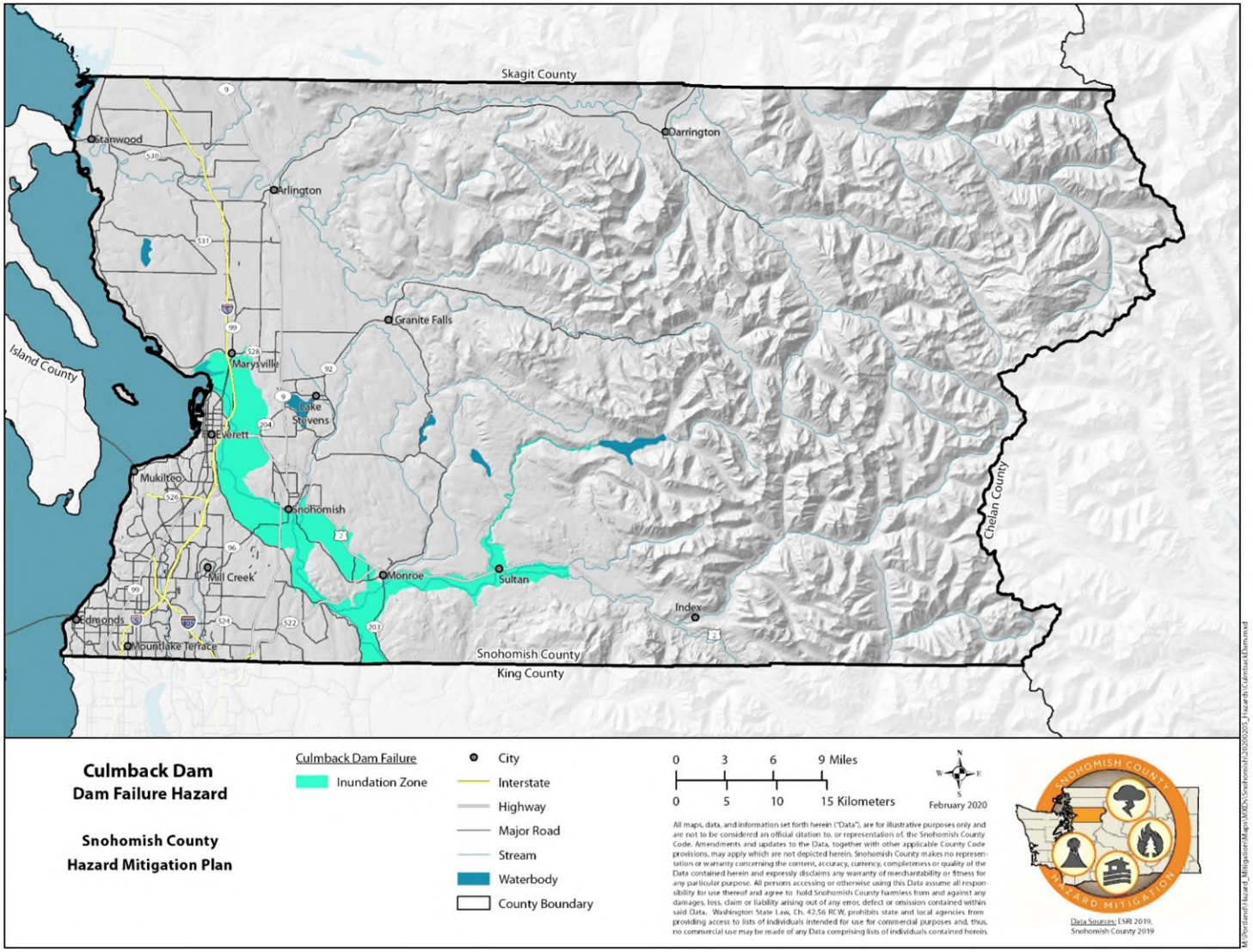
The most significant issue associated with dam failure involves the properties and populations in the inundation zones. Flooding as a result of a dam failure would significantly impact these areas. There is often limited warning time for dam failure. These events are frequently associated with other natural hazard events such as earthquakes, landslides, or severe weather, which limit their predictability and compound the hazard. Important issues associated with dam failure hazards include the following:

- Federally regulated dams have an adequate level of oversight and sophistication in the development of EAPs for public notification in the unlikely event of failure. However, state-regulated dams whose failure would pose a true threat to the people, property, and economy of Snohomish County need to be clearly identified.
- Mapping for federally regulated dams is already required and available; however, mapping for state-regulated dams that estimates inundation depths is needed to better assess the risk associated with dam failure from these facilities.
- Most dam failure mapping required at state and federal levels requires determination of the probable maximum flood. While the probable maximum flood represents a worst-case scenario, it is generally the event with the lowest probability of occurrence. Mapping of dam failure scenarios for state-regulated dams that are less extreme than the probable maximum flood, but have a higher probability of occurrence, can be valuable to emergency managers and community officials downstream of these high hazard facilities. This type of mapping can illustrate areas

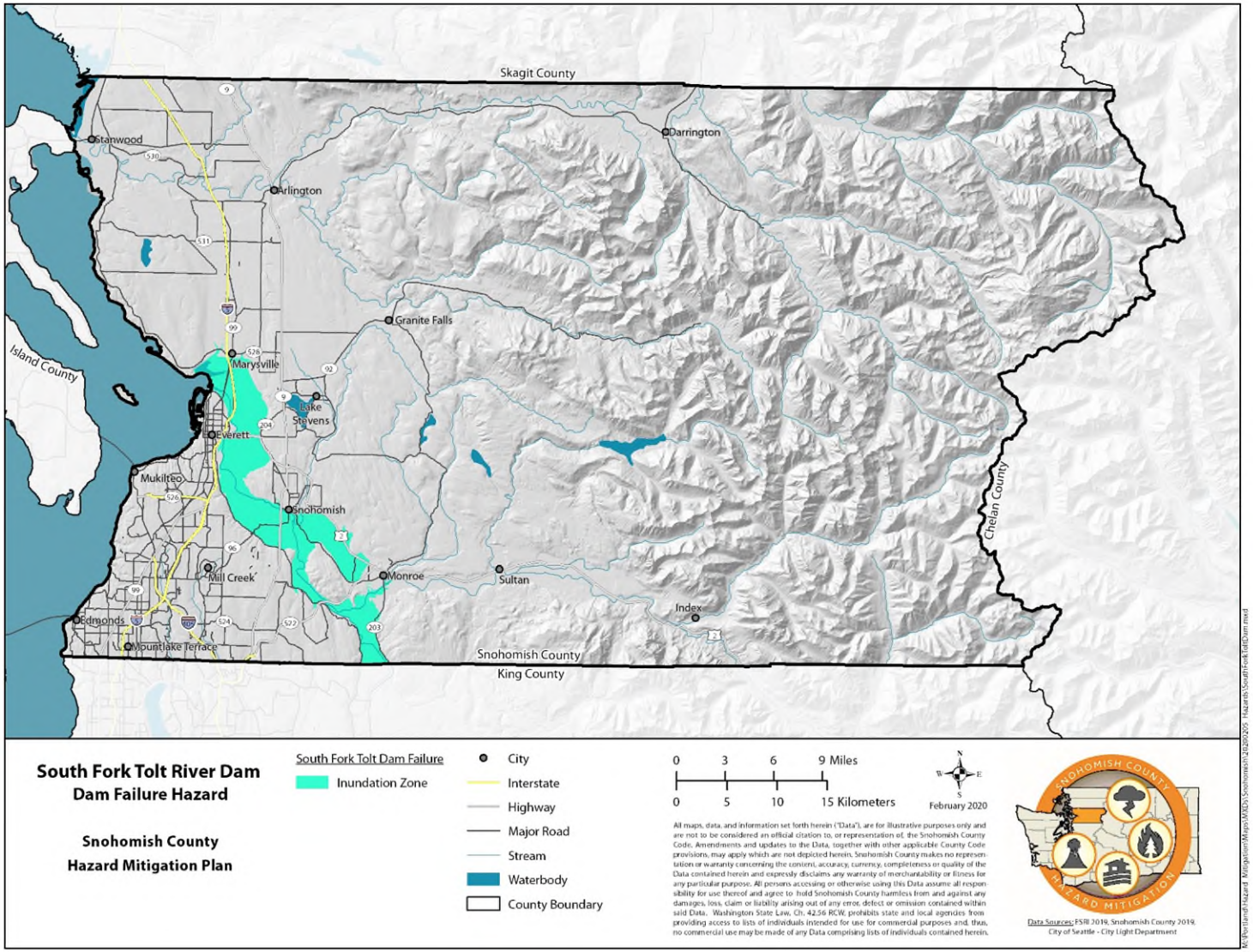
potentially impacted by more frequent events to support emergency response and preparedness actions.

- The concept of residual risk associated with structural flood control projects should be considered in the design of capital projects and the application of land use regulations.
- Addressing security concerns and the need to inform the public of the risk associated with dam failure is a challenge for public officials.

9.8 Hazard Maps



Map 9-1 Jackson Hydroelectric Project Culmback Dam Failure Inundation Zone



Map 9-2 South Fork Tolt River Dam Failure Inundation Zone

10 Earthquake

10.1 General Background

An earthquake results from sudden stress changes in the earth due to the slip of a fault, or volcanic activity, and the resulting ground shaking and radiated seismic energy. Earthquakes can last from a few seconds to over five minutes; they may also occur as a series of tremors over a period of several days.

While most seismic hazards occur or are projected to occur on well-known active faults, determining if a fault is active or potentially active depends on geologic evidence that may not be available. Although there may be some unrecognized active faults, active faults represent the highest hazard.

Earthquakes are more likely to occur on a fault if they have more rapid rates of movement, have had recent earthquakes, experience greater total displacements, or are aligned so that movement relieves accumulating tectonic stresses. There is a direct relationship between the length and location of a fault and its ability to generate damaging ground motion at a given site.

In some areas, smaller, local faults produce lower-magnitude quakes, but ground shaking can be strong, and damage can be significant as a result of the fault's proximity to the area. In contrast, large regional faults can generate great magnitudes but, because of their distance and depth, may result in only moderate shaking in the area.

DEFINITIONS

Earthquake – The 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.

Epicenter – The point on the earth's surface directly above the hypocenter of an earthquake. The location of an earthquake is commonly described by the geographic position of its epicenter and by its focal depth.

Fault – A fracture in the earth's crust along which two blocks of the crust have slipped with respect to each other. Most common is a strike-slip, normal, or thrust fault.

Focal Depth – The depth from the earth's surface to the hypocenter.

Hypocenter – The region underground where an earthquake's energy originates.

10.1.1 Potential Impacts from Earthquakes

Casualties may result from falling objects and debris because earthquakes can shake, damage or demolish buildings and other structures. Disruption of communications, electrical power supplies; and gas, sewer, and water lines should be expected. Earthquakes may trigger fires, dam failures, landslides, or releases of hazardous material, compounding their disastrous effects.

10.2 Snohomish County Hazard Profile

The Puget Sound region is seismically active, with hundreds of earthquakes occurring each year; however, most are so small that only sensitive instruments can detect them. While many of these events register a magnitude of 3 or lower on the Richter scale, earthquakes measuring up to 7.1 magnitude have been recorded; Table 10-1 describes earthquake magnitude classes.

Recent studies suggest that earthquakes of a magnitude 8 or greater have occurred in the region and that similar seismic events are possible in the future.

Table 10-1
Earthquake Magnitude Classes

Magnitude Class	Magnitude Range
Great	M > 8
Major	7 ≤ M < 7.9
Strong	6 ≤ M < 6.9
Moderate	5 ≤ M < 5.9
Light	4 ≤ M < 4.9
Minor	3 ≤ M < 3.9
Micro	M < 3

Several major faults are located in the Puget Sound area. Small shallow earthquakes (up to magnitude 4) associated with these faults are likely. Shallow earthquakes of greater magnitude are expected to occur infrequently in this area. Geologists generally agree that three source zones exist for Puget Sound quakes: a shallow (crustal) zone; the Cascadia Subduction Zone (CSZ); and a deep, intra-plate "Benioff" zone. These are shown in Figure 6-1. More than 90 percent of Pacific Northwest earthquakes occur along the boundary between the Juan de Fuca plate and the North American plate.

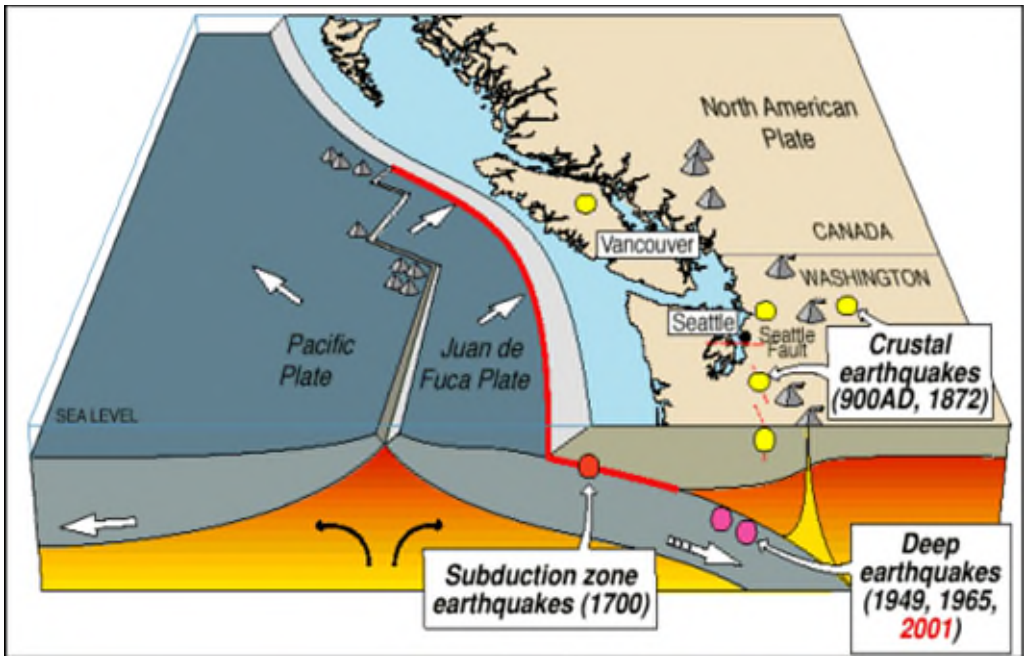


Figure 6-1 Earthquake Types in Western Washington State

Snohomish County is located in the CSZ, an area prone to earthquakes with little warning (rapid onset) and potentially catastrophic impacts to communities and infrastructure (PNSN 2019a). Earthquakes are generated in the CSZ, which extends from northern California to British Columbia, Canada, when the Juan de Fuca Plate moves under the North American Plate in the Pacific Ocean. In addition to the Southern Whidbey Island Fault (SWIF) and the CSZ, the county is exposed to deep intraplate, crustal faulting, and volcanic earthquakes (PNSN 2019b).

10.2.1 Hazard Ranking

The Steering Committee and Planning Team completed a hazard ranking survey during the Snohomish County 2020 HMP update process for a range of hazard-related factors based on worst-case and most likely scenarios; definitions of the hazard ranking factors may be found in Table K-1 in Appendix K. The results of the survey were averaged together for each factor to generate a total average score and rank, enabling the prioritization of hazards by type. When compared against the other hazards included in the 2020 hazard ranking survey, earthquakes were ranked as the number one worst-case scenario and the second most likely scenario (see Table 10-2).

Table 10-2
Hazard Ranking Output

Severity (1=lowest, 5=highest)	Magnitude (1=lowest, 5=highest)	Frequency (1=lowest, 5=highest)	Onset (1=slowest, 5=fastest)	Duration (1=shortest, 5=longest)	Perceived Change in Risk	Average	Rank
Worst-case Scenario							
5.00	4.69	2.88	4.81	3.50	0.4	4.18	1
Most Likely Scenario							
2.31	2.31	2.06	4.00	2.00	0.4	2.54	2

10.2.2 Past Events

At least 20 damaging earthquakes have occurred in Western Washington during the past 125 years. Large earthquakes in 1945, 1949, 1965, 1981, and 2001 killed 16 people and caused more than $2 billion in damage. The last known megathrust earthquake (estimated magnitude 9) in the region was in January of 1700 (University of Washington 2015b). Between January 2000 and September 2019, the Snohomish County region experienced 14 earthquakes of a 3.0 magnitude or greater, with the strongest having a 4.6 magnitude (PNSN 2019). Two earthquakes resulted in a disaster declaration, as shown in Appendix K, Table K-2 (FEMA 2019c).

10.2.3 Locations Where Earthquakes Appear

10.2.3.1 Cascadia Subduction Zone

In Western Washington, the primary plates of interest are the Juan De Fuca and North American plates. The Juan De Fuca plate moves northeast with respect to the North American plate at a rate of about an inch and a half per year. The boundary where these plates converge, the CSZ, lies approximately 50 miles offshore of the west coastline and extends from the middle of Vancouver Island in British Columbia to northern California. As it collides with the North American plate, the Juan De Fuca plate slides beneath the continent and sinks into the earth's mantle. The sliding of one plate below another is called "subduction." Subduction zone earthquakes occur as a direct result of the convergence of these two plates. Earthquakes at subduction zone boundaries produce the world's greatest earthquakes. A subduction earthquake off the coast of Washington or Oregon where the plates converge would typically have a minute or more of strong ground shaking at magnitude 8 to 9.5 on the Richter scale. Usually, damaging tsunamis and numerous large aftershocks immediately follow these types of earthquakes.

10.2.3.2 Benioff Deep Zone

Western Washington can experience deep earthquakes of magnitude 6 to 7.4 on the Richter scale. This occurs within the Juan de Fuca plate at depths of about 30 to 40 miles. As the Juan de Fuca plate moves

beneath North America, it becomes denser than the surrounding mantle rocks and breaks apart, causing Benioff zone earthquakes. The largest Benioff zone earthquakes occur where the Juan de Fuca plate begins to bend even more steeply downward, forming a knee.

The largest of these events recorded in modern times include the 7.1-magnitude Olympia earthquake in 1949 and the 6.8-magnitude Nisqually earthquake in 2001. Strong shaking during the Olympia earthquake lasted about 20 seconds. During the Nisqually quake, shaking lasted from 30 seconds to greater than 2 minutes. Since 1870, there have been seven deep earthquakes in the Puget Sound basin with measured or estimated magnitudes of 6.0 or larger. The epicenters of all these events have occurred between Olympia and just north of Tacoma, within about 50 miles of each other. Scientists estimate the recurrence interval to be 30 to 40 years for a magnitude 6.5 quake and 50 to 70 years for magnitude 7.0. Because of their depth, intra-plate earthquakes are least likely to produce significant aftershocks.

10.2.3.3 Crustal Zone

The third source zone is the crust of the North American plate, which are known as shallow earthquakes. Shallow earthquakes with a magnitude of 7 or more on the Richter scale can happen anywhere in the Puget Sound region, such as the SWIF. Such earthquakes have the potential to cause greater loss of life and property than any other kind of disaster but may occur no more than once every 1,000 years.

The SWIF was assessed as capable of generating the largest crustal earthquake in Puget Sound. The SWIF is now known to be a broad, north-side-up fault zone dipping steeply to the northeast. LIDAR (a remote sensing method used to examine the surface of the Earth) and aeromagnetic data confirm that the SWIF projects onto the mainland near Everett, in Snohomish County, and continues southeast towards Woodinville, in King County. Based on radiocarbon and stratigraphic data, researchers concluded that the SWIF can produce a magnitude 6.5 to 7.5 earthquake (Washington Department of Natural Resources 2013).

The structure of the crust in the Puget Sound area is complex, with large sedimentary rock-filled basins beneath Tacoma, Seattle, and Everett. The Seattle basin is the deepest, at about 5 to 6 miles. In addition to the 1872 Mount Baker earthquake, seismologists have found evidence that a devastating crustal quake occurred on a fault near Seattle approximately 1,100 years ago. The Duvall Fault near Lake Margaret on the King-Snohomish County border has produced two magnitude 5.3 earthquakes in the past 70 years (1932 and 1996). How many other crustal faults pose significant earthquake hazards to the Puget Sound region is not yet known.

Crustal earthquakes are the least predictable of Puget Sound's seismic threats and are the most likely to be followed by significant aftershocks. Following a great crustal earthquake of magnitude 7.0 or more, one of the greatest dangers to human life is that buildings or other structures damaged in the initial shock but still in use and believed safe could collapse in a strong aftershock.

10.2.4 Frequency

The Puget Sound region experiences hundreds of earthquakes each year, the majority of which are below a magnitude of 3.0 and observed only by sensitive equipment. The USGS estimated that a CSZ earthquake has a 10 to 15 percent probability of occurrence in 50 years, and a crustal zone earthquake has a recurrence interval of 500 to 600 years. In general, it is difficult to estimate the probability of occurrence of crustal earthquake events.

Earthquakes on the SWIF and Seattle Fault 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 not yet enough information on the Devil's Mountain Fault-North Whidbey Fault complex to determine the probability of occurrence of an event on this complex.

10.2.5 Severity

The severity of an earthquake can be expressed in terms of intensity or magnitude (USGS, n.d. [a]). Intensity represents the observed effects of ground shaking at any specified location. The intensity of earthquake shaking lessens with distance from the earthquake epicenter. Tabulated peak ground accelerations for a listed "maximum credible earthquakes" (MCE) are a measure of how a site will be affected by seismic events on distant faults.

Magnitude represents the amount of seismic energy released at the hypocenter of the earthquake. It is based on the amplitude of the earthquake waves recorded on instruments. Magnitude is thus represented by a single, instrumentally determined value. The potential magnitude, in the most extreme scenarios, of earthquakes in the county by type are the CSZ (9.3 for approximately 4 minutes with aftershocks), Benioff (7.4 with no aftershocks), and Crustal, North Whidbey-Devil's Peak Complex, South Whidbey Island, Possible Everett Fault (7.5 with some aftershocks).

10.2.6 Warning Time

There is currently no reliable way to predict the day or month that an earthquake will occur at any given location. Research is being done with warning systems that use the low-energy waves that precede major earthquakes. These low-energy waves arrive at seismic detection stations before destructive energy waves, and the stations transmit data to the Pacific Northwest Seismic Network (PNSN). The PNSN can then issue an earthquake early warning (EEW), warning persons in the area of approaching strong tremors. These potential warning systems give approximately 40 seconds notice that a major earthquake is about to occur. The warning time is very short, but it could allow for someone to get under a desk, step away from a hazardous material, or shut down a computer system.

10.3 Secondary Hazards

Earthquakes can cause large and sometimes disastrous landslides and mudslides. River valleys are vulnerable to slope failure, often as a result of loss of cohesion in clay-rich soils. Soil liquefaction occurs when water-saturated sands, silts, or gravelly soils are shaken so violently that the individual grains lose contact with one another and "float" freely in the water, turning the ground into a pudding-like liquid. Building and road foundations lose load-bearing strength and may sink quicksand-like into what was previously solid ground. Unless properly secured, hazardous materials can be released, causing significant damage to the environment and people.

Earthen dams and levees are highly susceptible to seismic events, and the impacts of their eventual failures can be considered secondary risk exposure to earthquakes. Depending on the location, earthquakes can also trigger

DEFINITIONS

Seiche – A standing wave in an enclosed or partly enclosed body of water, normally caused by earthquake activity; can affect harbors, bays, lakes, rivers, and canals.

Tsunami – 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.

tsunamis. Tsunamis significantly damage many locations beyond what the earthquake struck; however, coastal communities near the earthquake epicenter that are also vulnerable to tsunamis could experience devastating impacts. Additionally, fires can result from gas lines or power lines that are broken or downed during the earthquake. It may be difficult to control a fire, particularly if the water lines feeding fire hydrants are also broken.

10.4 Potential Impacts from Future Climate Conditions

The impacts of global climate change on earthquake probability are unknown; however, the secondary impacts of earthquakes could be magnified by climate change. Soils saturated by repetitive storms could fail during seismic activity due to the increased saturation. Steep slope failure may increase where changes in river hydrology or sea-level weakens slope stability. Dams storing increased volumes of water due to changes in the hydrograph could fail during seismic events. Fire risks associated with earthquakes could be significantly enhanced by drought conditions triggered by climate change. There are currently no models available to estimate these impacts.

10.5 Exposure and Vulnerability

The exposure assessment outputs in this section were generated by intersecting earthquake hazard data with U.S. Census data for populations and property and facility data from the County and the participating jurisdictions.

The vulnerability assessment outputs in this section was generated using the HAZUS-MH program for earthquakes. Once the location and size of a hypothetical earthquake are identified, HAZUS-MH estimates the intensity of the ground shaking, the number of buildings damaged, the number of casualties, the amount of damage to transportation systems and utilities, the number of people displaced from their homes, and the estimated cost of repair and cleanup.

10.5.1 Population

The entire population of Snohomish County is potentially exposed to earthquakes. Although the vulnerability is low, cities are more at risk than rural areas due to higher density. Towns are also more vulnerable because they are typically located in small valleys alongside streams, which typically have softer soils. Many communities in Snohomish County have buildings that were built during the beginning of the twentieth century and were not subject to the building codes implemented over the last 30 years, which require that structures be able to better withstand earthquakes. Ornamentation (such as parapets) and chimneys may be shaken loose during an earthquake and fall on people below.

10.5.1.1 Vulnerability

There are an estimated 226,703 people in 84,591 households living on soils with moderate to very high liquefaction potential in the planning area, or about 28.3 percent of the total population. Three groups are particularly vulnerable to earthquake hazards:

- **Linguistically Isolated Populations**—In all, 30,083 persons are listed as being linguistically isolated (they do not speak English as their native language) in the census block groups on National Earthquake Hazard Reduction Program (NEHRP) D, E, and F soils. This is about 3.8 percent of the people in these census block groups. They are particularly vulnerable during earthquake events because of communication issues with the predominantly English-speaking media and

government. A difficulty arises when there is an urgent need to inform non-English speaking residents of an earthquake event or response.

- **Population below poverty level –** An estimated 20,674 people are listed as being below the poverty level within the census block groups on NEHRP D, E, and F soils. They make up about 2.6 percent of the total county population. Persons below the poverty level are more vulnerable because they may not have the financial ability to secure or improve their homes to prevent or mitigate earthquake damage. Additionally, they are also less likely to have insurance to compensate for losses in earthquakes. This means that they have the most to lose during an event and are the least prepared to deal with losses.
- **Population over 65 Years Old**—In all, 22,630 people are over 65 years old in the census block groups on NEHRP D, E, and F soils. This makes up about 2.8 percent of the total county population. This population group is more vulnerable because they are more likely to need special medical attention, which may not be available due to isolation caused by earthquakes. Persons over 65 also have more difficulty leaving their homes during earthquake events and could be stranded in dangerous situations.

10.5.2 Property

According to the Snohomish County Assessor, there are approximately 333,007 buildings in Snohomish County, with a total replacement value of $106.9 billion. Most of these buildings (93.2 percent) are residential. Since all structures in the planning area are susceptible to earthquake impacts to varying degrees, this represents the exposure to seismic events within the county. All are exposed to the earthquake hazard.

The Washington State Building Code Council identifies significant milestones in building and seismic code requirements that directly affect the structural integrity of development in Washington. Using these time periods, the planning team used HAZUS to identify the number of structures within the county by date of construction. Table 10-3 shows the results of this analysis.

Table 10-3
Age of Structures Across Snohomish County

Time Period	Number of Structures	Significance of Time Frame
Pre-1933	12,237	Before 1933, there were no explicit earthquake requirements in building codes. State law did not require local governments to have building officials or issue building permits.
1933-1940	2,393	In 1940, the first strong motion recording was made.
1941-1960	23,731	In 1960, the Structural Engineers Association of California published guidelines on recommended earthquake provisions
1961-1975	36,693	In 1975, significant improvements were made to lateral force requirements.
1976-1994	86,449	In 1994, the Uniform Building Code was amended to include provisions for seismic safety.
1995-Present	124,316	Seismic codes are enforced.
Total	285,819	

The number of structures does not reflect the number of total housing units, as many multi-family units and attached housing units are reported as one structure. Approximately 39.2 percent of structures in the planning area were built after the Uniform Building Code was amended in 1994 to include seismic safety provisions. Roughly 6.5 percent of the structures were built before 1933 when there were no building permits, inspections, or seismic standards.

10.5.2.1 Vulnerability

Loss estimates for the planning area were generated for the 100-year and 500-year earthquake events, as well as the three scenario events through a Level 2 analysis using HAZUS-MH. The results of these analyses are summarized in Tables 10-4 and 10-5. The data are segregated into structural and non-structural categories. Structural losses represent damage to individual structures. Non-structural losses represent the cost of contents, inventory, relocation, income loss, rental loss, and wage loss. A summary of results is as follows:

- For a 100-year earthquake, the estimated damage potential is $7.4 billion, or 8.6 percent of the total structural value for the planning area.
- For a 500-year earthquake, the estimated damage potential is $8.6 billion, or 10 percent of the total structural value for the planning area.
- For a 7.4-magnitude event on the Devils Mountain Fault, the estimated damage potential is $3.2 billion, or 3.7 percent of the total structural value for the planning area.
- For a 7.5-magnitude event on the South Whidbey Island Fault, the estimated damage potential is $13.7 billion, or 16 percent of the total structural value for the planning area.
- For a 9.3-magnitude event on the CSZ, the estimated damage potential is $7.4 billion, or 8.6 percent of the total structural value for the planning area.

Other potential losses estimated by HAZUS-MH include the following:

- A 100-year event within the planning area could displace up to 293 households, with over 171 persons needing short-term shelter. A 500-year event could displace up to 3,800 households with over 2,209 persons requiring short-term shelter.
- A Devil's Mountain event could displace up to 741 households, with over 430 persons needing short-term shelter. A SWIF event could displace up to 16,963 households with over 9,673 persons requiring short-term shelter.
- A 100-year event could create as much as 242,000 tons of debris to be removed, and a 500-year event could create as much as 1.7 million tons of debris within the planning area.
- A Devil's Mountain fault event could generate as much as 561,000 tons of debris, and a SWIF event could generate over 4.5 million tons of debris.

Table 10-4
Probabilistic Earthquake Building Loss Potential

Jurisdiction	Estimated Earthquake Losses by Occupancy Class	
	100-Year Probabilistic Earthquake Economic Loss Total	500-Year Probabilistic Earthquake Economic Loss Total
Arlington	$483,093,128	$568,431,660
Brier	$36,802,860	$49,996,205
Darrington	$17,405,500	$36,789,567

Table 10-4 Probabilistic Earthquake Building Loss Potential		
Jurisdiction	Estimated Earthquake Losses by Occupancy Class	
	100-Year Probabilistic Earthquake Economic Loss Total	500-Year Probabilistic Earthquake Economic Loss Total
Edmonds	$462,450,466	$513,583,921
Gold Bar	$29,594,555	$33,043,779
Granite Falls	$46,651,845	$69,035,304
Index	$3,430,415	$4,725,383
Lake Stevens	$177,973,749	$218,024,525
Lynnwood	$561,190,622	$573,604,156
Marysville	$766,939,207	$927,063,222
Mill Creek	$235,006,019	$327,412,668
Monroe	$574,467,329	$546,339,159
Mountlake Terrace	$283,694,653	$285,069,751
Mukilteo	$317,572,250	$359,164,140
Snohomish	$160,435,580	$157,189,269
Stanwood	$135,398,847	$136,543,551
Sultan	$72,940,910	$78,842,299
Unincorporated	$2,989,738,827	$3,692,661,736
Woodway	$23,627,715	$30,684,551
Total	$7,378,414,477	$8,608,204,847

Table 10-5 Earthquake Scenario Events Building Loss Potential			
Jurisdiction	Estimated Earthquake Losses by Occupancy Class		
	7.4-magnitude Devil's Mountain Fault Economic Loss Total	7.5-magnitude Whidbey Fault Economic Loss Total	9.3-magnitude Cascadia Subduction Zone Economic Loss Total
Arlington	$471,583,553	$291,586,367	$483,093,128
Brier	$4,414,674	$73,631,233	$36,802,860
Darrington	$66,893,362	$2,271,185	$17,405,500
Edmonds	$63,629,526	$633,141,016	$462,450,466
Gold Bar	$11,347,365	$21,469,549	$29,594,555
Granite Falls	$43,167,399	$29,915,690	$46,651,845
Index	$643,679	$1,454,370	$3,430,415
Lake Stevens	$93,932,446	$298,397,941	$177,973,749
Lynnwood	$81,313,403	$1,074,344,988	$561,190,622
Marysville	$429,944,251	$738,676,424	$766,939,207
Mill Creek	$51,310,864	$985,315,638	$235,006,019
Monroe	$116,688,977	$670,841,428	$574,467,329
Mountlake Terrace	$37,110,569	$368,577,527	$283,694,653
Mukilteo	$68,324,011	$919,714,011	$317,572,250
Snohomish	$47,052,618	$262,618,492	$160,435,580

Table 10-5 Earthquake Scenario Events Building Loss Potential			
Jurisdiction	Estimated Earthquake Losses by Occupancy Class		
	7.4-magnitude Devil's Mountain Fault Economic Loss Total	7.5-magnitude Whidbey Fault Economic Loss Total	9.3-magnitude Cascadia Subduction Zone Economic Loss Total
Stanwood	$170,482,755	$101,373,344	$135,398,847
Sultan	$26,001,841	$67,435,681	$72,940,910
Unincorporated	$1,364,994,849	$7,163,129,979	$2,989,738,827
Woodway	$2,539,086	$28,035,220	$23,627,715
Total	$3,151,375,228	$13,731,930,082	$7,378,414,477

10.5.3 Critical Facilities and Infrastructures

All critical facilities in Snohomish County are exposed to the earthquake hazard. Table 10-6 lists the number of each type of facility exposed.[g]

Table 10-6 Snohomish County Critical Facilities Exposed to Earthquakes	
Category	Number of Facilities Exposed
Airport	9
Bridge	389
Communication	7
Dam	27
Emergency Center	3
Ferry	5
Fire/EMS	79
Government	56
Hazmat	28
Medical	32
Natural Gas Facility	4
Oil Facility	2
Other	22
Police	27
Port Facility	11
Power Facility	9
School	248
Wastewater Facility	97
Water Facility	10
Water Storage	35
Total	1100

[g] Note: these figures were produced using the critical facilities available in GIS as it is a more comprehensive and accurate data set, as opposed to HAZUS.

The critical facilities identified for this plan are classified in the HAZUS-MH program as facilities (buildings), hazardous material sites, or infrastructure. Hazardous materials releases from fixed facilities and transportation-related releases can occur during an earthquake event. Transportation corridors, such as Interstate (I-) 5, State Route (SR-) 2, SR-9, and the BNSF railroad, can be disrupted during an earthquake and release materials into the surrounding environment.

Facilities holding hazardous materials are of concern because of possible isolation of neighborhoods surrounding them. There are 11 businesses that have Tier II hazardous materials on NEHRP D, E, and F soils. During an earthquake, structures storing these materials could rupture and leak into the surrounding area, a river, or Puget Sound, having a disastrous effect on the environment.

10.5.3.1 Vulnerability—Level of Damage

The inventory of critical facilities as defined by the Steering Committee was entered into HAZUS-MH to determine the vulnerability of these facilities to earthquake damage. Critical facilities were categorized into the following levels of vulnerability: no damage, slight damage, moderate damage, extensive damage, or complete damage. HAZUS-MH calculated the probability of damage under each of these categories for the 100-year probabilistic event, the SWIF event, and the CSZ event. These events were selected because they have the highest probability of occurrence (100-year event) and the largest potential impact on the planning area (SWIF and CSZ events). Tables 10-7 through 10-11 summarize the results.

Table 10-7
Liquefaction Severity of Critical Facilities Locations

Category	None	Very Low	Low	Moderate	High
Airport Facility		4		10	
Communication Facility		1	1	1	
Power Facility			1	2	
Emergency Center		2			
Fire Station	1	34	6	20	2
Care Facility		1	1	3	
Police Station		7	2	9	1
School	2	138	32	72	
Ferry Facility		2		1	
Natural Gas Facility	1	3			
Bridge	33	80	50	189	37
Rail Facility	1	1		2	3
Oil Facility		1			1
Port Facility		2		5	3
Portable Water Facility		1			1
Wastewater Facility		2	1	4	1
Total	38	279	94	318	49

Table 10-8 Shaking Intensity of Critical Facilities Locations				
Category	Moderate-Strong	Strong-Very Strong	Very Strong-Severe	Severe-Violent
Airport Facility	2		8	4
Communication Facility			2	1
Power Facility		1	2	
Emergency Center			1	1
Fire Station	1	12	35	15
Care Facility		1	4	
Police Station		2	14	3
School	2	17	174	51
Ferry Facility			1	2
Natural Gas Facility			1	3
Bridge	45	94	229	21
Rail Facility		2	5	
Oil Facility	1		1	
Port Facility			9	1
Portable Water Facility			2	
Wastewater Facility		2	6	
Total	51	131	494	102

Table 10-9 Vulnerability of Critical Facilities to a 100-Year Earthquake Event					
Category	No Damage	Slight Damage	Moderate Damage	Extensive Damage	Complete Damage
Airport Facility	9	5			
Emergency Center	2				
Police Station	19				
Care Facility	5				
Schools	244				
Natural Gas Facility	4				
Oil Facility	1	1			
Fire Station	63				
Bridges	389				
Rail Facility	3	4			
Port Facility		10			
Portable Water Facility	1	1			
Wastewater	3	5			
Power	1	2			
Communications	2	1			
Total	746	29			

Table 10-10 Vulnerability of Critical Facilities to a South Whidbey Island Fault Event					
Category	No Damage	Slight Damage	Moderate Damage	Extensive Damage	Complete Damage
Airport Facility	10	3	1		
Communication Facility		1	1	1	
Power Facility	1		2		
Emergency Center	1			1	
Fire Station	36	2	11	13	1
Care Facility	2		1	2	
Police Station	11		2	5	1
School	101	5	75	56	7
Ferry Facility		1	1	1	
Natural Gas Facility			2	2	
Bridge	342		1	13	33
Rail Facility		3	4		
Oil Facility	1	1			
Port Facility		9		1	
Portable Water Facility		1	1		
Wastewater Facility	1	3	4		
Total	**506**	**29**	**106**	**95**	**42**

Table 10-11 Vulnerability of Critical Facilities to a Cascadia Subduction Zone Event					
Category	No Damage	Slight Damage	Moderate Damage	Extensive Damage	Complete Damage
Airport Facility	9	5			
Communication Facility		3			
Power Facility	1	2			
Emergency Center	2				
Fire Station	62		1		
Care Facility	5				
Police Station	19				
School	240		4		
Ferry Facility		3			
Natural Gas Facility		4			
Bridge	373		2	5	9
Rail Facility	3	3			
Oil Facility		2			
Port Facility	1	11			
Portable Water Facility		1			
Wastewater Facility	1	7			
Total	716	41	7	5	9

10.5.3.2 Vulnerability—Time to Return to Functionality

HAZUS-MH estimates the expected time required to restore critical facilities to fully functional use. HAZUS-MH presents this data in the form of percent probability of being functional at specified time increments post-event: 1, 3, 7, 14, 30 and 90 days after the event occurs. For example, HAZUS-MH may estimate that a facility has 5 percent chance of being fully functional at Day 3, and a 95 percent chance of being fully functional at Day 90. The functionality analysis was performed for all critical facilities and infrastructure components in the planning area for both the 100-year and SWIF earthquake events. Results are summarized in Tables 10-12 and 10-13.

Table 10-12
Post-100-Year Earthquake Functionality of Critical Facilities

Category	Number of Critical Facilities	Probability of Being Fully Functional as a Percentage after…					
		Day 1	Day 3	Day 7	Day 14	Day 30	Day 90
Airport Facility	14	93%	97%	98%	98%	98%	99%
Communication Facility	3	88%	97%	98%	99%	100%	100%
Power Facility	3	53%	84%	97%	99%	100%	100%
Emergency Center	2	89%	89%	96%	96%	99%	100%
Fire Station	63	80%	80%	91%	91%	95%	97%
Care Facility	5	69%	69%	83%	83%	91%	95%
Police Station	19	73%	73%	85%	85%	92%	95%
School	244	77%	77%	89%	89%	95%	97%
Natural Gas Facility	4	83%	96%	99%	100%	100%	100%
Bridge	389	87%	89%	91%	92%	92%	95%
Rail Facility	7	89%	92%	94%	94%	95%	98%
Oil Facility	2	60%	78%	83%	91%	96%	100%
Port Facility	10	88%	94%	96%	96%	96%	98%
Portable Water Facility	2	68%	92%	96%	96%	97%	99%
Wastewater Facility	8	48%	80%	93%	95%	96%	99%
Total	778	82%	84%	90%	91%	93%	96%

Table 10-13
Post-Whidbey Island Fault Earthquake Functionality of Critical Facilities

Category	Number of Critical Facilities	Probability of Being Fully Functional as a Percentage after…					
		Day 1	Day 3	Day 7	Day 14	Day 30	Day 90
Airport Facility	14	84%	89%	90%	91%	92%	96%
Communication Facility	3	59%	79%	84%	92%	96%	99%
Power Facility	3	39%	67%	89%	97%	98%	100%
Emergency Center	2	20%	20%	36%	36%	68%	80%
Fire Station	63	37%	38%	56%	57%	77%	85%
Care Facility	5	30%	30%	47%	48%	71%	81%

Table 10-13 Post-Whidbey Island Fault Earthquake Functionality of Critical Facilities							
Category	Number of Critical Facilities	Probability of Being Fully Functional as a Percentage after…					
		Day 1	Day 3	Day 7	Day 14	Day 30	Day 90
Police Station	19	33%	33%	50%	50%	72%	82%
School	244	24%	25%	42%	42%	69%	80%
Ferry Facility	3	54%	67%	72%	73%	75%	87%
Natural Gas Facility	4	24%	41%	62%	74%	91%	100%
Bridge	389	70%	74%	77%	77%	78%	85%
Rail Facility	7	76%	82%	85%	85%	86%	93%
Oil Facility	2	73%	83%	86%	92%	96%	100%
Port Facility	10	50%	82%	88%	89%	92%	98%
Portable Water Facility	2	63%	74%	79%	79%	82%	91%
Wastewater Facility	8	33%	64%	83%	87%	88%	97%
Total	778	48%	59%	70%	73%	83%	91%

10.5.4 Environment

Environmental problems as a result of an earthquake can be numerous. Secondary hazards will likely have some of the most damaging effects on the environment. Earthquake-induced landslides in landslide-prone areas can significantly damage surrounding habitat. It is also possible for streams to be rerouted after an earthquake. Rerouting can change the water quality, possibly damaging habitat and feeding areas. There is a possibility that streams fed by groundwater wells will dry up because of changes in underlying geology.

10.6 Development Trends

The geologic hazard portions of the planning area are heavily regulated pursuant to Washington State Growth Management Act (GMA) mandates as well as provisions stipulated for seismic risk under the International Building Code. Development will occur in the planning area, but it will be regulated such that the degree of risk will be reduced through building standards and performance measures.

10.7 Issues

Important issues associated with an earthquake include but are not limited to the following:

- Appropriate geotechnical standards should be established that consider the probable impacts from earthquakes in the design and construction of new or enhanced facilities.
- The county has over 114 miles of earthen levees and revetments on soft, unstable soil. These soils are prone to liquefaction, which would severely undermine the integrity of these facilities.
- Earthquakes could trigger other natural hazard events such as dam failures, landslides, or volcanic activity, which could severely impact county facilities.
- A worst-case scenario would be the occurrence of a large seismic event during a flood or high-water event. Levee failures would happen at multiple locations, increasing the impacts of the individual events.

10.8 Hazard Maps

The impact of an earthquake is largely a function of ground shaking (ground motion accelerations), liquefaction (soil instability), and distance from the source (both horizontally and vertically). Mapping that shows the impacts of these components was used to assess the risk to earthquakes within the planning area. While the impacts from each of these components can build upon each other during an earthquake event, the mapping looks at each component individually, so each map is mutually exclusive of the other. For example, liquefaction classifications have no direct correlation to soil classifications. The mapping used in this assessment is described below.

10.8.1 Shake Maps

A shake map is a representation of ground shaking produced by an earthquake. The information it presents is different from the earthquake magnitude and epicenter that are released after an earthquake because shake maps focus on the ground shaking produced by the earthquake, rather than the parameters describing the earthquake source. An earthquake has only one magnitude and one epicenter, but it produces a range of ground shaking at sites throughout the region depending on the distance from the earthquake, the rock and soil conditions at sites, and variations in the propagation of seismic waves from the earthquake due to complexities in the structure of the earth's crust. A shake map is designed as a rapid response tool to portray the extent and variation of ground shaking throughout an affected region immediately following significant earthquakes.

Ground motion and intensity maps are derived from peak ground motion amplitudes recorded on seismic sensors (accelerometers), with interpolation based on estimated amplitudes where data are lacking, and site amplification corrections. These readings are recorded by state and federal agencies. Color-coded instrumental intensity maps are derived from empirical relations between peak ground motions and Modified Mercalli intensity. The Modified Mercalli intensity scale is composed of increasing levels of intensity that range from imperceptible shaking to total destruction. The scale is not mathematically based; instead it is a ranking based on observed effects.

A probabilistic seismic hazard map shows the hazard from earthquakes that geologists and seismologists agree could occur. The maps are expressed in terms of probability of exceeding a certain ground motion, such as the 10 percent probability of exceedance in 50 years. This level of ground shaking has been used for designing buildings in high seismic areas.

Earthquake scenarios describe the expected ground motions and effects of specific hypothetical large earthquakes for a region. Maps of these scenarios can be used to support all phases of emergency management. For the Snohomish County planning area, shake maps are available for four scenarios:

- Seattle Fault Zone Peak Ground Acceleration 7.2 Magnitude Scenario Shake Map (Map 10-1)
- Cascadia Megathrust Peak Ground Acceleration 9.3 Magnitude Scenario Shake Map (Map 10-2)
- Devils Mountain Fault Peak Ground Acceleration 7.4 Magnitude Scenario Shake Map (Map 10-3). This scenario is for a Magnitude 7.4 event with a shallow depth and epicenter 14 miles northeast of Arlington.
- South Whidbey Fault Peak Ground Acceleration 7.5-Magnitude Scenario Shake Map (Map 10-4). This scenario is for a Magnitude 7.5 event with a depth of 0 miles and an epicenter 2 miles northeast of Langley.

10.8.2 NEHRP Soil Maps

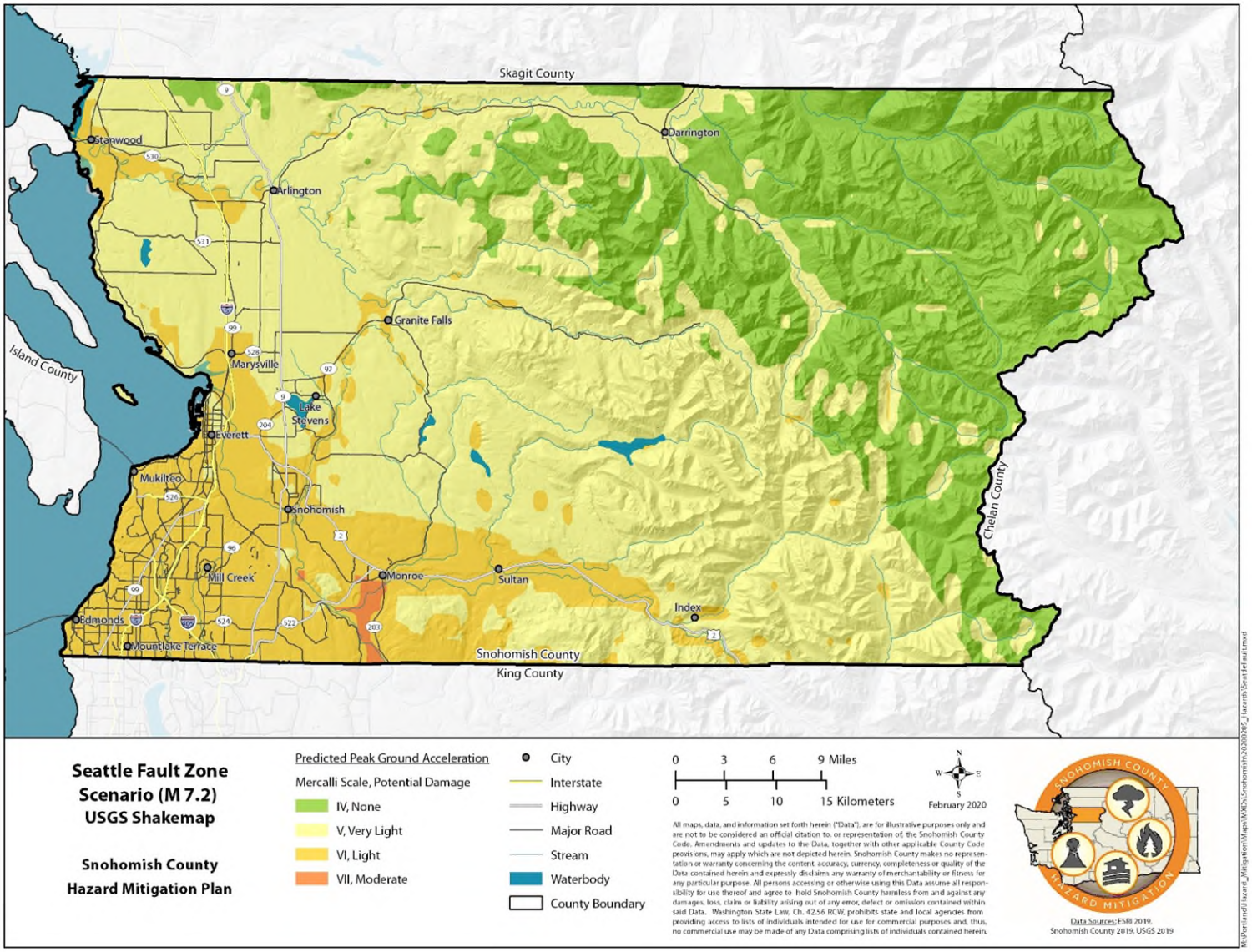
NEHRP soil types define the locations that will be significantly impacted by an earthquake. NEHRP B and C soils typically can sustain low-magnitude ground shaking without much effect. The areas that are most commonly affected by ground shaking have NEHRP D, E, and F soils (see Table 10-14). Map 10-5 shows NEHRP soil classifications in the county.

Table 10-14
NEHRP Soil Classification System

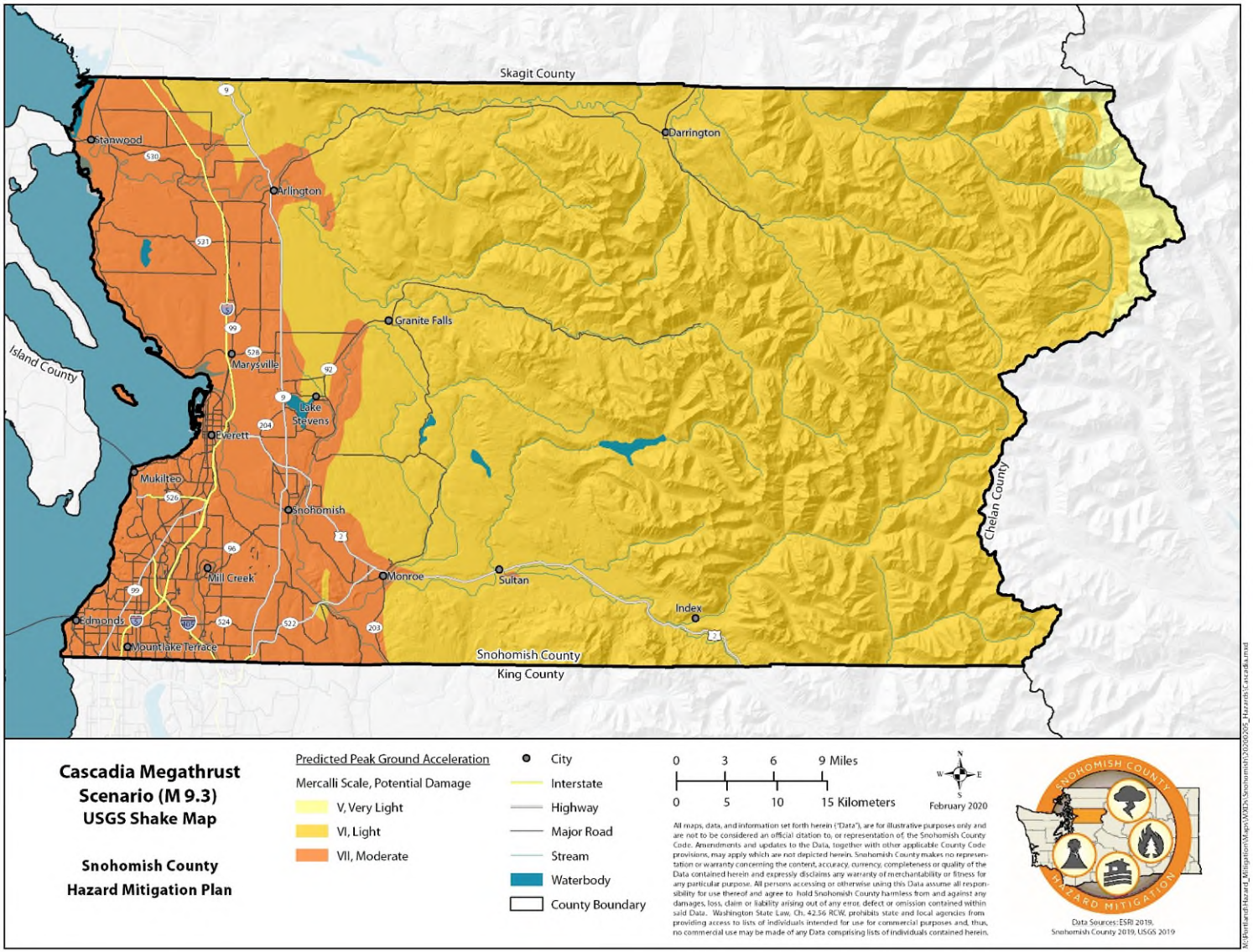
NEHRP Soil Type	Description	Mean Shear Velocity to 30 m (m/s)
A	Hard Rock	1,500
B	Firm to Hard Rock	760-1,500
C	Dense Soil/Soft Rock	360-760
D	Stiff Soil	180-360
E	Soft Clays	<180
F	Special Study Soils (liquefiable soils, sensitive clays, organic soils, soft clays >36 m thick)	

10.8.3 Liquefaction Maps

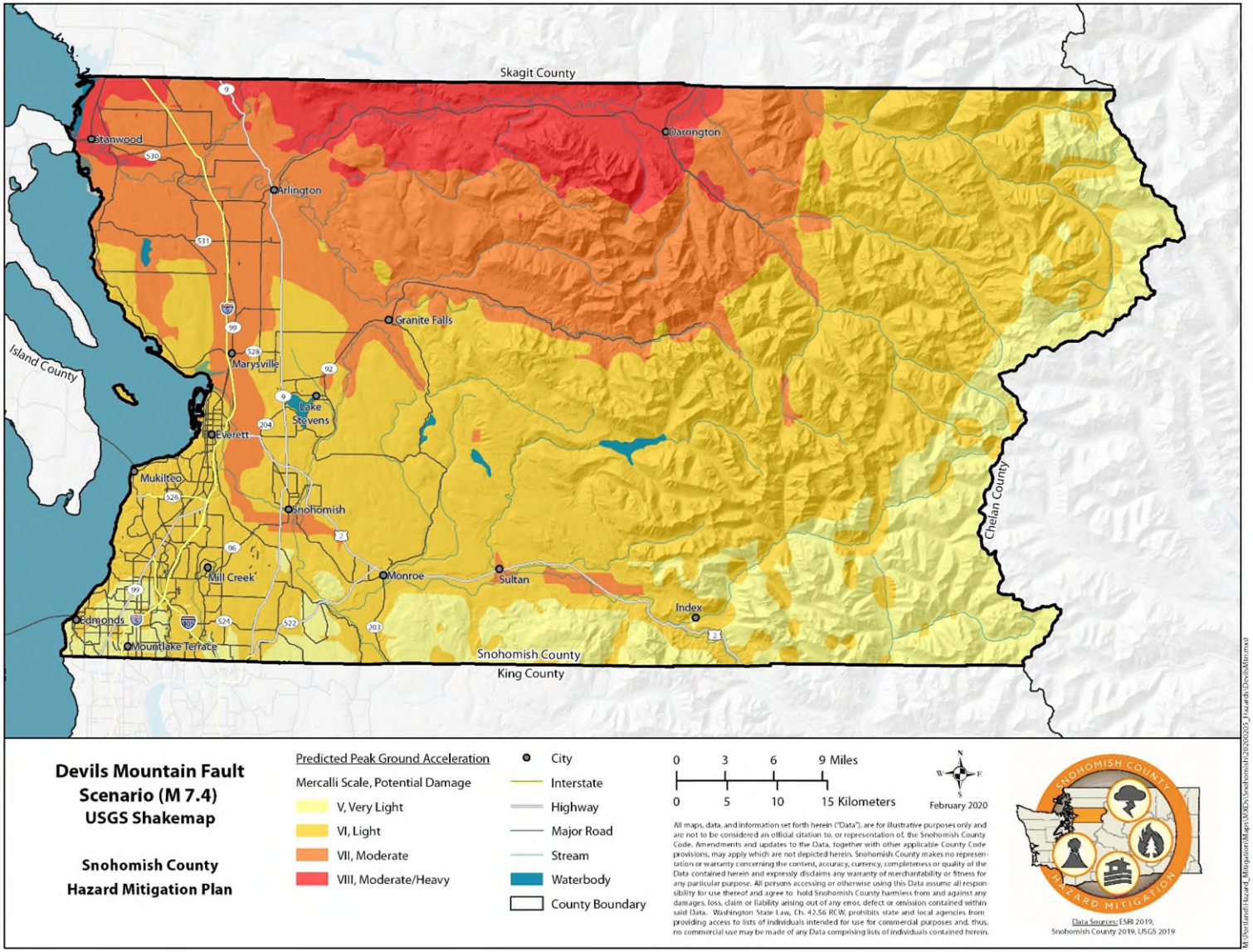
In general areas with NEHRP D, E, and F soils are also susceptible to liquefaction, a secondary effect of an earthquake in which soils lose their shear strength and flow or behave as liquid, thereby damaging structures that derive their support from the soil. If there is a dry soil crust, excess water will sometimes come to the surface through cracks in the confining layer, bringing liquefied sand with it, creating sand boils, colloquially called “sand volcanoes.” Soil liquefaction maps are useful tools to assess potential damage from earthquakes. Map 10-6 shows the liquefaction susceptibility in Snohomish County.



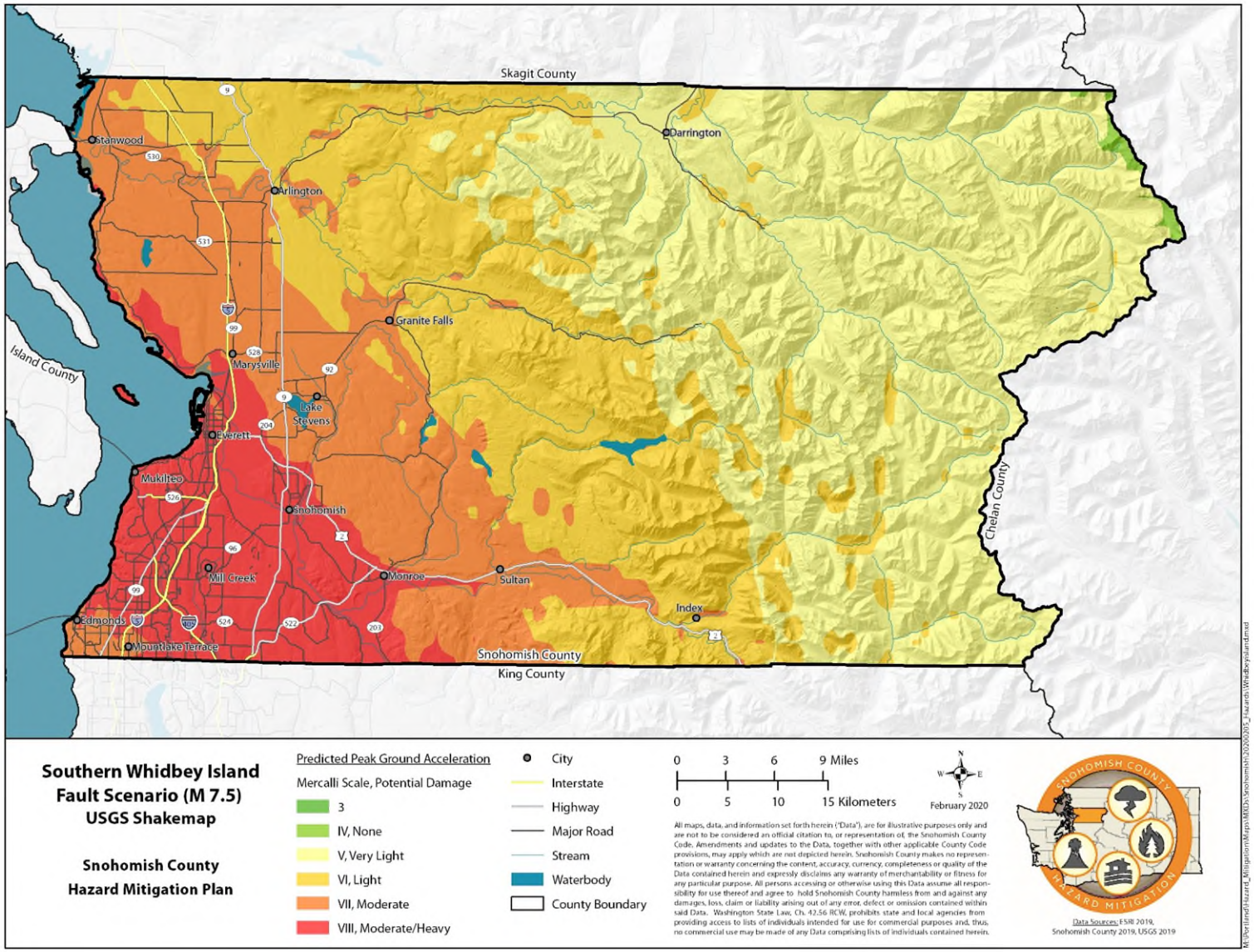
Map 10-1 Seattle Fault Zone Peak Ground Acceleration 7.2 Magnitude Scenario Shake Map



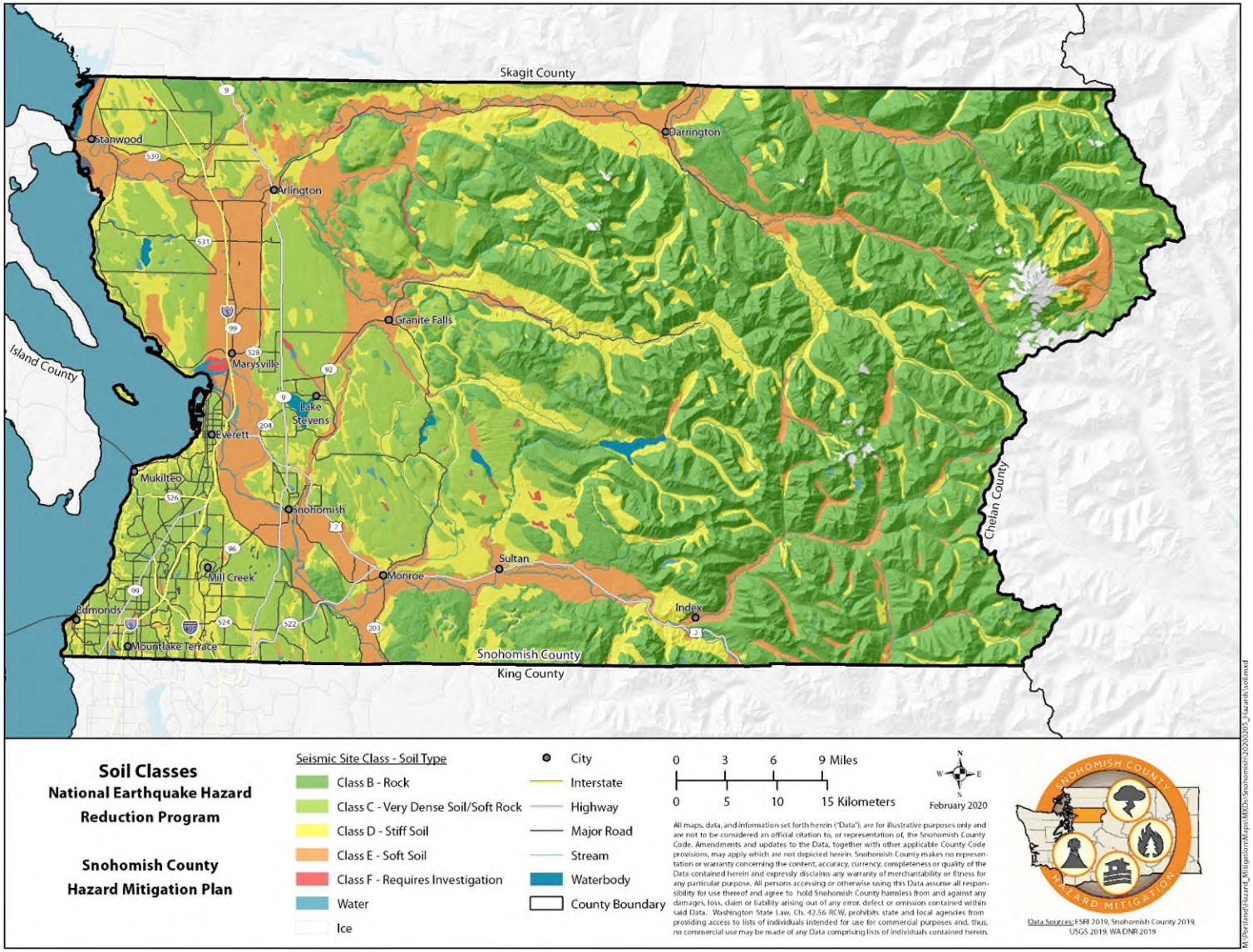
Map 10-2 Cascadia Megathrust Peak Ground Acceleration 9.3 Magnitude Scenario Shake Map



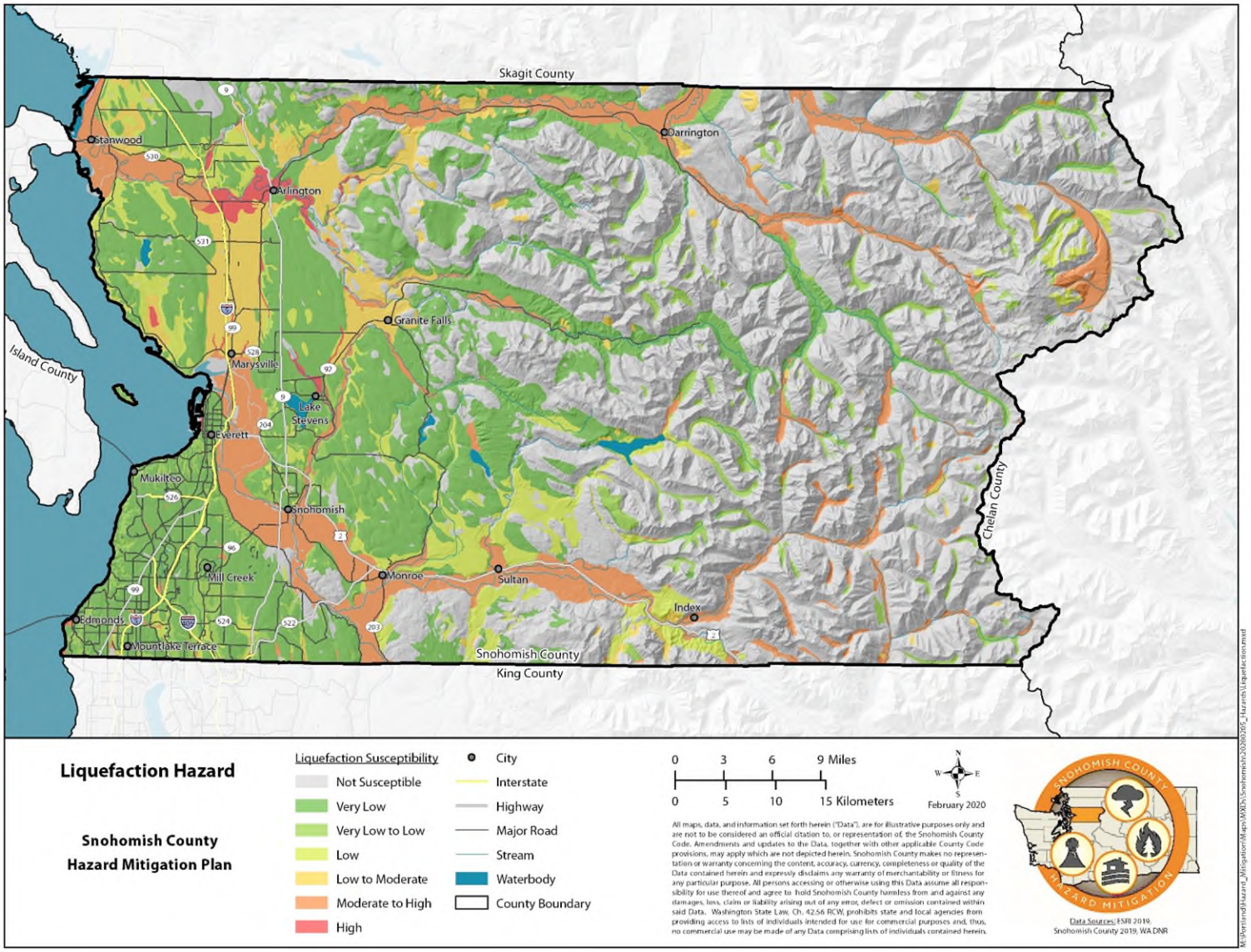
Map 10-3 Devils Mountain Fault Peak Ground Acceleration 7.4 Magnitude Scenario Shake Map



Map 10-4 South Whidbey Fault Peak Ground Acceleration 7.5-Magnitude Scenario Shake Map



Map 10-5 National Earthquake Hazard Reduction Program (NEHRP) Soil Class Site



Map 10-6 Liquefaction Susceptibility

11 Epidemic

11.1 General Background

Epidemics of infectious diseases are occurring more often, spreading faster and further all over the world. Diseases that are occurring are both newly-discovered and re-emerging (WHO 2018). For example, Sever Acute Respiratory Syndrome (SARS) was unheard of before 2003, and an outbreak of the plague occurred in Madagascar in 2017 (WHO 2018). Diseases very rarely disappear and new ones are constantly being discovered (WHO 2018). Magnifying vulnerability to both newly-discovered and re-emerging diseases are new strains of pathogens and anti-vaccination movements (Washington Emergency Management Division 2018).

Outbreaks may occur on a periodic basis (e.g., influenza), may be rare but result in a severe disease (e.g., meningococcal meningitis), occur after a disaster (e.g., cholera), or occur due to an intentional release of an agent (e.g., bioterrorism). Agents causing outbreaks can be viruses, bacteria, parasites, fungi or toxins, and can be spread by people, contaminated food or water, healthcare procedures, animals, insects and other arthropods, or directly from the environment. An individual may be exposed by breathing, eating, drinking, or having direct contact. Some agents have multiple means of spreading, while others are only spread person to person (Washington Emergency Management Division 2018).

11.1.1 Potential Damage from Epidemics

Epidemics can spread more widely and quickly than before, potentially affecting ever-greater numbers of people, having a significant impact of the economy of the affected community and spilling over into the global economy, disrupting travel, trade, and livelihoods (WHO 2018). Local outbreaks can overwhelm medical facilities, and a pandemic could jeopardize essential community services by causing critical positions to go unfilled (Washington Emergency Management Division 2018).

Basic public services such as health care, law enforcement, fire and emergency response, communications, transportation, and utilities could be disrupted or severely reduced (Washington Emergency Management Division

DEFINITIONS

Cluster – An aggregation of cases grouped in place and time that are suspected to be greater than the number expected.

Endemic – Refers to the constant presence and/or usual prevalence of a disease or infectious agent in a population within a geographic area.

Epidemic – An increase, often sudden, in the number of cases of a disease above what is normally expected in that population in that area.

Hyperendemic – Persistent, high levels of disease occurrence.

Medical Countermeasures – life-saving medicines and medical supplies that can be used to diagnose, prevent, protect from, or treat conditions associated with chemical, biological, radiological, or nuclear threats, emerging infectious disease, or natural disaster.

Outbreak – The same definition of epidemic but is often used for a more limited geographic area, jurisdiction, or group of people.

Pandemic – An epidemic that has spread over several countries or continents, usually affecting many people.

Sporadic – Refers to a disease that occurs infrequently or irregularly.

2018). The length of the epidemic or pandemic would stress societal systems and local and outside resources (Washington Emergency Management Division 2018).

11.2 Snohomish County Hazard Profile

The State of Washington has one of the highest rates of student vaccine exemptions in the nation; data for the 2017-2018 school year from the Department of Health shows 75 schools in King, Snohomish, Pierce, and Kitsap counties where at least 10 percent of K-12 students received an exemption for the measles-mumps-rubella (MMR) vaccine. In the Seattle area, Snohomish County has the highest rate of exemptions at 6 percent (Balk 2019). These high exemption rates contributing to low immunization coverage rates are below the recommended immunization percentages necessary to allow for herd immunity in the community.

Imported foods have been linked to Salmonella outbreaks; warmer-than-usual water and air can cause more bacterial growth in ocean waters, contaminating shellfish and increasing chances to an infectious outbreak (Washington Emergency Management Division 2018). Epidemics and outbreaks do not need to start in the county to affect it; because the county is close to the Seattle metropolitan area, there is a higher probability for a spread of an infectious disease from a visitor or tourist.

Disease outbreaks could also be associated with bioterrorism. Bioterrorism is the intentional release of viruses, bacteria, or other germs that can sicken or kill people, livestock, or crops. These types of attacks are identified as high importance. These events could result in high mortality rates. Six potential agents could pose the greatest threat to the area including: anthrax, botulism, plague, smallpox, tularemia, and viral hemorrhagic fevers.

The 2019 National Health Security Preparedness Index showed Washington State operating below the national average for health security and preparedness. According to the report, the State of Washington showed significantly below the national average scores in the domains Healthcare Delivery and Incident and Information Management, although there were significant gains to the Countermeasures Management domain.

11.2.1 Hazard Ranking

The Steering Committee and Planning Team completed a hazard ranking survey during the Snohomish County 2020 HMP update process for a range of hazard-related factors based on worst-case and most likely scenarios; definitions of the hazard ranking factors may be found in Table K-1 in Appendix K. The results of the survey were averaged together for each factor to generate a total average score and rank, enabling the prioritization of hazards by type. When compared against the other hazards included in the 2020 hazard ranking survey, epidemics were ranked as the third worst-case scenario and the tenth most likely scenario (see Table 11-1).

Table 11-1 Hazard Ranking Output							
Severity (1=lowest, 5=highest)	Magnitude (1=lowest, 5=highest)	Frequency (1=lowest, 5=highest)	Onset (1=slowest, 5=fastest)	Duration (1=shortest, 5=longest)	Perceived Change in Risk	Average	Rank
Worst-case Scenario							
4.50	4.75	2.94	3.63	4.06	0.6	3.98	3
Most Likely Scenario							
1.94	2.38	2.25	2.38	2.81	0.6	2.35	10

11.2.2 Past Events

The highly contagious measles virus, which was declared eliminated in 2000, has started to re-emerge throughout the United States with cases confirmed in 31 states, including Washington State. There were over 1,200 new cases of the measles virus in 2019, compared to 375 new cases in 2018 (CDC 2019). Clark County, Washington, experienced 71 cases of measles in 2019, which resulted in roughly 19,000 response hours totaling $864,679 (Clark County Public Health 2019). Snohomish County could experience similar impacts to an infectious disease outbreak that yield similar impacts that could bring economic, medical, social, and developmental burden on the area.

In 2009, Snohomish County residents were exposed to the H1N1 virus, known as "swine flu," which resulted in more than 1,650 hospitalizations and deaths across the State of Washington; H1N1 was the first influenza pandemic of the 21st century.

11.2.3 Location

All of Snohomish County is susceptible to human health hazards and epidemics. Communicable diseases can cause exposure to the county from outside the local region. Local residents who travel or commute can become exposed and bring diseases back into the county. It is difficult to map the extent of an outbreak or epidemic.

11.2.4 Frequency

Due to increased air travel, commuters, and population growth, the probability of an epidemic or outbreak occurring is growing. The frequency of epidemics is difficult to establish, depending largely on unique circumstances surrounding the outbreak and expansion into epidemics and eventually pandemics.

11.2.5 Severity

The severity of a disease or epidemic varies from individual to individual. Typically, vulnerable populations (specifically young children and elderly adults) are more susceptible to acquiring communicable diseases due to immune system challenges and capabilities. In general, severity depends on the pathology of the disease, the health of the individual, vaccinations, and availability of treatments for symptoms or curing the disease.

11.2.6 Warning Time

Warning time for public health risks varies from a few hours or days to a few months, depending on the illness and outbreak.

11.3 Cascading Impacts/Secondary Hazards

The largest secondary impact caused by an epidemic or outbreak would be economic. The reduction in workforce and labor hours would cause businesses and agencies to be greatly impacted. With a reduced workforce, there may be transportation route closures or supply chain disruptions, resulting in a lack of food, water, or medical resources. Another large and costly secondary impact would be fear or stigmatization, which may result in isolation or social unrest. Hospitals and public health facilities may be inundated with individuals, including those with the disease and concerned about having contracted it. Finally, the disease may mutate, rendering cures and research unusable and contributing to the previously identified secondary impacts.

11.4 Potential Impacts from Future Climate Conditions

Future climate conditions and continued improvement of the ability to travel will contribute to the development and spread of diseases.

11.5 Exposure & Vulnerability

11.5.1 Population

All residents and visitors in the county could be susceptible to the effects and exposed to infectious disease. A large outbreak or epidemic could have devastating effects on the population. Those with compromised immune systems, children, individuals that are socioeconomic or health disadvantaged, and individuals with access and functional needs are considered some of the most vulnerable to diseases.

11.5.2 Property

Epidemics and diseases would not have a significant measurable impact on property in the county.

11.5.3 Critical Facilities

Health care facilities may reach capacity and become inundated with people. Early identification of shelters, alternate treatment facilities, isolation capacity, and methods to expand resources can help health care facilities and governments cope with an epidemic. However, epidemics and diseases would not have significant measurable impact on the critical facilities or infrastructure of the county.

11.5.4 Environment

Epidemics and diseases would not have a significant measurable impact on the environment in the county.

11.6 Development Trends

The potential for an epidemic or outbreak is not likely to slow expected growth in the county.

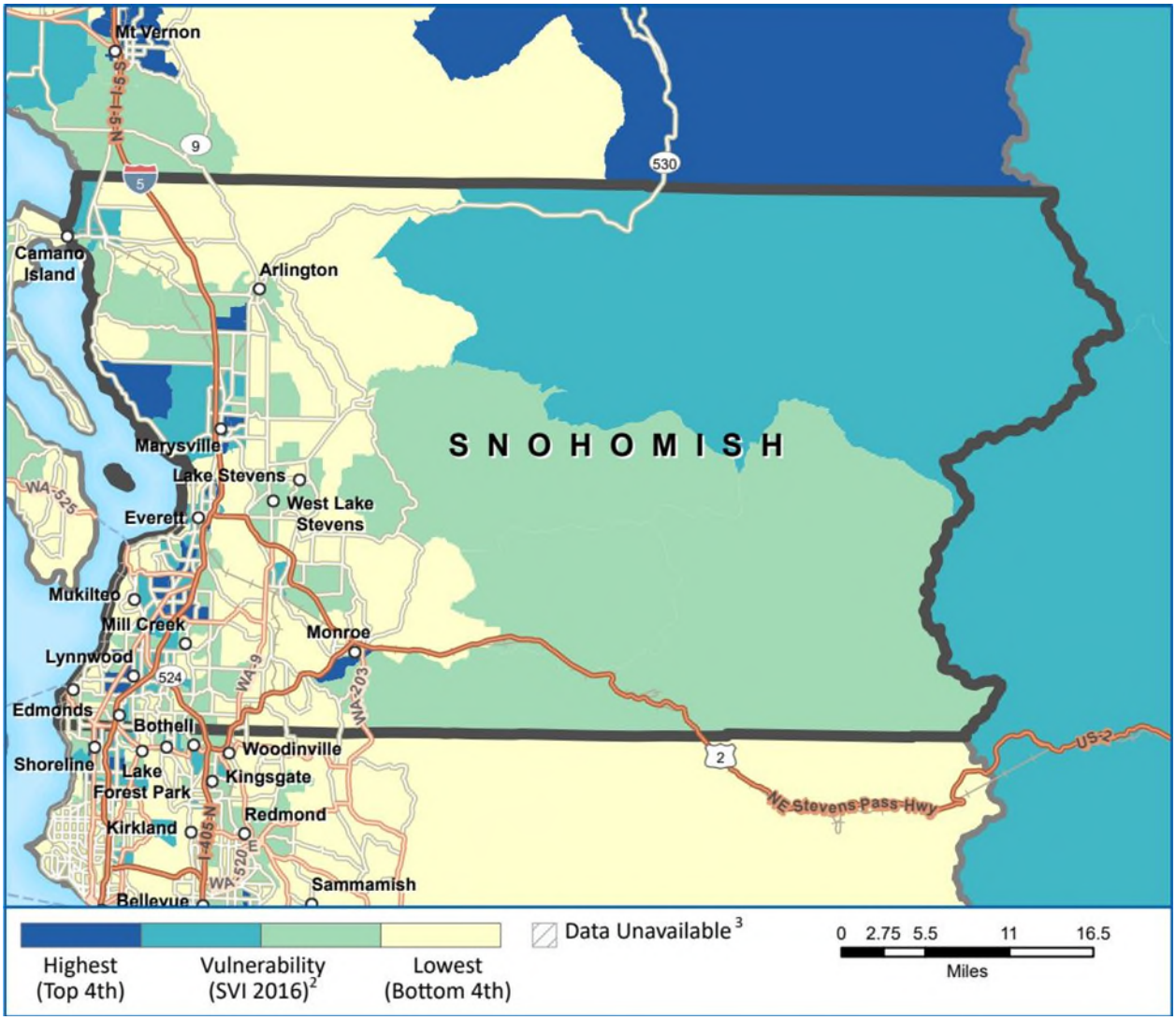
11.7 Issues

Important issues associated with epidemics and outbreaks include:

- Providing culturally appropriate preventative health care to changing demographic and aging population, including vaccination and education to help reduce the impacts;
- Overuse and misuse of antibiotics contributing to antibiotic resistance;
- Medical and response personnel need to be integrated into a response to provide care when needed;
- Medical and response personnel must be adequately trained and supplied;

- A system needs to be in place for informing the public with a clear message and facts about the disease and care options; and
- Health agencies and facilities require surge capacity management and adaptation to the rising number and needs of the area.

11.8 Hazard Maps



Map 11-1 Social Vulnerability Index

12 Flood

12.1 General Background

Floods are one of the most common hazards in the United States. They can develop over a period of days or occur rapidly without warning. The effects of floods can be local (impacting a neighborhood or community) to regional (impacting counties or states). A floodplain is defined as the land adjoining a channel of a river, stream, ocean, lake, or other watercourse or waterbody that becomes inundated with water during a flood. The extent to which a floodplain becomes inundated during a flood depends partly on the magnitude of the flood and partly on the surrounding landscape (University of Washington 2015b).

Connections between a water source and its floodplain are most apparent during and after major flood events. These areas form a complex physical and biological system that not only supports a variety of natural resources but also provides natural flood and erosion control. When a river is separated from its floodplain by levees and other flood control facilities, natural, built-in benefits can be lost, altered, or significantly reduced (Wright 2007).

12.1.1 Potential Damage from Floods

Floods impact individuals and communities, resulting in social, economic, and environmental consequences. Floods can result in loss of human life, damage to property, and destruction of agricultural products. General infrastructure such as utilities, roads, bridges, and communication technology can be damaged and disrupted.

12.2 Snohomish County Hazard Profile

The headwaters and middle reaches of rivers in Snohomish County are typically steep and dominated by bedrock and boulders. In these areas, floodplains are often narrow or absent. When these rivers eventually reach the Puget Sound lowlands, they flatten out, deposit sediments, and form floodplains that are often broad, ecologically complex, and biologically productive.

In the relatively brief time since Euro-American settlement began in the Puget Sound basin, the region's floodplains have been altered extensively by development. Initially these changes were caused by land clearing and installation of drainage systems that supported land uses such as farming, mining, and railroad transportation. More recently, intensive residential, commercial, and industrial land uses have come to

DEFINITIONS

Flood – Inundation of normally dry land resulting from rising and overflowing of a body of water.

Floodplain – Land area along the sides of a river that becomes inundated with water during a flood

100-Year Floodplain – The area flooded by the flood 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.

500-year Floodplain – Also known as the 0.2-percent annual chance flood. The area inundated by floodwaters that has a 0.2-percent chance of being equaled or exceeded each year.

Return Period – The average period of time in years between occurrences of a particular hazard (equal to the inverse of the annual frequency of occurrence).

occupy the downstream portions of some of Snohomish County's river valleys, increasing floodplain management conflicts and costs. It is in these flat, lowland floodplain areas that human development and flooding coincide, posing some of the greatest management challenges.

12.2.1 Hazard Ranking

The Steering Committee and Planning Team completed a hazard ranking survey during the Snohomish County 2020 HMP update process for a range of hazard-related factors based on worst-case and most likely scenarios; definitions of the hazard ranking factors may be found in Table K-1 in Appendix K. The results of the survey were averaged together for each factor to generate a total average score and rank, enabling the prioritization of hazards by type. When compared against the other hazards included in the 2020 hazard ranking survey, floods were ranked as the fourteenth worst-case scenario and the eleventh most likely scenario (see Table 12-1).

Table 12-1
Hazard Ranking Output

Severity (1=lowest, 5=highest)	Magnitude (1=lowest, 5=highest)	Frequency (1=lowest, 5=highest)	Onset (1=slowest, 5=fastest)	Duration (1=shortest, 5=longest)	Perceived Change in Risk	Average	Rank
Worst-case Scenario							
2.63	3.50	3.25	3.94	3.63	0.5	3.39	14
Most Likely Scenario							
1.50	1.81	2.88	3.19	2.13	0.5	2.30	11

12.2.2 Past Events

Flooding in Snohomish County has been documented by gage records, high water marks, damage surveys, and personal accounts. Since 1964, there have been 16 flood events that have resulted in property damage, FEMA disaster declarations, or deaths and injuries. Ten floods resulted in a disaster declaration, as shown in Appendix K, Table K-2.

12.2.3 Location

Principal flooding sources for Snohomish County include the following waterbodies:

- Sauk River
- Stillaguamish River
- Ebey Slough
- Snohomish River
- Skykomish River
- Snoqualmie River
- Pilchuck River

12.2.4 Frequency

Snohomish County experiences episodes of river flooding nearly every winter. Large, damaging floods have typically occurred every two to ten years. Urban portions of the county annually experience nuisance flooding related to drainage issues.

12.2.5 Severity

The principal factors affecting flood damage are flood depth and velocity. The deeper and faster flood flows become, the more damage they can cause. Shallow flooding with high velocities can cause as much

damage as deep flooding with slow velocity. Flood severity is often evaluated by examining peak discharges.

12.2.6 Warning Time

Snohomish County's flood warning program warns of impending flooding on major rivers so that residents and agencies can prepare before serious flooding occurs. In most locations, the warning system provides at least two hours of lead time before floodwaters reach damaging levels. The system is a phased program with response protocols for four phases of observed stream flow conditions:

- Phase 1
  - County staff is put on alert.
  - The Emergency Management Duty Officer monitors the situation.
  - Actual flooding is rare.
- Phase 2
  - Minor flooding and some road closures may occur.
  - Preparations are made to open the County's Emergency Coordination Center, if warranted.
  - Staff begins monitoring river gages and flood conditions around the clock.
  - Flood information phone lines are updated hourly with current river gage information.
- Phase 3
  - Moderate to severe flooding can be expected, with numerous road closures and some levee overtopping.
  - Investigation crews are sent to monitor flood control facilities such as levees.
  - County Emergency Coordination Center opens.
- Phase 4
  - All agencies respond in anticipation of major flooding and widespread damage.

12.3 Cascading Impacts/Secondary Hazards

The most problematic secondary hazard for flooding is bank erosion and rapid channel migration. In many cases, the threat and effects of bank erosion are more harmful than actual flooding. Flooding is also responsible for hazards such as landslides when high flows oversaturate soils on steep slopes, causing them the fail. Hazardous material spills can also occur if storage tanks rupture or sewage/manure lagoons overtop and spill into streams, rivers, or drainage sewers.

Flooding can cause increased mold growth within a home. People with asthma, allergies, or other breathing conditions may be more susceptible to mold. Sensitive persons may experience a stuffy nose, irritated eyes, wheezing, or skin irritation. There is also a possibility of power outages after a major flood event.

12.4 Potential Impacts from Future Climate Conditions

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. Projected estimations indicate that high-frequency flood events (e.g. 10-year floods) as well as less-frequent flood events (e.g. 100-year flood) will occur more often with a changing climate.

12.5 Exposure

The Level 2 Hazards United States – Multi-Hazards (HAZUS-MH) protocol was used to assess risk and vulnerability to flooding within the planning area. The model used census data at the block level and FEMA floodplain data, which have a level of accuracy acceptable for planning purposes. Where possible, HAZUS-MH default data was enhanced by use of local GIS data from county, state, and federal sources.

12.5.1 Population

Population counts of those living in the floodplain within the planning area were generated by distributing the population throughout residential buildings in each jurisdiction and calculating the population within the 100-year flood hazard areas. This approach yielded an estimated exposed population within the entire county of 10,417 persons, 1.3 percent of the total county population.

12.5.1.1 Vulnerability

A geographic analysis of demographics, using the data from the U.S. Census Bureau, identified populations vulnerable to the flood hazard as follows:

- **Economically Disadvantaged Populations** – It is estimated that 9.3 percent of the people within the 100-year floodplain are economically disadvantaged, defined as having household incomes of $10,000 or less.
- **Population over 65 Years Old** – It is estimated that 9.8 percent of the population in the census block that intersects the 100-year floodplain are over 65 years old.
- **Population under 16 Years Old** – It is estimated that 26 percent of the population within census blocks located in or near the 100-year floodplain are under 18 years of age.

HAZUS estimated that a 100-year flood would cause 4,285 people to seek short-term shelter.

12.5.2 Property

Tables 12-2 and 12-3 summarize the number of structures in the floodplain by municipality. The GIS analysis indicates that there are 8,545 structures within the 100-year floodplain and 2,347 additional structures within the 500-year floodplain across the county; over 67 percent of these structures are in unincorporated areas.

Some land uses are more vulnerable to flooding, such as single-family homes, while others are less vulnerable, such as agricultural land or parks. Table 12-4 shows the land use of all parcels in the 100-year floodplain, and Table 12-5 shows land use of all parcels in the 500-year floodplain.

Table 12-2
Value of Property Exposed to 100-Year Floodplain

Jurisdiction	Buildings Exposed	% of All Buildings	Assessed Value		
			Structure	Contents	Total
Arlington	39	0.4%	$9,651,350	$5,766,940	$15,418,290
Brier	38	2%	$8,455,850	$4,227,925	$12,683,775
Darrington	24	25%	$21,904,290	$32,643,275	$54,547,565
Edmonds	87	2%	$64,458,470	$59,556,835	$124,015,305
Gold Bar	23	2%	$1,817,370	$908,685	$2,726,055
Granite Falls	25	0.2%	$461,140	$230,570	$691,710
Index	35	16%	$2,330,567	$1,321,513	$3,652,080

Table 12-2 Value of Property Exposed to 100-Year Floodplain					
Jurisdiction	Buildings Exposed	% of All Buildings	Assessed Value		
			Structure	Contents	Total
Lake Stevens	56	0.3%	$5,998,655	$3,012,902	$9,011,557
Lynnwood	4	0.1%	$1,648,930	$1,685,380	$3,334,310
Marysville	95	1%	$23,188,559	$24,237,189	$47,425,748
Monroe	98	7%	$93,290,368	$93,459,922	$186,750,290
Mountlake Terrace	23	1%	$6,907,932	$7,156,953	$14,064,885
Mukilteo	50	1%	$13,743,872	$8,185,897	$21,929,769
Snohomish	40	1%	$4,317,951	$4,063,955	$8,381,906
Stanwood	628	21%	$110,693,622	$87,184,127	$197,877,749
Sultan	651	26%	$72,696,972	$48,131,655	$120,828,626
Unincorporated	6,629	2%	$549,558,533	$377,721,071	$927,279,605
Grand Total	8,545	2%	$991,124,430	$759,494,795	$1,750,619,225

Table 12-3 Value of Property Exposed to 500-Year Floodplain					
Jurisdiction	Buildings Exposed	% of All Buildings	Assessed Value		
			Structure	Contents	Total
Arlington	17	0.1%	$1,919,500	$1,656,975	$3,576,475
Darrington	3	0.1%	$136,000	$68,000	$204,000
Gold Bar	673	58%	$58,608,559	$30,915,210	$89,523,769
Index	34	16%	$2,145,586	$1,493,693	$3,639,279
Lynnwood	5	0.0%	$310,879	$459,194	$770,073
Marysville	10	0.0%	$1,661,370	$830,685	$2,492,055
Monroe	422	7%	$101,874,430	$92,239,333	$194,113,763
Snohomish	5	0.0%	$236,070	$118,035	$354,105
Sultan	501	20%	$60,264,536	$34,239,685	$94,504,221
Unincorporated	677	0.2%	$51,491,543	$31,869,488	$83,361,031
Grand Total	2347	1%	$278,648,473	$193,890,298	$472,538,771

Table 12-4 Land Use of All Parcels in 100-Year Floodplain		
Parcel Type	Number of Parcels	Acres
Cultural, Entertainment, Recreation	218	3795
Forest	39	11873
Goods/Products	47	413
Manufacturing	68	176
Open Space	223	3709
Open Water	427	3799
Other	8980	2045885
Residential	10733	841625

Table 12-4 Land Use of All Parcels in 100-Year Floodplain		
Parcel Type	Number of Parcels	Acres
Resource Production/Extraction	1468	37198
Retail	217	622
Services	277	799
Transportation/Utility	326	2041
Undeveloped	3801	96447
Open Space Type – Government Owned Deed Restricted	62	68
Open Space Type – Government Owned Open space	38	5155
Open Space Type - Parks	188	4413
Open Space Type – Private Wildlife/Nature Preserve	66	2192
Grand Total	27178	3060211

Table 12-5 Land Use of All Parcels in 500-Year Floodplain		
Parcel Type	Number of Parcels	Acres
Cultural, Entertainment, Recreation	61	843
Forest	12	984
Goods/Products	11	208
Manufacturing	13	39
Open Space	95	1638
Open Water	6	21
Other	140	635
Residential	2652	6542
Resource Production/Extraction	385	12388
Retail	26	84
Services	37	497
Transportation/Utility	46	402
Undeveloped	779	9646
Open Space Type – Government Owned Deed Restricted	31	68
Open Space Type – Government Owned Open space	8	544
Open Space Type - Parks	50	970
Open Space Type – Private Wildlife/Nature Preserve	5	96
Open Space Type – School Parcels	1	21
Grand Total	4358	35625

12.5.2.1 Vulnerability

HAZUS-MH calculates losses to structures from flooding by looking at depth of flooding and type of structure. Using historical flood insurance claim data, HAZUS-MH estimates the percentage of damage to structures and their contents by applying established damage functions to an inventory. For this analysis, local data on facilities was used instead to the default inventory data provided with HAZUS-MH.

The analysis is summarized in Tables 12-2 and 12-3 for the 100-year and 500-year flood events, respectively. It is estimated that there would be up to $2.12 billion of flood loss from a 100-year flood event in the planning area. It is estimated that there would be $3.3 billion of flood loss from a 500-year flood event.

12.5.3 Critical Facilities

Table 12-6 summarizes the critical facilities and infrastructure in the 100-year floodplain; Table 12-7 summarizes the critical facilities and infrastructure in the 500-year floodplain. Critical facilities and infrastructure include utilities and associated infrastructure, roads, bridges, water and sewer systems, dikes and levees, railroads, and Tier II hazardous materials facilities.

Table 12-6
Critical Facilities Within Snohomish County's 100-Year Floodplain

Airport	1
Bridge	124
Communication	2
Dam	8
Ferry	3
Fire/EMS	5
Government	9
Hazmat	1
Medical	1
Oil Facility	1
Other	7
Police	4
Port Facility	8
School	4
Wastewater Facility	20
Water Facility	1
Total	199

Table 12-7
Critical Facilities Within Snohomish County's 500-Year Floodplain

Bridge	4
Fire/EMS	1
Government	1
School	3
Total	9

12.5.3.1 Vulnerability

HAZUS-MH was used to estimate the flood loss potential to critical facilities exposed to the flood risk. Using depth/damage function curves to estimate the percentage of damage to the building and contents of critical facilities, HAZUS-MH correlates these estimates into an estimate of functional downtime (the estimated time it will take to restore a facility to 100 percent of its functionality). This helps to gauge how long the planning area could have limited usage of facilities deemed critical to flood response and

recovery. The HAZUS critical facility results, including schools, police stations, fire stations, and wastewater facilities, are as follows:

- 100-year flood event – On average, critical facilities would receive 26 percent damage to the structure and 34 percent damage to the contents during a 100-year flood event. The estimated time to restore these facilitates to 100 percent of their functionality is 648 days.
- 500-year flood event – A 500-year flood event would damage the structures an average of 25 percent and the contents an average 45 percent. The estimated time to restore these facilities to 100 percent of their functionality after a 500-year flood event is 603 days.

12.5.4 Environment

Flooding is a natural event, and floodplains provide many natural and beneficial functions. Nonetheless, with human development factored in, flooding can impact the environment in negative ways. Migrating fish can wash into roads or over dikes into flooded fields, with no possibility of escape. Pollution from roads, such as oil, and hazardous materials can wash into rivers and streams. During floods, these can settle onto normally dry soils, polluting them for agricultural uses. Human development such as bridge abutments and levees can increase stream bank erosion, causing rivers and streams to migrate into non-natural courses.

12.5.4.1 Vulnerability

The environment vulnerable to flood hazard is the same as the environment exposed to the hazard. Loss estimation platforms such as HAZUS-MH are not currently equipped to measure environmental impacts of flood hazards. The best gauge of vulnerability of the environment would be a review of damage from past flood events. Loss data that segregates damage to the environment were not available at the time of this plan. Capturing this data from future events could prove to be beneficial in measuring the vulnerability of the environment for future updates.

Additionally, while the vulnerability assessment typically focuses on human vulnerability to flood events, the opposite is also worth noting. Floodplains have many natural and beneficial functions; however, due to negative impacts of floods, many structural and other measures have been devised to limit how far a floodplain can extend. Disruption of natural systems can have long-term consequences for entire regions; however, this potential impact has only recently been noted. Some well-known, water-related functions of floodplains (noted by FEMA) include:

- Natural flood and erosion control
- Provide flood storage and conveyance
- Reduce flood velocities
- Reduce flood peaks
- Reduce sedimentation
- Surface water quality maintenance
- Filter nutrients and impurities from runoff
- Process organic wastes
- Moderate temperatures of water
- Groundwater recharge
- Promote infiltration and aquifer recharge
- Reduce frequency and duration of low surface flows

Areas within the floodplain that typically provide these natural functions are wetlands, riparian areas, sensitive areas, and habitats for rare and endangered species.

12.6 Development Trends

Snohomish County and its planning partner cities are subject to the provisions of the GMA, which regulates identified critical areas. Snohomish County critical areas regulations apply to five types of critical areas, including frequently flooded areas, defined as the FEMA 100-year mapped floodplain. The GMA establishes review and evaluation programs that monitor commercial, residential, and industrial development and the densities at which this development has occurred under each jurisdiction's GMA comprehensive plan and development regulations. An evaluation is required at least every five years of the sufficiency of remaining land within urban growth areas (UGAs) to accommodate projected residential, commercial and industrial growth at development densities observed since the adoption of GMA plans. This report compares planned versus actual urban densities in order to determine whether original plan assumptions were accurate.

Snohomish County's 2012 buildable lands report (BLR) was adopted in June of 2013. It excludes areas designated as critical areas from consideration as buildable lands due to the scope of regulations affecting them. Some floodplains in the planning area can be developed but are subject to regulatory provisions in the building codes of Snohomish County and its partner cities. The buildable lands analysis assumes that these regulations will discourage development from these areas. The key findings of the BLR are as follows:

- At the countywide UGA level:
    - Urban densities are being achieved that are consistent with GMA comprehensive plans.
    - There is adequate land capacity outside of recognized critical areas to accommodate the adopted 2025 UGA population and growth targets.
- There appears to be a 2025 population capacity shortfall within the Town of Darrington (although the Darrington UGA as a whole has enough capacity to accommodate the 2025 growth), and the cities of Monroe and Sultan.
- Within the Southwest Urban Growth Area (SWUGA), which has enough overall capacity to accommodate the projected 2025 growth, there appear to be 2025 population capacity shortfalls within the cities of Bothell, Brier, Mill Creek, and Mukilteo.

Within cities overall, there is adequate land capacity to accommodate the adopted 2025 total city population growth targets.

For all other UGAs and cities not mentioned in the bulleted text above, the BLR determined that there is adequate capacity for accommodating the adopted 2025 population growth targets.

There are no individual UGAs or cities within UGAs where there is a 2025 employment capacity shortfall.

The county and cities are already in the process of updating growth targets and comprehensive plans by 2020, so the inconsistencies identified above may be resolved through that update process.

Based on these findings, Snohomish County and its planning partners appear to be well equipped to deal with future growth and development. The floodplain portions of the planning area are regulated pursuant to mandates of the GMA and the National Flood Insurance Program. Development will occur in the floodplain; however, it will be regulated, such that the degree of risk will be reduced through building standards and performance measures.

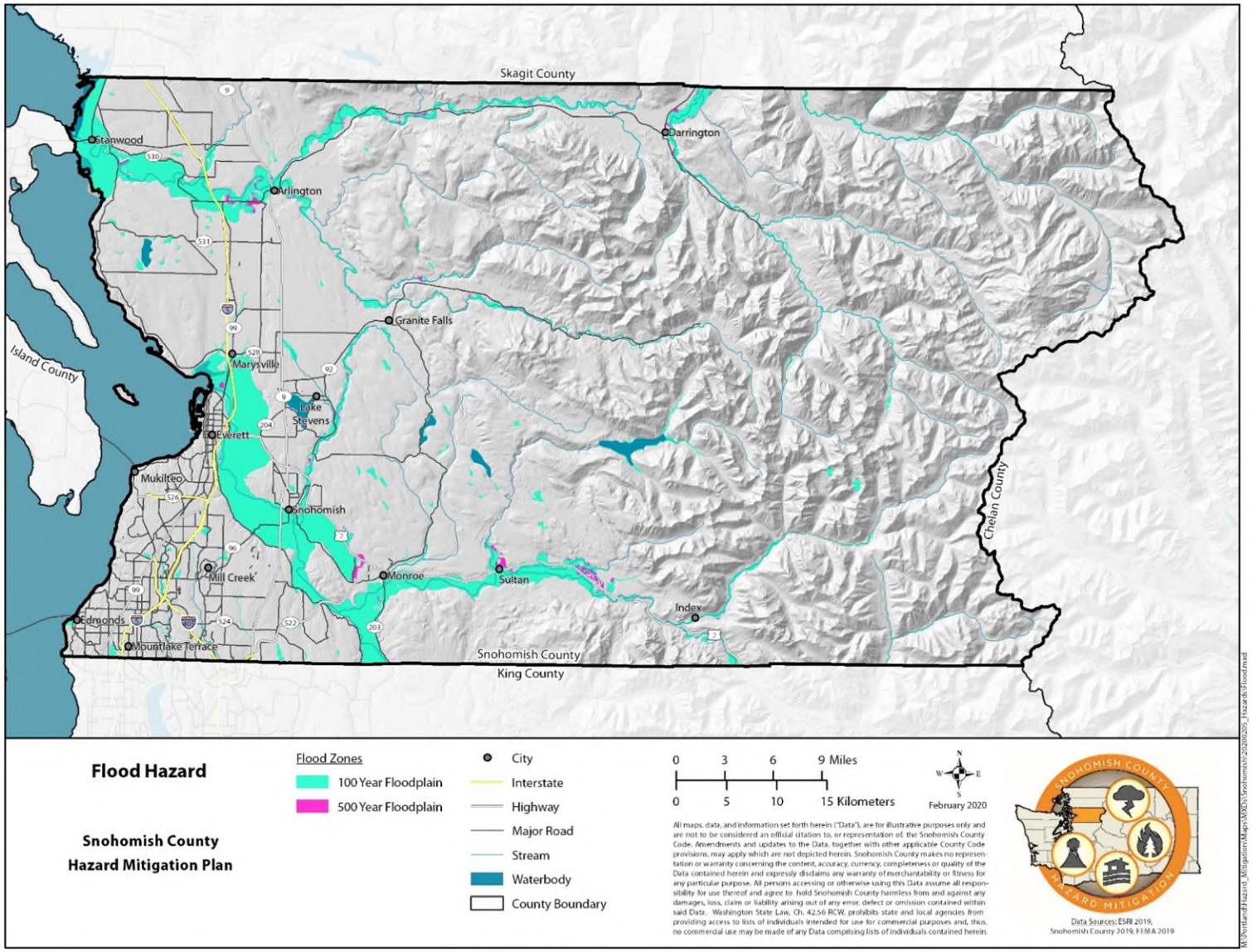
Based on the analysis performed by Snohomish County for its 2009 Community Rating System (CRS) re-verification, 43 percent of the regulated floodplain in the unincorporated county is currently in an open space use. Also, 45 percent of the regulated floodplain has a specified minimum lot density of 1 structure per 5 acres or larger and is zoned for land uses that support agricultural productions.

12.7 Issues

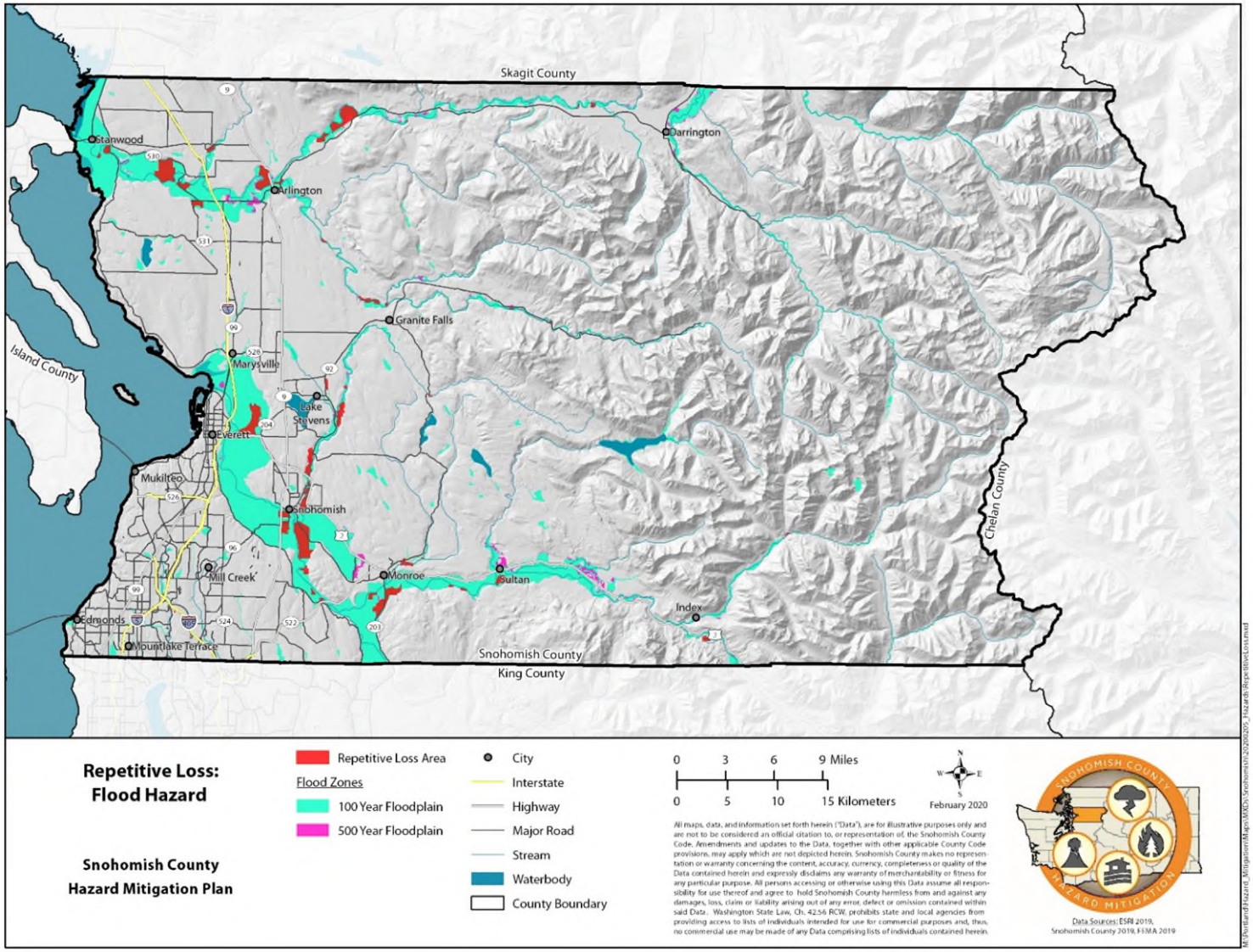
Important issues associated with flood hazards include but are not limited to the following:

- Older levees are subject to failure or do not meet current building practices for flood protection.
- More information is needed on flood risk to support the concept of risk-based analysis of capital projects.
- A sustained effort to gather historical damage data, such as high-water marks on structures and damage reports, is needed in order to measure the cost-effectiveness of future mitigation projects.
- Ongoing flood hazard mitigation will require funding from multiple sources to continue.
- A coordinated hazard mitigation effort between jurisdictions affected by flood hazards in the county is needed.
- Floodplain residents need to continue to be educated about flood preparedness and their sources available during and after floods.
- The risk associated with the flood hazard overlaps the risk associated with other hazards, such as earthquake and landslide. This provides an opportunity to seek mitigation alternatives with multiple objectives that can reduce risk for multiple hazards.
- Stream bank erosion is still a major problem on most of the county's rivers and streams.
- The concept of residual risk should be considered in the design of future capital flood control projects and should be communicated with residents living in the floodplain.
- The promotion of flood insurance as a means of protecting private property owners from the economic impacts of frequent flood events should continue.
- Existing floodplain-compatible uses such as agricultural and open space need to be maintained. There is constant pressure to convert these existing uses to more intense uses, especially along the Stillaguamish and Snohomish Rivers.
- The economy has an impact on a jurisdiction's abilities to manage its floodplains. Budget cuts and personnel losses can tax many resources needed to support floodplain management.
- Flood Insurance Rate Maps (FIRMs) and DFIRMs do not provide accurate estimates of future risk due to climate change.

12.8 Hazard Maps



Map 12-1 Snohomish County Flood Hazard Areas



Map 12-2 Snohomish County Repetitive Loss Flood Areas

13 Hazardous Materials

13.1 General Background

A hazardous material may cause damage to people, property, or the environment when released to soil, water, or air. Hazardous materials are substances or materials that pose and unreasonable risk to health, safety, and property, and include hazardous substances, hazardous wastes, marine pollutants, elevated temperature materials, and others. Hazardous materials are used and stored in homes and businesses. Products are shipped daily on highways, railroads, waterways, and pipelines.

Starting in 1986, the Emergency Planning and Community Right-to-Know Act required certain industries to report the locations and quantities of chemicals stored on-site to government officials. The Toxic Release Inventory database makes public the information about releases and transfers of toxic chemicals from facilities to certain industrial sectors (EPA 2019).

13.1.1 Potential Damage from Hazardous Materials

Small releases can have the potential to endanger public health and contaminate groundwater, surface water, and soils. Environmental damage from such releases depends on the material spilled and the extent of contamination. Many are releases of small quantities that are contained and cleaned up quickly with little damage to the environment. Even small releases can incur thousands of dollars of cleanup costs and damages. Large releases can cost communities and companies millions of dollars.

DEFINITIONS

Hazardous Substance – Those substances listed in Appendix A of 49 CFR §172.101; does not include petroleum, natural gas, liquefied natural gas, or fuel.

Hazardous waste – Materials subject to 40 CFR §262.

Marine pollutant – Materials listed in Appendix B of 49 CFR §172.101.

Elevated temperature material – Materials which are in a liquid phase at a temperature at or above 212°F; or is in a liquid phase with a flash point at or above 100°F; or is in a solid phase at a temperature at or above 464°F.

Navigable waters – Waters of the United States, including territorial seas.

PHMSA – Pipeline and Hazardous Materials Safetv Administration

Damage from hazardous materials can occur from the material's flammability, toxicity, corrosiveness, chemical instability, and/or combustibility. Material releases seep through the soil and eventually into the groundwater, making water supplies unsafe to drink. Vapors from spilled materials can collect in houses and businesses, sometimes in low-lying areas, creating fire, explosion, and toxic inhalation hazards. Public health impacts of a release can vary from temporary skin irritation to death. Exposure can pose short- and long-term toxicological threats to humans, terrestrial and aquatic plants, and to land and marine wildlife.

13.2 Snohomish County Hazard Profile

Accidental releases of petroleum, toxic chemicals, gases, and other hazardous materials occur frequently throughout Snohomish County. They occur on transportation corridors that include highways, railroads, air/flight paths, pipelines, and navigable waterways. Major transportation routes through Snohomish County include I-5, I-405, U.S. Route 2, SR-104, SR-99, SR-524, SR-527, SR-525, SR-522, SR-203, SR-9, SR-529, SR-92, SR-528, SR-530, SR-531, and SR-532. Potential for a spill also exists on routes used for

business and industrial purposes. BNSF railroad also runs along the west coast and southern portion of the county.

13.2.1 Hazard Ranking

The Steering Committee and Planning Team completed a hazard ranking survey during the Snohomish County 2020 HMP update process for a range of hazard-related factors based on worst case and most likely scenarios; definitions of the hazard ranking factors are found in Table K-1 in Appendix K. The results of the survey were averaged together for each factor to generate a total average score and rank, enabling the prioritization of hazards by type. When compared against the other hazards included in the 2020 hazard ranking survey, hazardous material incidents were ranked as the number four worst-case scenario and the second most likely scenario (see Table 13-1).

Table 13-1
Hazard Ranking Output

Severity (1=lowest, 5=highest)	Magnitude (1=lowest, 5=highest)	Frequency (1=lowest, 5=highest)	Onset (1=slowest, 5=fastest)	Duration (1=shortest, 5=longest)	Perceived Change in Risk	Average	Rank
Worst-case Scenario							
4.44	3.38	3.19	5.00	3.63	0.2	3.93	4
Most Likely Scenario							
2.13	1.69	1.75	4.50	2.63	0.2	2.54	2

13.2.2 Past Events

Snohomish County experienced 150 oil spills between July 1, 2015 to September 30, 2019 (Washington Department of Ecology 2019b). Ninety-seven percent of these spills were under 100 gallons; 5 were 100 gallons and over.

- July 1, 2015 – 150 gallons of diesel spilled into a ditch
- March 21, 2016 – 100 gallons spilled into fresh water after a truck collision on Highway 530
- July 27, 2018 – 100 gallons spilled from a facility into a storm water retention pond
- September 18, 2018 – 340 gallons spilled from a facility into fresh water
- November 23, 2018 – 100 gallons spilled from a vehicle into a creek

A review of the Pipeline and Hazardous Materials Safety Administration incident reporting database showed the hazardous materials incidents along transportation corridors since 1975 (Pipeline and Hazardous Materials Safety Administration 2019). Snohomish County experienced 189 incidents (USDOT, n.d.). Table 13-2 shows incidents with 100 LGA and over released in Snohomish County:

Table 13-2 Hazardous Materials Incidents in Snohomish County over 100 LGA				
Incident Route	Incident City	Date of Incident	Quantity Released	Commodity Name
	PAINE FIELD	June 6, 1978	110 LGA	FUEL OIL
	EDMONDS	June 14, 1980	1470 LGA	GASOLINE
	EVERETT	September 11, 1991	500 LGA	TARS, LIQUID
SR9 & LOWELL LARIMER RD	SNOHOMISH	February 14, 1992	150 LGA	PAINT
2600 FEDERAL BOX 925	EVERETT	March 17, 1992	100 LGA	SULFURIC ACID
CUSTOMER'S PREMISES	EVERETT	March 17, 1993	100 LGA	FLAMMABLE LIQUIDS, Not Otherwise Specified (N.O.S.)
7200 HARDESON RD	EVERETT	January 19, 1994	110 LGA	CAUSTIC ALKALI LIQUIDS, N.O.S.
BNRR DELTA YARD	EVERETT	June 10, 1994	100 LGA	CORROSIVE LIQUIDS, N.O.S.
19220 HWY 2	MONROE	May 12, 1995	360 LGA	LIQUEFIED PETROLEUM GAS
2900 BOND ST	EVERETT	March 4, 1996	200 SLB	ENVIRONMENTALLY HAZARDOUS SUBSTANCES, SOLID, N.O.S.
3102 HILL ST	EVERETT	August 6, 1998	200 LGA	GASOLINE
INTERSTATE 5	LYNNWOOD	July 12, 2003	5100 LGA	GASOLINE
INTERSTATE 5	LYNNWOOD	July 12, 2003	6200 LGA	GASOLINE
923 100TH STREET S.E.	EVERETT	March 17, 2006	153 LGA	ETHANOL OR ETHYL ALCOHOL
	EVERETT	December 9, 2014	240 SLB	HAZARDOUS WASTE, SOLID, N.O.S.
	EVERETT	December 10, 2014	120 SLB	HAZARDOUS WASTE, SOLID, N.O.S.

Source: PHMSA

13.2.3 Location

Hazardous material releases are more likely to occur in areas surrounding fixed site facilities and along major transportation routes in the county. There are 287 Tier II facilities listed in Snohomish County. Additionally, the EPA identifies 92 facilities under the Toxic Release Inventory. These facilities are required to report annually how much of each chemical is recycled, combusted for energy recovery, treated for

destruction, and disposed of or otherwise released on and off site. In 2018, the 24 TRI facilities in Snohomish County reported a total of 145.9 tons of on- and off-site disposal or other releases.[h]

There are two EPA-designated Superfund Sites in Snohomish County. Both sites are in Marysville: the Boeing Company Tulalip Test Site and the Tulalip Landfill.[i]

13.2.4 Frequency

Dozens of hazardous materials incidents happen each year in Snohomish County, although most are small and result in little environmental, personal, or property damage. Federal, state, and local rules and regulations continue to become more stringent and lower the chances for an incident. With increased utilization of hazardous material and increasing transportation along major transportation routes, the chances for a large hazardous material incident in the county remains a risk. The probability of a hazardous materials release in Everett is higher than the rest of Snohomish County.

13.2.5 Severity

Severity regarding a hazardous material release varies greatly depending on the material and the amount released. The extent of a hazardous substance release depends on whether the substance is released from a fixed or mobile source, the size of the impacted area, the toxicity and properties of the substance, the duration of the release, and environmental conditions. Air, water, and soils can become contaminated resulting in injuries or death. Exacerbating conditions magnifying effects of a release include weather conditions, micro-meteorological effects of buildings and terrain, and maintenance failures.

Other factors that determine the severity of a potential incident include quick and solid decision-making by emergency officials, evacuation and shelter-in-place needs and communication, public health concerns, and relevant economic considerations. While most incidents are generally brief, the resulting recovery and cleanup may take time and money.

13.2.6 Warning Time

Hazardous material incidents usually offer little to no warning time before the incident occurs. People in the immediate vicinity have the least amount of warning and response time. Surrounding community members will usually have more time to shelter-in-place or evacuate the area. The initial identification of specific hazardous materials types can increase response capabilities.

13.3 Cascading Impacts/Secondary Hazards

Hazardous material incidents can result in the contamination of air, water, and soils, leaving lasting long-term exposure and negative impacts on plants, animals, and even humans. Large-scale incidents can require long-term health and environmental monitoring costs to monitor impacts on humans and the environment. With certain materials, there is a chance for fire, which can result in an urban fire or wildfire. Long-term environmental impacts can in turn cause negative economic impacts to tourism or fishing.

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[h] United States Environmental Protection Agency (EPA). (2019). *TRI Explorer.* Retrieved from https://enviro.epa.gov/triexplorer/release_chem?p_view=COCH&trilib=TRIQ1&sort=_VIEW_&sort_fmt=1&state=53&county=53061&chemical=All+chemicals&industry=ALL&year=2018&tab_rpt=1&fld=RELLBY&fld=TSFDSP.

[i] EPA. (2019). *Search for Superfund Sites Where You Live.* Retrieved from https://www.epa.gov/superfund/search-superfund-sites-where-you-live.

13.4 Potential Impacts from Future Climate Conditions

Non-natural incidents such as hazardous substance incidents are not typically considered vulnerable to climate change. Climate change and its impact on hazardous material sites, particularly waste sites, is a growing concern. Hazardous waste sites near rivers and marine waters are tentatively at highest risk because extreme storms and higher water levels could release pollution into the environment. Many of these sites were built in locations believed to be removed from potential contamination or exposure increasing factors. However, development, floodplain boundary change, and an increase in extreme events from climate change are increasing the possibility that water may reach hazardous material and waste sites.

Increased severe weather events can increase the chances of a hazardous materials incident as a secondary hazard.

13.5 Exposure

Exposure and vulnerability due to hazardous material incidents are difficult to quantify due to many variables and human elements.

13.5.1 Population

The entire population of Snohomish County is vulnerable to a hazardous material incident due to widespread use and storage throughout communities. Although the vulnerability is low, populations are more at risk due to higher utilization and transportation of hazardous materials. Communities along major transportation highway and rail transportation routes are at a higher risk for an incident. The general population may be exposed to a hazardous material release through inhalation, ingestion, or dermal exposure.

13.5.1.1 Vulnerability

Vulnerable populations are all populations that may be exposed to an incident and are incapable of escaping the area within the allowable time frame. This population includes the elderly and young, who may be unable to get themselves out of the inundation area. Other vulnerable populations also include those who may not have adequate warning, such as linguistically isolated people.

13.5.2 Property

Some hazardous materials pose a reactivity, fire, or explosion risk. Materials improperly stored in buildings have the potential to mix with incompatible substances which can result in polymerization, the production of heat, combustion or fire, and even an explosion.

13.5.2.1 Vulnerability

It is difficult to determine potential losses and vulnerabilities to properties due to the variable nature and amount of hazardous materials being stored. Hazardous material incidents can pose a serious long-term threat to property.

13.5.3 Critical Facilities

Multiple critical facilities in Snohomish County are vulnerable to a hazardous material incident. It is difficult to quantify losses of critical facilities due to an incident. Potential losses may include inaccessibility, loss of service, contamination, and/or potential structural and content loss if an explosion occurs. Cost of clean-up and potential future monitoring can put extra strain on the facility and may contribute to bankruptcy.

13.5.3.1 Vulnerability

A majority of critical facilities store hazardous materials, increasing vulnerability and likelihood of an incident. Transportation infrastructure such as I-5, I-405, U.S. Routes 2 and 9, Highway 99, the Port of Everett, and the BNSF railway are used to transport hazardous materials and thus are vulnerable to potential disruption in the event of a materials release.

13.5.4 Environment

Environmental damage resulting from a hazardous material incident can be on a scale from limited to disastrous. Released materials can end up in the air, soil, and water. Some materials contribute to the destruction of the ozone. As materials soak into the soil, they can kill microorganisms and nutrients that contribute to the livelihood of plants and animals. Hazardous materials can eventually reach the groundwater, potentially toxifying community drinking water systems. Materials that end up in bodies of water can kill aquatic plants and animals and strain an ecosystem.

13.6 Development Trends

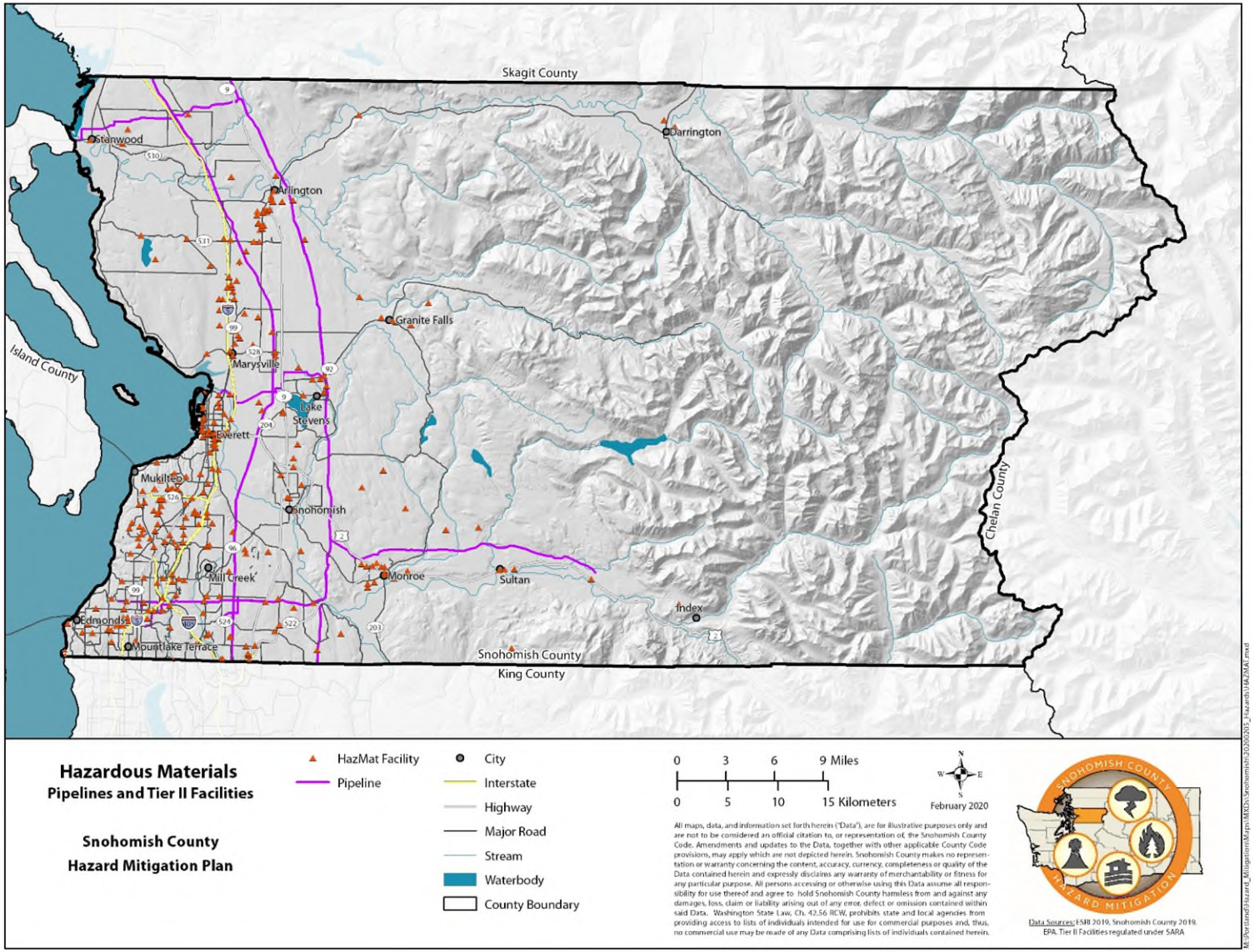
The number and types of hazardous chemicals stored in and transported through the county will likely continue to increase. As population grows, the number of people vulnerable to the impacts of hazardous materials incidents will increase. Population and business growth along major transportation corridors increases the vulnerability to transportation hazardous material spills.

13.7 Issues

The major issues for hazardous materials incidents include the following:

- Continue all facets of emergency preparedness training for police, fire, public works, and public information staff in order to respond quickly.
- Work proactively with hazardous materials facilities to follow best management practices:
    - Placards and labeling of containers
    - Emergency plans and coordination
    - Standardized response procedures
    - Notification of the types of materials being transported through the planning area
    - Random inspections of transporters
    - Installation of mitigating techniques along critical locations
    - Routine hazard communication initiatives
    - Consideration of using safer alternative products
- Work with the private sector to enhance and create Business Continuity Plans in the event of an emergency.
- Maintain a regional emergency services information line that the public can contact 24 hours a day during an emergency incident.
- Coordinate with planning area school districts to ensure that their emergency preparedness plan includes preparation for hazardous material spills.

13.8 Hazard Map



Map 13-1 Snohomish County Tier II Hazardous Materials Facilities and Pipelines

14 Mass Earth Movement

14.1 General Background

Mass earth movement can be defined as a debris flow, mudslide, rock fall, sinkhole, or landslide. A landslide is defined as the movement of a mass of rock, debris, or earth down a slope (USGS, n.d. [b]). Mass earth movements denote any down-slope movement of soil, rock, or debris under the direct influence of gravity. There are five modes of slope movement: falls, topples, slides, spreads, and flows. Slope movement occurs when forces acting down-slope exceed the strength of the earth materials that compose the slope. Landslides can be initiated in slopes already on the verge of movement by rainfall, snowmelt, changes in water level, stream erosion, changes in ground water, earthquakes, volcanic activity, disturbance by human activities, or any combination of these factors.

A debris flow is a moving mass of loose mud, sand, soil, rock, water and air that travels down a slope under the influence of gravity. To be considered a debris flow, more than half of the solids must be larger than sand grains. A mud flow is a mass of water and fine-grained earth materials that flow down a stream, ravine, canyon, arroyo, or gulch (Colorado Geological Survey, n.d.).

14.1.1 Potential Damage from Mass Earth Movement

Mass earth movement can result in property damage, destruction, and human injury or loss of life. The displaced earth can dam rivers, destroy highways, and sever railroad lines. This can result in flooding, delayed response time for assistance, and train derailments. An event can occur with little to no warning, posing an increased hazard.

DEFINITIONS

Debris Flow – A form of rapid mass movement in which loose soil, rock, and sometimes organic matter combine with water to form a slurry that flows downslope.

Landslide—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.

Mass Movement—A collective term for landslides, debris flows, falls, and sinkholes.

Mudslide (or Mudflow)—A river of rock, earth, organic matter, and other materials saturated with water.

Sinkhole—A collapse depression in the ground with no visible outlet. Its drainage is subterranean. It is commonly vertical-sided or funnel-shaped.

14.2 Snohomish County Hazard Profile

In general, landslide hazard areas are where the land has characteristics that contribute to the risk of the downhill movement of material, such as:

- A slope greater than 33 percent
- A history of landslide activity or movement in the past 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 of an alluvial fan, indicating vulnerability to the flow or debris or sediments
- The presence of impermeable soils, such as silt or clay, which are mixed with granular soils, such as sand and gravel (University of Washington 2015b).

The most common slide is the shallow colluvial slide, occurring particularly in response to intense, short-duration storms. Less common, the largest and most destructive slides are deep-seated slides. The county's shoreline contains many large, deep-seated dormant landslides. Most landslides occur in January after the water table has risen during the wet months of November and December. In addition to the coastal bluffs, landslides are most prevalent around the slopes of the county's steep, linear hills. Water is involved in nearly all cases, and human influence has been identified in more than 80 percent of reported slides.

14.2.1 Hazard Ranking

The Steering Committee and Planning Team completed a hazard ranking survey during the Snohomish County 2020 HMP update process for a range of hazard-related factors based on worst case and most likely scenarios; definitions of the hazard ranking factors may be found in Table K-1 in Appendix K. The results of the survey were averaged together for each factor to generate a total average score and rank, enabling the prioritization of hazards by type. When compared against the other hazards included in the 2020 hazard ranking survey, mass earth movements were ranked as the number 13 worst-case scenario and the eleventh most likely scenario (see Table 14-1).

Table 14-1
Hazard Ranking Output

Severity (1=lowest, 5=highest)	Magnitude (1=lowest, 5=highest)	Frequency (1=lowest, 5=highest)	Onset (1=slowest, 5=fastest)	Duration (1=shortest, 5=longest)	Perceived Change in Risk	Average	Rank
Worst-case Scenario							
3.31	3.06	2.69	5.00	3.25	0.2	3.46	13
Most Likely Scenario							
1.63	1.63	1.81	3.94	2.50	0.2	2.30	11

14.2.2 Past Events

There are two FEMA disaster declarations for landslides/mudslides in Snohomish County and six events listed in the NOAA Storm Events Database. Disaster declarations are shown in Table K-2 in Appendix K.

In 1997, a large slide occurred in Woodway, just north of the Richmond Beach neighborhood. It cut 50 feet into the property above, passed over the railroad tracks and knocked a freight train into the Puget Sound. The 2014 Oso landslide resulting in a FEMA declaration is the only known slide known to have caused fatalities in the county.

Map 14-1 shows mass earth movement hazard areas in Snohomish County. Current 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, slope angle, and height (University of Washington 2015b). Scientific research is ongoing to understand how these and other factors determine slide run-out. Finally, the recognition of ancient dormant mass movement sites is important in the identification of areas susceptible to flows and slides because they can be reactivated by earthquakes, exceptionally wet weather, natural weathering and strength reduction processes, and are vulnerable to construction-triggered sliding.

14.2.3 Frequency

Mass earth movements are often triggered by other natural hazards, such as earthquakes, heavy rain, floods, or wildland fires; movement frequency is related to the frequency of these other hazards. In Snohomish County, movements typically occur during and after major storms. Mass earth movements can occur any month of the year and stand a good chance of occurring annually, although may prove to be unpredictable.

14.2.4 Severity

Mass earth movements destroy property and infrastructure and can injure and kill people. Slope failures cause an estimated 25 to 50 deaths and $3.5 billion in damage each year in the United States (National Geographic, n.d.).

14.2.5 Warning Time

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 height, slope angle, material, and water content. Some methods used to monitor mass movements can provide an idea of the type of movement and the amount of time prior to failure. Currently, there is no practical warning system for individual landslides. The standard operating procedure is to monitor situations on a case-by-case basis.

Generally accepted warning signs for landslide activity include:

- Springs, seeps, or saturated ground in areas that have not typically been wet before
- New cracks or unusual bulges in the ground, street pavements, or sidewalks
- Soil moving away from foundations
- Ancillary structures, such as decks and patios tilting and/or moving relative to the main structure
- Tilting or cracking of concrete floors and foundations
- Broken water lines and other underground utilities
- Leaning telephone poles, trees, retaining walls, or fences
- Offset fence lines
- Sunken or down-dropped roadbeds
- Rapid increase in creek water levels, possibly accompanied by increased turbidity (soil content)
- Sudden decrease in creek water levels though rain is still falling or just recently stopped
- Sticking doors and windows, and visible open spaces indicating jambs and frames out of plumb
- A faint rumbling sound that increases in volume as the landslide nears
- Unusual sounds, such as trees cracking or boulders knocking together

14.3 Cascading Impacts/Secondary Hazards

Mass earth movements can cause several types of cascading impacts and secondary hazards. Roads can become blocked or destroyed, isolating residents, communities, and businesses and delaying commercial, public, and private transportation. Poles can be knocked over resulting in loss of power and communication. There is also a risk of destabilizing the foundations of structures, resulting in property and monetary losses for businesses and homeowners. Earth movements can also block waterways, resulting in flooding, reduced water quality, and potential harm to fisheries and spawning habitat.

14.4 Potential Impacts from Future Climate Conditions

Future climate conditions may increase the probability of more frequent, intense storms with varying duration. Snowpack can also be affected, changing the ability to hold and store water. Droughts may increase in occurrence and duration, increasing the chances for wildland fires, affecting vegetation that helps support steep slopes. These factors by themselves or together would increase the probability for a mass earth movement within the county.

14.5 Exposure

14.5.1 Population

Population could not be examined by mass earth movement hazard area because census block group areas do not coincide with the risk areas. A population estimate was made using the structure count of building within the earth movement hazard areas and applying the census value of 2.68 persons per household for Snohomish County. Using this approach, the estimated county population living in earth movement risk areas is 233,967.

14.5.1.1 Vulnerability

It is difficult to determine demographics of populations vulnerable to mass earth movements due to the nature of census block group data. In general, all of the estimated 233,967 persons that are exposed to the hazard are also vulnerable. Due to the county's increasing population density and structures built on property atop bluffs, below bluffs, and on steep slopes subject to mass movement, vulnerability has increased.

14.5.2 Property

Table 14-2 shows the total number of buildings exposed, the percentage of all buildings exposed, and the assessed value of structures exposed to at least a moderate landslide hazard by jurisdiction; categories 4-6 (yellow) on the Snohomish County Landslide Hazard Areas map (Map 14-1). Nearly 12,000 buildings worth an assessed value of approximately $32.3 billion are exposed to landslides.

Table 14-2
Value of Property Exposed to Landslides

Jurisdiction	Number Buildings Exposed	% of all Buildings Exposed	Assessed Value of Exposed Buildings		
			Structure	Contents	Total
Arlington	5,875	83%	$1,663,896,945	$1,461,900,648	$3,125,797,594
Brier	569	23%	$110,272,759	$55,413,187	$165,685,946
Darrington	1,232	97%	$119,850,563	$96,511,807	$216,362,370
Edmonds	6,783	51%	$1,799,442,996	$1,137,716,224	$2,937,159,220
Gold Bar	1,217	100%	$98,741,694	$54,736,840	$153,478,534
Granite Falls	1,626	100%	$243,041,952	$159,716,975	$402,758,927
Index	191	100%	$14,467,946	$8,398,928	$22,866,874
Lake Stevens	2,130	18%	$362,056,651	$195,529,158	$557,585,808
Lynnwood	669	6%	$176,472,189	$138,135,475	$314,607,665
Marysville	16,619	71%	$2,971,140,416	$1,878,175,059	$4,849,315,475

Table 14-2 Value of Property Exposed to Landslides					
Jurisdiction	Number Buildings Exposed	% of all Buildings Exposed	Assessed Value of Exposed Buildings		
			Structure	Contents	Total
Mill Creek	1,355	26%	$611,417,964	$397,697,937	$1,009,115,901
Monroe	5,260	91%	$1,388,726,502	$1,163,096,729	$2,551,823,231
Mountlake Terrace	1,149	30%	$393,562,453	$308,394,752	$701,957,205
Mukilteo	2,013	22%	$588,770,918	$319,130,924	$907,901,841
Snohomish	2,181	46%	$373,395,660	$254,193,001	$627,588,662
Stanwood	12,32	37%	$208,773,324	$142,837,461	$351,610,785
Sultan	2,200	98%	$275,078,919	$178,519,111	$453,598,030
Unincorporated	64,745	30%	$8,152,974,339	$4,699,953,581	$12,852,927,920
Woodway	290	35%	$95,875,423	$48,232,477	$144,107,900
Grand Total	11,7336	38%	19,647,959,613	$12,698,290,274	32,346,249,887

Table 14-3 shows the general land use of parcels exposed to mass earth movements across Snohomish County. Land used for forestry or parks are less vulnerable, while lands used for manufactured homes are highly vulnerable. The predominant land uses for parcels in cities are single-family, vacant, and manufactured homes. These uses (as well as timber) are the predominant land uses for exposed parcels in unincorporated Snohomish County.

Table 14-3 Snohomish County Land Use of Parcels Exposed to Mass Earth Movement		
Parcel Type	# of Parcels	Acres
Cultural, Entertainment, Recreation	782	22,255
Forest	219	47,061
Goods/Products	147	1,021
Manufacturing	356	5,239
Open Space	848	12,684
Open Water	418	4,206
Other	7,080	1,565,234
Residential	97,676	971,064
Resource Production/Extraction	3,542	119,912
Retail	2,008	6,168
Services	2,203	6,159
Transportation/Utility	1,118	8,605
Undeveloped	15,461	411,275
Total	131,858	3,180,883

14.5.2.1 Vulnerability

A study completed for Seattle Public Utilities in 2000 showed that only about 1 percent of the land area of the region is actually vulnerable to landslides or other mass movements. This study also showed that 84 percent of the slides recorded had human-related causes. Consequently, there is greater potential for damage or destruction to private and public property than if stringent landslide policies were adopted.

Although complete historical documentation of the mass movement threat in Snohomish County is unavailable, the effects of slide and flow activity seen during the SR 530 slide of 2014 and winter storms of 1996–97 suggest a significant vulnerability to such hazards. Countywide, the tens of millions of dollars in damage attributable to mass movement during those storms affected private property and public infrastructure and facilities.

14.5.3 Critical Facilities

Table 14-4 summarizes the critical facilities exposed to the mass earth movement hazard. No loss estimation of these facilities was performed due to the lack of established damage functions for the mass movement hazard. A significant amount of infrastructure (roads, bridges, railroads, and utilities) can be exposed to mass movements.

Table 14-4
Critical Facilities Within Snohomish County's Landslides Hazard Areas

Airport	6
Bridge	299
Communication	3
Dam	15
Ferry	4
Fire/EMS	37
Government	44
Hazmat	11
Medical	24
Natural Gas Facility	1
Oil Facility	1
Other	17
Police	17
Port Facility	8
Power Facility	6
School	102
Wastewater Facility	74
Water Facility	5
Water Storage	6
Total	680

14.5.3.1 Vulnerability

Highly susceptible areas of the county include the mountain and coastal roads and transportation infrastructure.

14.5.4 Environment

Environmental problems as a result of mass movements can be numerous. Simply, earth movements alter the landscape. Landslides can impact the topography/morphology of both subaerial and submarine surfaces, rivers, streams, forests, and grasslands, and the habitats of native fauna, both on land and in water (Schuster and Highland 2001). Mass earth movements that affect rivers can lead to blockage, the formation of lakes, or widespread flooding. Soil and sediment runoff can accumulate downslope, potentially blocking waterways, harming the quality of streams and other water bodies.

14.6 Development Trends

Landslide hazard areas are included in the "geologically hazardous areas," one category of critical areas regulated under the state GMA for Snohomish County. They are defined as follows:

Landslide hazard areas are areas potentially subject to mass earth movement based on a combination of geologic, topographic, and hydrologic factors, with a vertical height of 10 or more feet.

These include the following:

- Areas of historical landslides as evidenced by landslide deposits, avalanche tracks, and areas susceptible to basal undercutting by streams, rivers or waves
- Areas with slopes steeper than 15 percent that intersect geologic contacts with a relatively permeable sediment overlying a relatively impermeable sediment or bedrock, and which contain springs or ground water seeps
- Areas located in a canyon or an active alluvial fan, susceptible to inundation by debris flows or catastrophic flooding

Snohomish County's 2012 BLR excludes critical areas from consideration as buildable lands due to the scope of regulations affecting them. Based on the findings of this report, Snohomish County and its planning partners appear to be equipped to deal with future growth and development within the planning area. The landslide hazard portions of the planning area are regulated by county code (Title 30.62B) as well as by the International Building Code. Development will occur in landslide hazards within the planning area, but it will be regulated such that the degree of risk will be reduced through building standards and performance measures.

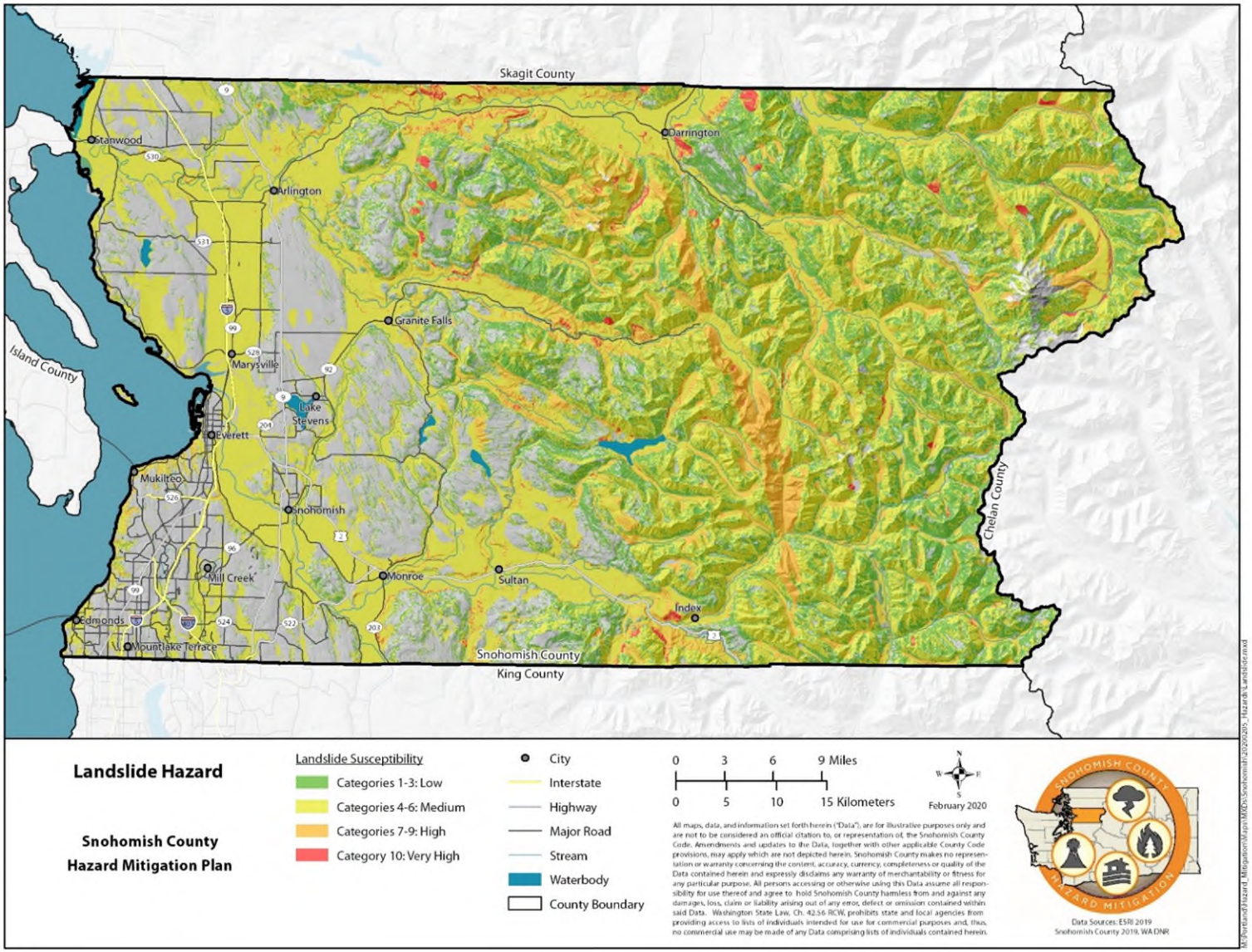
14.7 Issues

Important issues associated with landslides in Snohomish County include the following:

- There are existing homes in mass movement prone areas, specifically on the Puget Sound shoreline, with the cities of Everett, Mukilteo, Edmonds, and the Tulalip Reservation being affected significantly.
- Future development could lead to more homes in mass movement prone areas. These areas include the foothills of the Cascades, and steep slope areas above the river floodplains of the North and South Forks Stillaguamish River and the Skykomish River.

- The data and science regarding the mapping and assessment of landslide hazards is constantly evolving. As new data and science become available, assessments of landslide risk should be reevaluated.
- The impact of climate change on landslides is uncertain. If climate change impacts atmospheric conditions, exposure to landslide risks in Snohomish County is likely to increase.
- Landslides cause environmental changes, including temporary water quality degradation and habitat loss. However, these changes may also provide habitat benefits from sediment and nutrient transport.
- The risk associated with the landslide hazard overlaps the risk associated with other hazards such as earthquake, flood, and tsunami. This provides an opportunity to seek mitigation alternatives with multiple objectives that can reduce risk for multiple hazards.
- Current landslide hazard mapping does not include areas potentially impacted from the run-out of landslides.

14.8 Hazard Map



Map 14-1 Snohomish County Landslide Hazard Areas

15 Tsunami

15.1 General Background

Tsunamis are waves cause by earthquakes, volcanic eruptions, or landslides under the sea (NOAA 2019a). As waves travel inland, they build to higher heights as the depth of the ocean decreases. Waves can reach heights of over 100ft and can travel at speeds over 500 miles per hour, the same speed as a commercial jet plane (NOAA 2009). Major tsunamis occur about once per decade; 59 percent of the world's tsunamis occurred in the Pacific Ocean, 25 percent in the Mediterranean Sea, 12 percent in the Atlantic Ocean, and 4 percent in the Indian Ocean. Time before a tsunami hits can vary from minutes to hours; higher ground should be sought out immediately.

Natural warning signs for tsunamis include severe ground shaking from local earthquakes, water receding from the coast and exposing the ocean floor, reefs, and fish, and abnormal ocean activity (a wall of water) creating a loud roaring sound similar to that of a train or jet aircraft. A tsunami's height and impacts are influenced by local bathymetry and topography and the direction from which the tsunami arrives (NOAA, n.d. [a]).

15.1.1 Potential Damage from Tsunamis

Tsunamis typically cause the most severe damage and casualties near their source. Tsunamis with runups over one meter are particularly dangerous to people and property, but smaller tsunamis can also be dangerous. Strong current can injure and drown swimmers, damage boats, and destroy infrastructure in harbors. Low-lying areas such as beaches, bays, lagoons, harbors, river mouths, and areas along rivers and streams leading to the ocean are most vulnerable. Most tsunami damage and destruction are caused by flooding, wave impacts, erosion, strong currents, and floating debris. As water returns to the sea, it takes debris and people with it. In addition to loss of life and mass injuries, other potential impacts include damage to and destruction of homes and businesses, ports and harbors, cultural resources, utilities, and critical infrastructure and facilities. Utilities such as power, sewer, water, and communications may be lost or disrupted, and transportation, health, and public safety services may be delayed. Tsunamis can also cause hazardous material releases, contaminating water supplies and threatening public health.

DEFINITIONS

Runup – A measurement of the height of the water onshore observed above a reference sea level.

Tsunami – Comes from the Japanese words for *harbor* ("tsu") and *wave* ("nami"); a long high sea wave caused by an earthquake, submarine landslide, or other disturbance.

Tsunami from a large undersea earthquake – The earthquake must cause significant vertical deformation on the seafloor in order for a tsunami to occur.

Tsunami Advisory – Issued when strong currents and dangerous waves of 1–3 feet are expected.

Tsunami Warning – Issued by the National Tsunami Warning Center when a potential tsunami with significant widespread inundation is imminent or expected.

Tsunami Watch – Issued when an event may later impact the watch area; may be upgraded to tsunami warning.

15.2 Snohomish County Hazard Profile

Although Snohomish County would feel the effects of an earthquake located in the CSZ, a tsunami originating from that earthquake would pose moderate risk. However, the SWIF and Seattle fault pose the greater danger from a tsunami. An earthquake along the SWIF or Seattle fault could produce a tsunami with the ability to reach shores in 30 minutes, giving emergency management officials little time to warn and evacuate people (Schwarzen 2005). An additional potential derived tsunami source from earthquakes is the Tacoma Fault (TF). This would likely pose a lower risk than either the CSZ or Seattle fault, but would also have a response time of tens of minutes.

15.2.1 Hazard Ranking

The tsunami hazard was identified for inclusion in the Snohomish County 2020 HMP during the hazard ranking exercise; therefore, the hazard was not scored or ranked by worst case and most likely scenarios as most of the other hazards were.

15.2.2 Past Events

Multiple distant and local tsunamis have struck the coast of Washington (Washington State Department of Natural Resources, n.d.). Some notable events that have affected Washington include (Washington State Department of Natural Resources 2013):

- January 26, 1700 (Local Tsunami) – An estimated M8.7–9.2 earthquake occurred in the Cascadia Subduction Zone, creating waves up to 100 ft along the Washington and Oregon coast. The event is recorded in geologic record and in Native American oral history and was recorded in Japan on the same day.
- April 1, 1946 (Distant Tsunami) – An M8.1 earthquake occurred in the Aleutian Island of Alaska, resulting in a tsunami that caused 165 deaths and significant destruction in Alaska, Hawaii, and states bordering the Pacific Ocean. This event resulted in the formation of the Pacific Tsunami Warning Center.
- March 27, 1964 (Distant Tsunami) – An M9.2 earthquake occurred in Anchorage, Alaska, generating a tsunami that caused 110 deaths throughout different states affected on the Pacific Coast. This event resulted in the formation of the National Tsunami Warning Center in Palmer Alaska.

The table below lists one tsunami event that has struck Snohomish county since 1800.

Date	Event Type	Deaths/Injuries	Description
1820	Local Tsunami	2 Deaths	A large landslide from Camano Head created a tsunami that hit Hat Island, drowning an Indian village.[j]

Source: NOAA NGDC/WDS Tsunami Event Database[k]

[j] Island County, Washington Department of Emergency Management. (n.d.) *Natural Hazards on Whidbey Island*. Retrieved from https://www.islandcountywa.gov/DEM/PublicEducation/NaturalHazards-of-WhidbeyIsland.pdf.

[k] National Geophysical Data Center (NOAA). (n.d.). Global Historical Tsunami Database. Retrieved from https://www.ngdc.noaa.gov.

15.2.3 Location

Nearly every coast and river estuary are threatened by tsunamis. If an earthquake ruptures a fault at the surface of the ground and offsets the floor, it could generate a local tsunami. There is also the threat of distant tsunamis, such as those from Alaska, although they are less likely to have devastating effects within the county. The Southern Whidbey Island Fault is capable of generating a tsunami that would affect Snohomish County, however it is not the only source. Earthquakes that occur throughout the region can trigger landslides, which may create or amplify tsunamis. The locations most susceptible to the tsunami hazard are the western coast of the county, the rivers inland from the bay, and the lakes inland.

15.2.4 Frequency

The frequency of tsunamis is related to the frequency of events (earthquakes, volcanic activity, or landslides) that cause them. However, these three factors do not produce a tsunami every time. Major tsunamis occur about once per decade. A tsunami affecting Snohomish County has not happened since approximately 1820. There is a risk for the county to experience effects from a tsunami; however, the frequency of such an event is very low.

15.2.5 Severity

Earthquakes provide the energy to generate tsunamis through sudden movements in the water column; severity depends on the location, magnitude, and depth. Most earthquake-generated tsunamis come from magnitudes 7.0 and greater that are shallow (less than 62 miles below the surface). The earthquake must be big enough and close enough to generate vertical movement of the ocean floor. The amount of movement on the ocean floor, the size of the area which it occurs, and the depth of water at that point are all factors in determining severity of a tsunami (NOAA, n.d. [b]).

Tsunamis can also be generated by landslides (rock falls, slope failures, debris flows, slumps, ice falls, or glacial calving). This can happen when a landslide enters the water and displaces it from above, or when what is displaced ahead of and behand an underwater landslide. Severity of the tsunami will depend on the amount of material that displaces the water, the speed, and the depth to which it moves. This is a local tsunami that can impact coastlines with very little warning but poses little distant threat.

Six inches of fast-moving water can carry away an adult; twelve inches can carry away a small car; and 18–24 inches can carry away most large SUVs, vans, and trucks.

15.2.6 Warning Time

In Snohomish County, the single biggest warning of a potential tsunami is a large earthquake. Scientists also use networks of ocean sensors to detect and monitor tsunamis. The U.S. Tsunami Warning System is a system led by NOAA that uses observation networks to detect and measure earthquakes that could generate tsunamis and monitor tsunamis once they are generated. Washington State is served by the National Tsunami Warning Center, which monitors the observation networks, analyzes events, and can provide advance warning in case of a tsunami threat on the Washington Coast. There are four tsunami alert types:

- Warning – get to high ground or inland immediately; tsunami imminent with flooding, powerful currents, and/or wave heights over 3 feet or unknown.
- Advisory – stay out of the water and away from the shore; strong currents and dangerous waves in or very near coastal water, wave heights of 1-3 feet.

- Watch – be prepared to take action and stay tuned to local radio/television/NOAA alert weather radios; tsunami is possible, alert level may change with more information.
- Information Statement – no action needed; no tsunami impact expected, alert level may change with more information.

15.3 Cascading Impacts/Secondary Hazards

Tsunamis may bring in and produce tons of floating debris, endangering human lives and property. Ships moored in marinas or harbors may be completely destroyed or washed up onto shore. As vessels are broken up, they release oil and other hazardous materials into the environment; if any facilities on shore store hazardous substances those may also be released, contaminating the floodwater. Coastal structures such as breakwaters, piers, port facilities, and public utilities may be swept away from the force of the water or the erosion of the foundation below. The destruction of this property can hurt the economy of the area, affecting food, employment, and fuel. Utilities such as water, sewage, communications, and power may be disrupted or damaged.

15.4 Potential Impacts from Future Climate Conditions

Future climate conditions have no effect on earthquakes that may cause tsunamis. However, future climate conditions may change the probability of landslides occurring within the county, possibly leading to more or decreasing tsunami opportunities. Potential sea-level rise could also greatly impact the extent of the tsunami hazard zone.

15.5 Exposure

The tsunami mapping used as the basis for this assessment is informed by a single scenario, the Seattle Fault earthquake event, and likely represents areas at highest risk.

15.5.1 Population

The population living in tsunami hazard areas was estimated using the percent of residential buildings within the tsunami hazard area multiplied by the total estimated population. Using this approach, the estimated resident population living in tsunami hazard areas is 3,599, or approximately 0.4 percent of the population. The populations that would be most exposed to tsunamis are those along beaches, low-lying coastal areas, tidal flats, and stream deltas that empty into ocean-going waters. People visiting those areas would also be exposed.

15.5.1.1 Vulnerability

Populations most vulnerable to tsunami hazards are the elderly, disabled, and very young who reside and visit those areas most exposed to tsunamis. Visitors in or around inundation areas are vulnerable, as they may not be familiar with tsunami hazards, warnings, or ways to reach higher ground quickly.

15.5.2 Property

Spatial analysis indicates that there are 2,688 structures within the tsunami hazard areas (see Table 15-1). The estimated worth of building-and-contents exposed to the tsunami hazard is $821 million, representing 1 percent of the total replacement value of the planning area.

Table 15-1 Value of Property Exposed to Tsunamis					
Jurisdiction	Buildings Exposed	% of Total	Assessed Value		
			Structure	Contents	Total
Edmonds	328	4%	$141,838,375	$111,428,720	$253,267,094
Marysville	160	1%	$42,991,771	$43,720,296	$86,712,068
Mukilteo	84	1%	$20,961,567	$12,968,037	$33,929,605
Stanwood	658	22%	$118,171,061	$96,346,539	$214,517,600
Unincorporated	1,458	1%	$140,780,167	$92,508,795	$233,288,962
Grand Total	2,688	1%	$464,742,941	$356,972,387	$821,715,329

15.5.2.1 Vulnerability

All structures and property that are located along tsunami inundation areas would be vulnerable, and even more vulnerable with little to no warning time.

15.5.3 Critical Facilities

There are a total of 74 critical facilities in the tsunami hazard area. Table 15-2 shows a breakdown of critical facility types and how many are in the hazard area.

Table 15-2 Critical Facilities Within Snohomish County's Tsunami Inundation Zones	
Bridge	23
Communication	1
Dam	2
Government	8
Medical	1
Oil Facility	1
Other	3
Police	2
Port Facility	5
School	4
Water Facility	1
Wastewater Facility	23
Total	74

15.5.3.1 Vulnerability

All critical infrastructures that are located along tsunami inundation areas would be vulnerable, and even more vulnerable with little to no warning time.

15.5.4 Environment

A tsunami event has the potential to change the land, both above and below water. In some places it may rise, and in others it may fall. If the coast subsides, flooding may be extended to unexpected areas and tsunami barrier may not be effective. Tsunami events can also make waterways unnavigable. Other consequences include permanent changes to beaches, coastal features, loss of or changes to wildlife habitat, and the availability of fresh water. Agricultural land inundated by saltwater can become unusable.

15.6 Development Trends

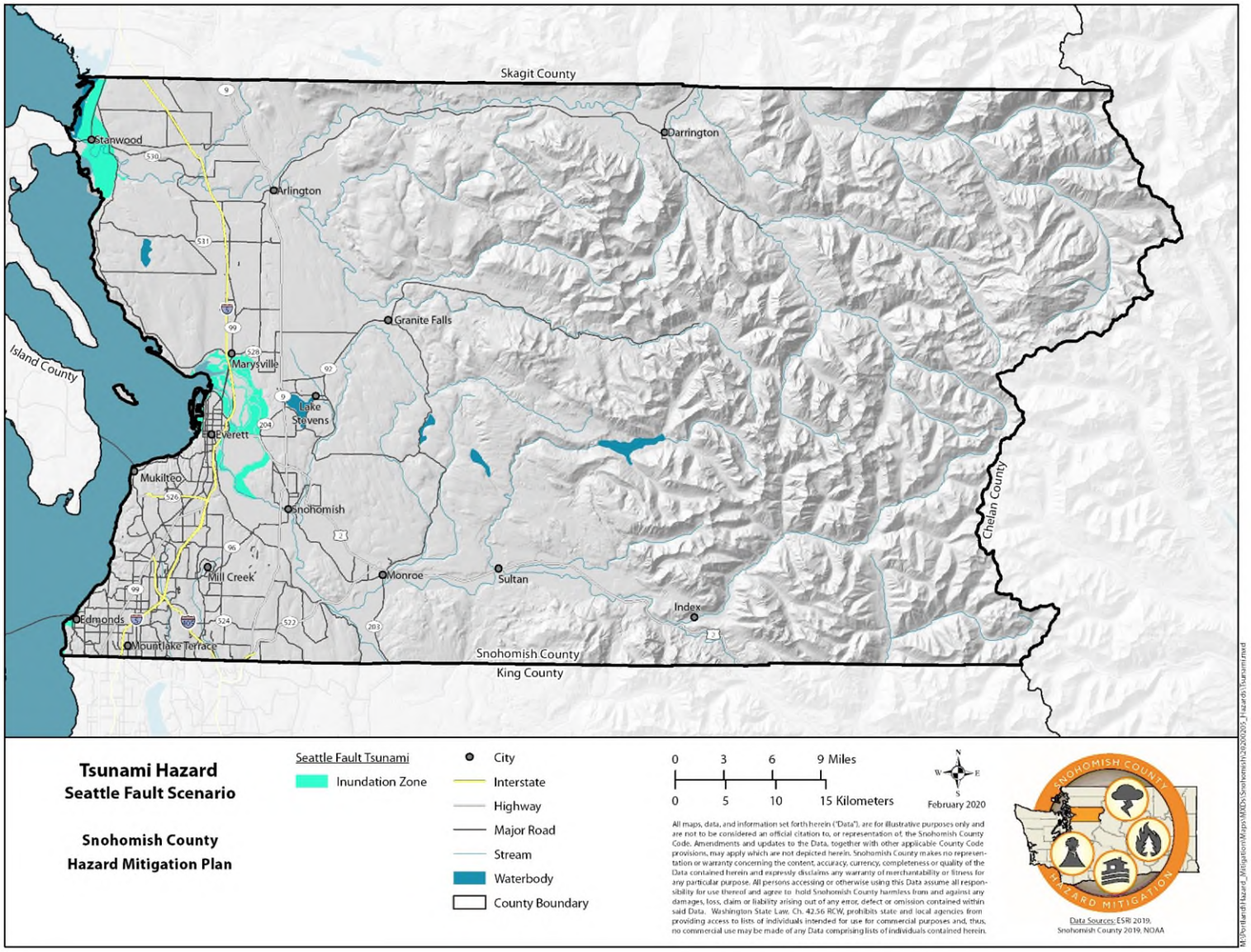
The County and its planning partners are equipped to handle future growth within tsunami inundation areas. Inundation maps offer jurisdictions a way to guide development away from tsunami-prone areas. With the coordination of plans, municipalities and the County will be better able to make prudent land use decisions as future growth impacts tsunami hazard areas.

15.7 Issues

The planning team has identified the following issues related to the tsunami hazard for the planning area:

- Hazard Identification—To truly measure and evaluate the probable impacts of tsunamis on planning, hazard mapping based on probabilistic scenarios must continue to be updated regularly. The science and technology in this field are emerging. Accurate probabilistic tsunami mapping will need to be a key component for tsunami hazard mitigation programs to be effective.
- Enhancement of Current Capabilities—As tsunami warning technologies evolve, the tsunami warning capability within the planning area will need to be enhanced to provide the highest degree of warning.
- Vulnerable Populations Planning—Special attention will need to be focused on the vulnerable communities in the tsunami zone and on hazard mitigation through public education, outreach, and warning capabilities. This issue may be especially important for visitors to Snohomish County.

15.8 Hazard Map



Map 15-1 Snohomish County Tsunami Hazard Areas

16 Volcanic Hazards

16.1 General Background

A volcano is a vent in the earth's crust through which magma, rock fragments, gases, or ash are ejected from earth's interior. Volcanoes may lie dormant for centuries between eruptions; therefore, the risk posed by volcanic activity is not always apparent. 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 different types of eruptive events include pyroclastic explosions, hot ash releases, lava flows, and gas emissions. Secondary hazards include flooding and lahars (i.e., mudflows), due to the melting of ice/snow and rainfall, and wildfires due to pyroclastic flows. Vulnerability factors to volcanic hazards include topographic factors (e.g., river channels), proximity of a population, non-load bearing roof structures for ash accumulations, and the lack of warning systems or evacuation plans.

16.1.1 Potential Damage from Volcanoes

Volcanoes can generate destructive lahars, ash fall, lava and pyroclastic flows, and debris avalanches. Acid rain, gases, fumes, and ash can negatively impact human and animal health. Ash can contaminate food and water, damage infrastructures and water systems, cause building collapses under accumulated weight, and interfere with communication systems and transportation (WHO, n.d.). The impacts on transportation (e.g., air travel) can cause high economic losses.

16.2 Snohomish County Hazard Profile

The 1980 eruption of Mount St. Helens buried 23 square miles of the North Fork Toutle and generated a pyroclastic flow that covered 230 square miles north of the volcano, causing 57 fatalities. Glacier Peak in eastern Snohomish County is a major Cascade stratovolcano thought to have erupted as recently as the eighteenth century. With the exception of Mount St. Helens, Glacier Peak has produced larger and more explosive eruptions than any other Washington volcano. The eruption of Glacier Peak 13,600 years ago was at least three times more voluminous than the eruption of Mount St. Helens in 1980. Since the end of the last glacial episode approximately 14,000 years ago, Glacier Peak has erupted at least a dozen times.

DEFINITIONS

Lahar—A rapidly flowing mixture of water and rock debris that originates from a volcano. While lahars are most commonly associated with eruptions, heavy rains, and debris accumulation, earthquakes may also trigger them.

Lava Flow—Slow-moving stream of molten rock. Generally the least hazardous threat posed by Cascade volcanoes.

Lava Dome—A pile of viscous lava that forms a steep-sided mound over an erupting vent.

Pyroclastic Flow—A ground-hugging current of hot ash and gas that travels outward at high speed away from a volcano.

Stratovolcano—Typically a large, steep-sided, symmetrical cone built of alternating layers of lava flows and tephra layers.

Tephra—Ash and fragmented rock material ejected by a volcanic explosion.

Volcanic ash—Fine-grained rock fragments less than 0.08" (2 mm) diameter.

16.2.1 Hazard Ranking

The Steering Committee and Planning Team completed a hazard ranking survey during the Snohomish County 2020 HMP update process for a range of hazard-related factors based on worst case and most likely scenarios; definitions of the hazard ranking factors may be found in Table K-1 in Appendix K. The results of the survey were averaged together for each factor to generate a total average score and rank, enabling the prioritization of hazards by type. When compared against the other hazards included in the 2020 hazard ranking survey, volcanoes were ranked as the sixteenth worst-case scenario and the seventeenth most likely scenario (see Table 16-1).

Table 16-1
Hazard Ranking Output

Severity (1=lowest, 5=highest)	Magnitude (1=lowest, 5=highest)	Frequency (1=lowest, 5=highest)	Onset (1=slowest, 5=fastest)	Duration (1=shortest, 5=longest)	Perceived Change in Risk	Average	Rank
Worst-case Scenario							
3.25	3.75	2.00	3.25	3.44	0.2	3.14	16
Most Likely Scenario							
2.06	2.38	1.25	1.75	2.69	0.2	2.03	17

16.2.2 Past Events

Glacier Peak generated a powerful sequence of explosive eruptions about 13,600 years ago, which generated voluminous pyroclastic flows and tephra as far away as Wyoming. Between 5,000 and 7,000 years ago, the volcano developed domes that eventually collapsed to form numerous pyroclastic flows and fine ash far downwind. Less voluminous dome forming eruptions have occurred at least six times in the past 4,000 years. The last of these, 300 to 500 years ago, produced thin ashfalls but no pyroclastic flows (Washington State Military Department 2012).

USGS scientists have described evidence of large prehistoric lahars from Glacier Peak for most of these eruptive episodes. During the eruptions of 13,600 and 5,000 to 7,000, lahars and post-eruption sedimentation were sufficiently voluminous to fill the Sauk valley at Darrington and allow the river to switch course into the North Fork of the Stillaguamish River. The Mount St. Helens volcanic eruption is the only event to result in a federal disaster declaration for this hazard, as shown in Table K-2 of Appendix K (FEMA 2019c).

16.2.3 Location

Map 16-1 shows the Glacier Peak lahar inundation zone in Snohomish County. Glacier Peak is the only volcano capable of producing a lahar that travels into the county. Only the eastern border of the county is at higher risk of ashfall from a Glacier Peak eruption, due to prevailing winds blowing toward the east. However, it is worth noting that surface-level winds do blow westward about 10 percent of the time; it would be possible for a significant eruption of Glacier Peak to deliver heavy ashfall to Snohomish County under these weather conditions.

Most of the county falls within the ashfall hazard zone of Mount St. Helens, which is over 110 miles to the south. Mount St. Helens has wide-reaching impacts here for two reasons: (1) it has much more frequent explosive activity than any other Cascades volcano, and (2) there is a greater likelihood of winds blowing the ash northward toward Snohomish County. None of the other Cascades stratovolcanoes, such as

Mount Rainier or Mount Baker, pose a statistically significant threat to this region due to their overall lower rates of explosive activity.

16.2.4 Frequency

The Cascades are home to multiple active volcanoes which have erupted on an average rate of one or two times per century over the past 12,000 years. It is anticipated that these active volcanoes will continue to erupt at a similar rate over the next several centuries. The USGS classifies Glacier Peak, Mount Adams, Mount Baker, Mount Hood, Mount St. Helens, and Mount Rainier as potentially active volcanoes that would impact Washington State. Regarding Glacier Peak, the annual probability of lahars inundating the Stillaguamish River valley is thought to be less than 1 in 10,000 (Washington State Military Department 2012).

16.2.5 Severity

A 1-inch deep layer of ash weighs an average of 10 pounds per square foot, increasing the risk of structural collapse due to excessive weight. Ash may also carry a high static charge for up to two days after being ejected from a volcano. When an ash cloud combines with rain, sulfur dioxide in the cloud combines with the rainwater to form diluted sulfuric acid that may cause minor, but painful burns to the skin, eyes, nose, and throat. Ash in the atmosphere can also interfere with communications and transportation.

16.2.6 Warning Time

Constant monitoring of the Cascades volcanoes by the USGS Cascades Volcano Observatory and the PNSN means that scientists are monitoring the background level of activity to identify warning signs of an impending eruption. Typically, stratovolcanoes in the Cascades undergo weeks to months of unrest before eruption. An important consideration for Glacier Peak is its location in a remote and protected wilderness area. There is only a single seismometer on the volcano, despite its ranking among the highest-threat volcanoes in the country (Doughton 2018). By comparison, Mount St. Helens has around 21 seismometers. The USGS is currently in the process of improving the monitoring network for Glacier Peak, but in the present situation, scientists have somewhat reduced ability to detect seismic unrest.

16.3 Cascading Impacts/Secondary Hazards

Ashfall can contaminate food and water, causing health issues. Persons with underlying respiratory problems may face medical difficulties with fine ash in the air. Although unlikely in Snohomish County, weight of ash accumulation may cause problems for buildings. Interference for communication systems, poor visibility, and slippery roads are all issues that may arise from ash. In addition, lahars, landslides, and mudslides may occur, and wildfires may spread from the heat of a pyroclastic flow.

16.4 Potential Impacts from Future Climate Conditions

Future climate conditions are not expected to impact the hazard from volcanic eruptions. However, largescale volcanic eruptions can influence climate patterns for years with the massive outpouring of gases and ash.

16.5 Exposure

Snohomish County is largely exposed to a Glacier Peak eruption that generates a lahar, traveling down the Sauk, Stillaguamish and Skagit Rivers toward the Puget Sound. The county is also exposed to ashfall from Glacier Peak if wind direction is to the west. There is approximately a 10 percent chance that wind would blow ash into the western, more populated parts of the county.

16.5.1 Population

Population counts of those exposed to the volcano hazard were generated by analyzing census blocks that intersect with the lahar hazard zones. Census blocks do not follow the same boundaries as the lahar zones. Therefore, the methodology used to generate these estimates evaluated census block groups whose centers are in the lahar zones or where the majority of the population most likely lives in or near the lahar zone. Using this approach, it was estimated that the exposed population is 7,696 (slightly less than 1 percent of the total county population).

16.5.1.1 Vulnerability

The entire population of Snohomish County is vulnerable to the effects of a volcanic eruption, mainly from volcanic ash. The elderly, youth, and those who experience respiratory problems are especially vulnerable to the airborne ash hazard. Since there is generally adequate warning time before a volcanic event, the population vulnerable to the lahar hazard consists of those who choose not to or are unable to evacuate. In the hazard area, there are 1,188 persons with a disability, 1,097 persons below the poverty line, and 407 persons who are linguistically isolated.

16.5.2 Property

Most of the county would be exposed to ash fall and tephra accumulation in the event of a volcanic eruption. Property located along the lahar inundation areas would be most exposed to lahar flows. Table 16-2 lists the total number of Snohomish County structures located in the lahar zones and their values. Most of these properties are in unincorporated Snohomish County; the rest are in the cities of Arlington, Darrington, and Stanwood.

Table 16-2
Value of Property Exposed to Lahars

Jurisdiction	Buildings Exposed	% of All Buildings	Assessed Value		
			Structure	Contents	Total
Arlington	580	3%	$75,510,246	$45,813,332	$121,323,577
Darrington	1236	100%	$122,246,673	$100,105,972	$222,352,645
Stanwood	646	22%	$116,153,735	$94,310,863	$210,464,598
Unincorporated	5170	2%	$387,919,674	$259,778,302	$647,697,976
Grand Total	7632	3%	$701,830,328	$500,008,469	$1,201,838,797

16.5.2.1 Vulnerability

There are currently no generally accepted damage functions for volcanic hazards in risk assessment platforms such as HAZUS-MH. The planning team was not able to generate damage estimates for this hazard. All properties listed in Table 16-2 are vulnerable to the lahar hazard in Snohomish County. These lahar inundation areas are the outflow areas of past volcanic eruptions and are potential outflow areas for future volcanic eruptions. The most vulnerable structures would be those that are located closest to the lahar outflow areas, and those that are not structurally sound.

Also vulnerable are other properties that are located throughout the county that are subject to ash fall. Among these properties, the most vulnerable structures are those that are not as structurally sound and may collapse under the excessive weight of tephra and possible rainfall.

16.5.3 Critical Facilities

As shown in Table 16-3, there are 100 critical facilities exposed to lahar inundation. These include bridges that cross the Stillaguamish, Sauk, and Skagit Rivers in the lahar zone, as well as the section of the BNSF Railway where it crosses the Stillaguamish River and outflows from the Skagit River. All transportation routes are exposed to ash fall and tephra accumulation, which could create hazardous driving conditions on roads and highways, challenging evacuations and response.

Table 16-3
Critical Facilities Within Snohomish County's Lahar Zone

Airport	1
Bridge	66
Communication	1
Dam	2
Fire/EMS	6
Hazmat	1
Government	5
Medical	1
Other	2
Police	2
Power Facility	1
School	8
Wastewater Facility	3
Water Facility	1
Total	100

16.5.3.1 Vulnerability

Transportation routes that intersect with the lahar inundation zone are most vulnerable, especially depending on their structural stability (e.g., roads, bridges, and the BNSF Railway). The most vulnerable spots are those that directly intersect with a lahar outflow area and are not structurally sound. Those in the direction of wind would also be vulnerable to tephra and ash fall accumulations.

Utilities are vulnerable to damage from lahars due to transported debris and ash produced during an eruption. Water treatment plants and wastewater treatment plants are vulnerable to contamination from ash fall and debris that may be carried by a lahar. Most vulnerable are those that are located on or near parcels that intersect with the lahar outflow area or those that receive input from area streams and rivers that lahar flow through.

16.5.4 Environment

The environment is highly exposed to the effects of a volcanic eruption. Even if the related ash fall from a volcanic eruption were to fall elsewhere, it could still be spread throughout the county by the surrounding rivers and streams. An explosive, ash-producing eruption would expose the local environment to many effects such as lower air quality, and many other elements that could harm local vegetation, forests, and water quality.

16.5.4.1 Vulnerability

The environment is highly vulnerable to the effects of a volcanic eruption. Snohomish County rivers and streams are vulnerable to damage due to ash fall, especially since ash fall can be carried throughout the county by means of the Stillaguamish, Skagit, and Sauk Rivers. The sulfuric acid contained in volcanic ash could be very damaging to area vegetation, waters, wildlife, and air quality. A lahar would be very damaging to area rivers and streams and could redirect water flow and cause changes in water courses. River channel sedimentation increase could lessen the capacity of channels, resulting in an increased probability of flooding.

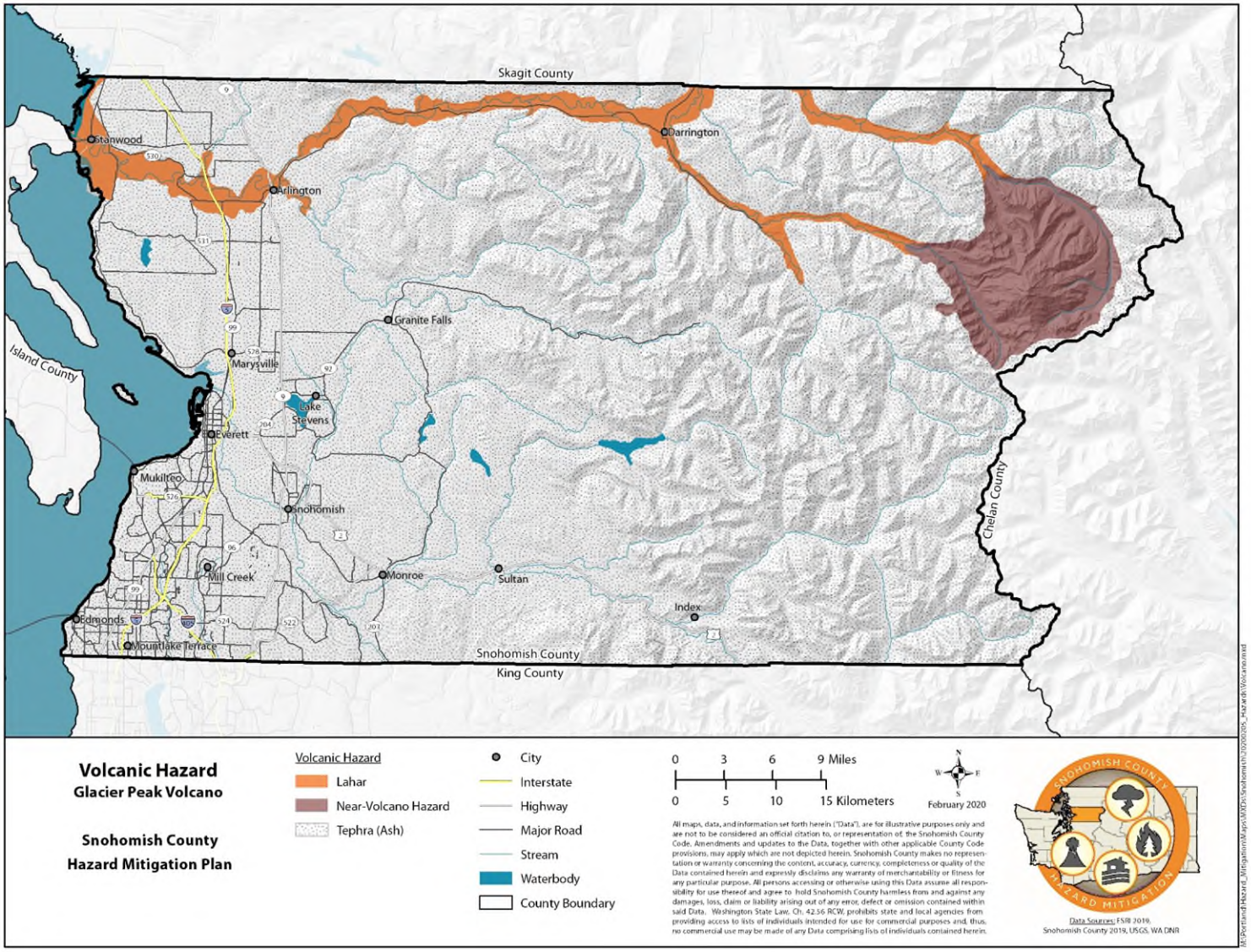
16.6 Development Trends

Lahar hazard zones are not identified as critical areas under the GMA. However, most of the lahar zones overlap the 100- and 500-year floodplains in Snohomish County, which are identified critical areas under the GMA. Therefore, a mechanism is in place within the planning area to look at potential impacts from lahars on future development.

16.7 Issues

Volcanic activity at Glacier Peak has been relatively low in historic times, so the chance of an eruption in the next few decades is also low. However, in the event of volcanic unrest at Glacier Peak, there would be major concern about loss of life and property and life-threatening hazards in the wilderness and Pacific Crest Trail areas. Multiple issues can arise with lasting environmental and economic impacts.

16.8 Hazard Maps



Map 16-1 Snohomish County Volcanic Hazard Areas

17 Weather Events

17.1 General Background

Severe weather can be defined as dangerous meteorological or hydro-meteorological phenomena, of varying duration, with risk of causing major damage, serious social disruption and loss of human life, and requiring measures for minimizing loss, mitigation, and avoidance (World Meteorological Organization 2004). Severe weather can include tornados, severe thunderstorms, flash floods, damaging winds, large hail, and winter storms (DHS, n.d. [b]).

Severe weather can be classified into two categories. Systems that form over wide geographic areas are classified as general severe weather, and those with a more limited geographic area are classified as localized severe weather.[1] Severe weather events are not the same as extreme weather; extreme weather refers to phenomena that are at the extremes of the historical distribution and are rare for a particular place and/or time (Institute of Medicine [US] Forum on Microbial Threats 2008).

17.1.1 Potential Damage from Weather Events

Damage from severe and extreme weather events varies. Examples can include destruction of structures and infrastructure, multiple injuries and deaths, hazardous material releases or oil discharges, and utility failure. Severe weather can also lead to mass earth movements. Damage from storms themselves and cascading impacts/secondary hazards can cost millions of dollars.

17.2 Snohomish County Hazard Profile

Western Washington has a predominantly marine climate. 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 190 days in the mountains and along the coast. Thunderstorms occur approximately 10 days each year over the lower elevations and around 15 days over the mountains. Damaging hailstorms are rare (University of Washington 2015b).

DEFINITIONS

Severe Local Storm—Small atmospheric systems including tornadoes, thunderstorms, and windstorms. 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 of varying sizes that generate winds more than 300 miles per hour, affecting an area up to ¾ of a mile wide. They are measured using the Enhanced Fujita Scale ranging from EF0 to EF5.

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.

During the summer months of July and August, weeks can pass with few showers. December and January bring precipitation, frequently recorded on 25 days or more each month. Snowfall is light in the lower elevations and heavier 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. The strongest winds are generally from the south or southwest and occur during fall and winter.

17.2.1 Hazard Ranking

The Steering Committee and Planning Team completed a hazard ranking survey during the Snohomish County 2020 HMP update process for a range of hazard-related factors based on worst case and most likely scenarios; definitions of the hazard ranking factors may be found in Table K-1 in Appendix K. The results of the survey were averaged together for each factor to generate a total average score and rank, enabling the prioritization of hazards by type. When compared against the other hazards included in the 2020 hazard ranking survey, severe weather events were ranked as the tenth worst-case scenario and the seventh most likely scenario (see Table 17-1).

Table 17-1
Hazard Ranking Output

Severity (1=lowest, 5=highest)	Magnitude (1=lowest, 5=highest)	Frequency (1=lowest, 5=highest)	Onset (1=slowest, 5=fastest)	Duration (1=shortest, 5=longest)	Perceived Change in Risk	Average	Rank
Worst-case Scenario							
3.38	4.50	3.56	3.88	3.00	0.8	3.66	10
Most Likely Scenario							
1.63	2.81	2.94	2.94	2.06	0.8	2.48	7

17.2.2 Past Events

NOAA has recorded a total of 112 weather events in Snohomish County, which have resulted in approximately $40.65 million in property damage and six deaths. Table K-3 in Appendix K summarizes these events since 1950 while Table K-2 covers the 13 severe weather events that resulted in presidentially declared disaster declarations.

17.2.3 Location

Severe weather events have the potential to happen anywhere in Snohomish County. Communities in low-lying areas next to stream, lakes, or shorelines are more susceptible to flooding. Wind events are most damaging to areas that are heavily wooded.[4] Maps 17-1, 17-2, 17-3, and 17-4 show the distribution of average weather conditions over the Snohomish County planning area.

17.2.4 Frequency

Predicting the frequency of severe weather events in a constantly changing climate is a difficult task. Looking at Table K-2 and Table K-3 in Appendix K, it can be assumed that the county can expect to experience exposure to and adverse impacts from some type of severe weather event at least annually.

17.2.5 Severity

The effects on Snohomish County from a strong thunderstorm, tornado, windstorm, or winter storm are likely to be similar: fallen trees, downed power lines and interruption of transportation lifelines, and damaged homes and buildings. Weather-related fatalities are uncommon, but as shown in Table K-3, they

can occur. The most common problems associated with severe storms are immobility and loss of utilities. Roads may become impassable due to flooding, ice or snow, landslides, or trees. 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 injury.

17.2.6 Warning Time

Meteorologists can often predict the likelihood of a severe storm. This can give several days of warning time. However, the exact time of onset or severity are not easily predicted. Some storms may come on more quickly and more severely than initially estimated, only giving a few hours of warning time.

17.3 Cascading Impacts/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 and stormwater from heavy rains can overwhelm both natural and manmade drainage systems, causing overflow and property destruction. Landslides occur when the soil on slopes becomes oversaturated and fails. Fires, both structural and wild, along with power outages, can occur as a result of lightning strikes.

17.4 Potential Impacts from Future Climate Conditions

Future climate conditions present 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. The changing hydrograph could have a significant impact on the intensity, duration, and frequency of storm events.

17.5 Exposure

17.5.1 Population

A lack of data separating severe weather damage from flooding and landslide damage prevented a detailed analysis for exposure and vulnerability. 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 in heavily wooded areas may be more susceptible to wind damage and utility loss, while populations living in low-lying areas are at an increased risk for flooding (University of Washington 2015a).

17.5.1.1 Vulnerability

Vulnerable populations include 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.

17.5.2 Property

According to the Snohomish County Assessor, there are 285,819 buildings within the census tracts that are exposed to weather events. Most of these buildings are residential. It is estimated that 17 percent of the residential structures were built without the influence of a 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. Table 17-2 shows the number of buildings exposed by jurisdiction and the estimated damage, based on 18 percent of the value.

Table 17-2
Buildings Exposed and Damage Estimated Based on 18% of Value

Jurisdiction	Buildings Exposed	Assessed Value	Estimated Damage
		Structure	18% of Value
Arlington	7,883	$2,073,337,070	$373,200,673
Brier	2,524	$474,164,389	$85,349,590
Darrington	1,236	$122,246,673	$22,004,401
Edmonds	1,6462	$3,632,758,360	$653,896,505
Gold Bar	1,217	$98,741,694	$17,773,505
Granite Falls	1,626	$243,041,952	$43,747,551
Index	191	$14,467,946	$2,604,230
Lake Stevens	11,998	$2,022,781,097	$364,100,597
Lynnwood	11,254	$3,251,712,550	$585,308,259
Marysville	23,250	$4,296,531,625	$773,375,693
Mill Creek	5,905	$2,522,478,338	$454,046,101
Monroe	5,974	$1,548,146,246	$278,666,324
Mountlake Terrace	7,145	$1,441,244,745	$259,424,054
Mukilteo	7,791	$2,451,634,815	$441,294,267
Snohomish	4,892	$820,030,156	$147,605,428
Stanwood	2,806	$584,687,961	$105,243,833
Sultan	2,281	$282,178,459	$50,792,123
Unincorporated	170,636	$27,035,053,262	$4,866,309,587
Woodway	748	$270,078,348	$48,614,103
Grand Total	285,819	$53,185,315,687	$9,573,356,824

17.5.2.1 Vulnerability

All of these buildings are considered to be vulnerable to the severe weather hazard, but structures in poor condition or in particularly vulnerable locations may risk the most damage. Those that are located under or near overhead lines or near large trees may be damaged in the event of a collapse. The frequency and degree of damage will depend on specific locations.

17.5.3 Critical Facilities

17.5.3.1 Exposure and Vulnerability

All critical facilities vulnerable to flooding (discussed in Chapter 12) 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.[5] Prolonged obstruction of major routes can disrupt the shipment of goods and other commerce. Large and prolonged storms can have negative economic impacts for an entire region.

17.5.4 Environment

Severe storm events can drastically affect the physical environment, changing natural landscapes. 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 caused by severe weather can cause stream channel migration. Storm surges can erode beachfront bluffs and redistribute sediment loads. Additionally, snowmelt after snowstorms can cause riverine flooding, potentially damaging riparian habitat.

17.6 Development Trends

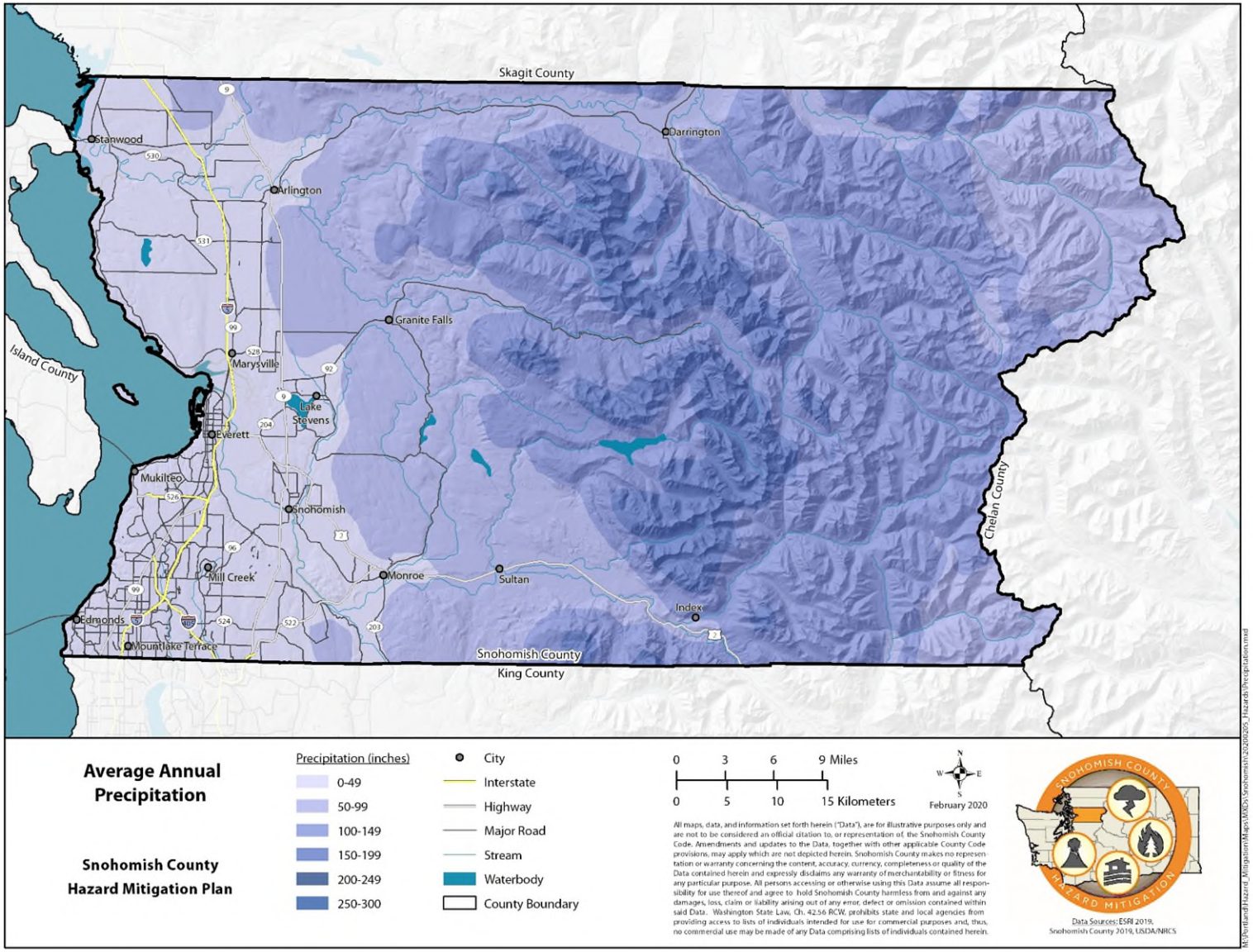
All future development will be affected by severe storms. The ability to withstand impacts lies in sound land use practices and consistent enforcement of codes and regulations for new construction. The County and city planning partners have adopted the International Building Code (IBC) in response to 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 equipped to deal with future growth and the associated impacts of severe weather.

17.7 Issues

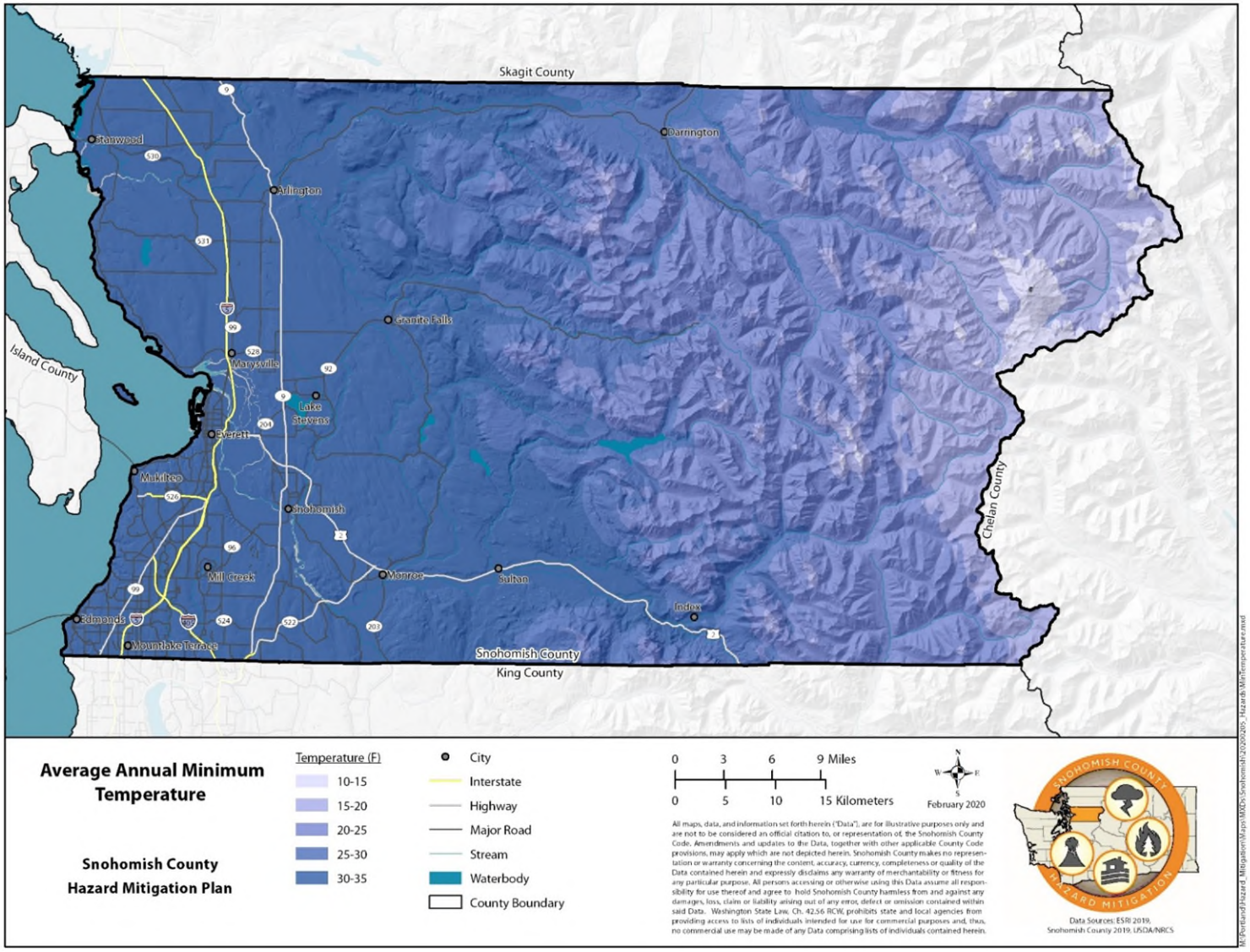
In general, every household and resident in the county is likely to be exposed to severe weather, but some are more likely than others to experience isolation as a result. Those residing in higher elevations with limited transportation routes may have the greatest vulnerability to isolation from storms.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

- 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.
- Capacity for backup power generation is limited.
- 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.

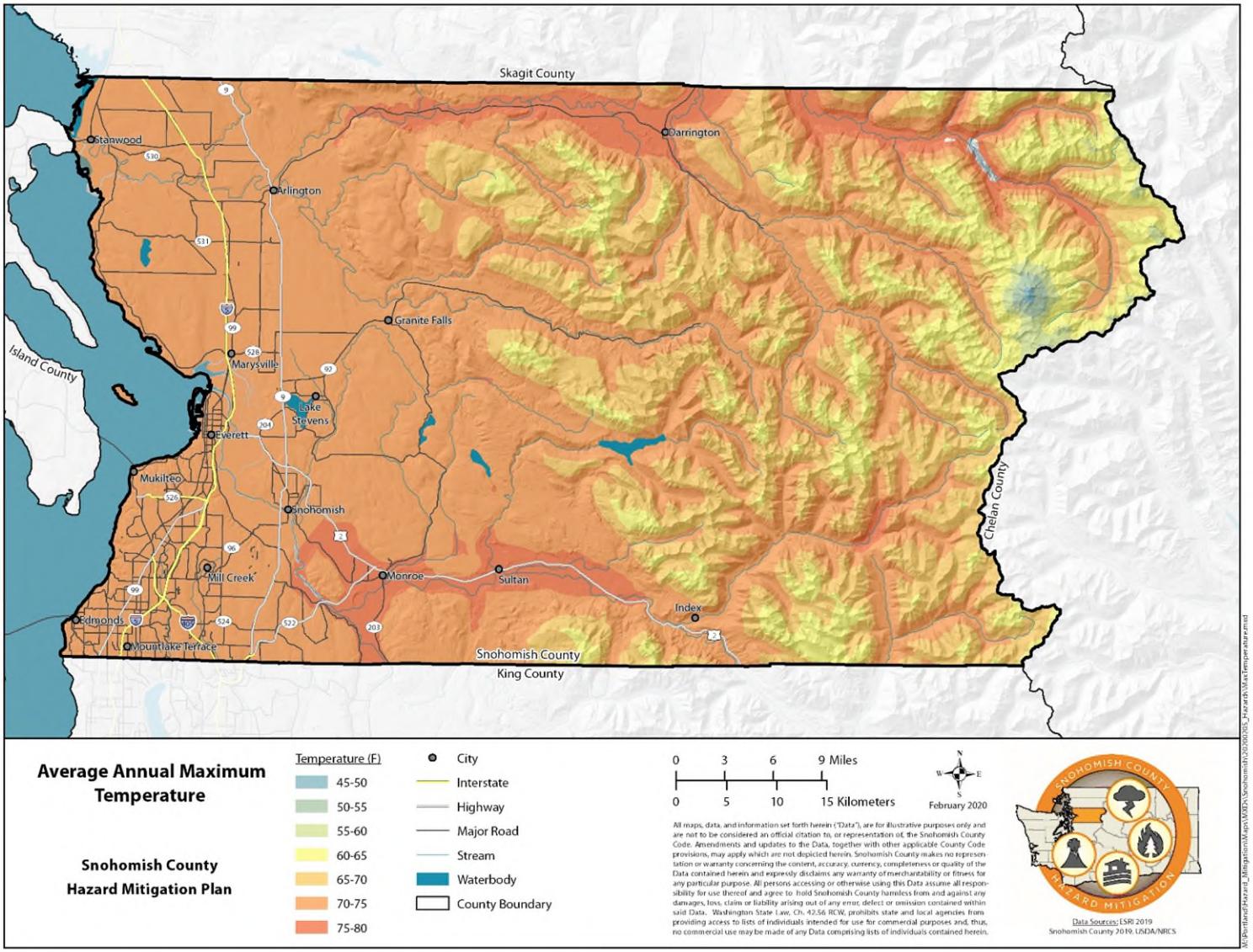
17.8 Hazard Maps



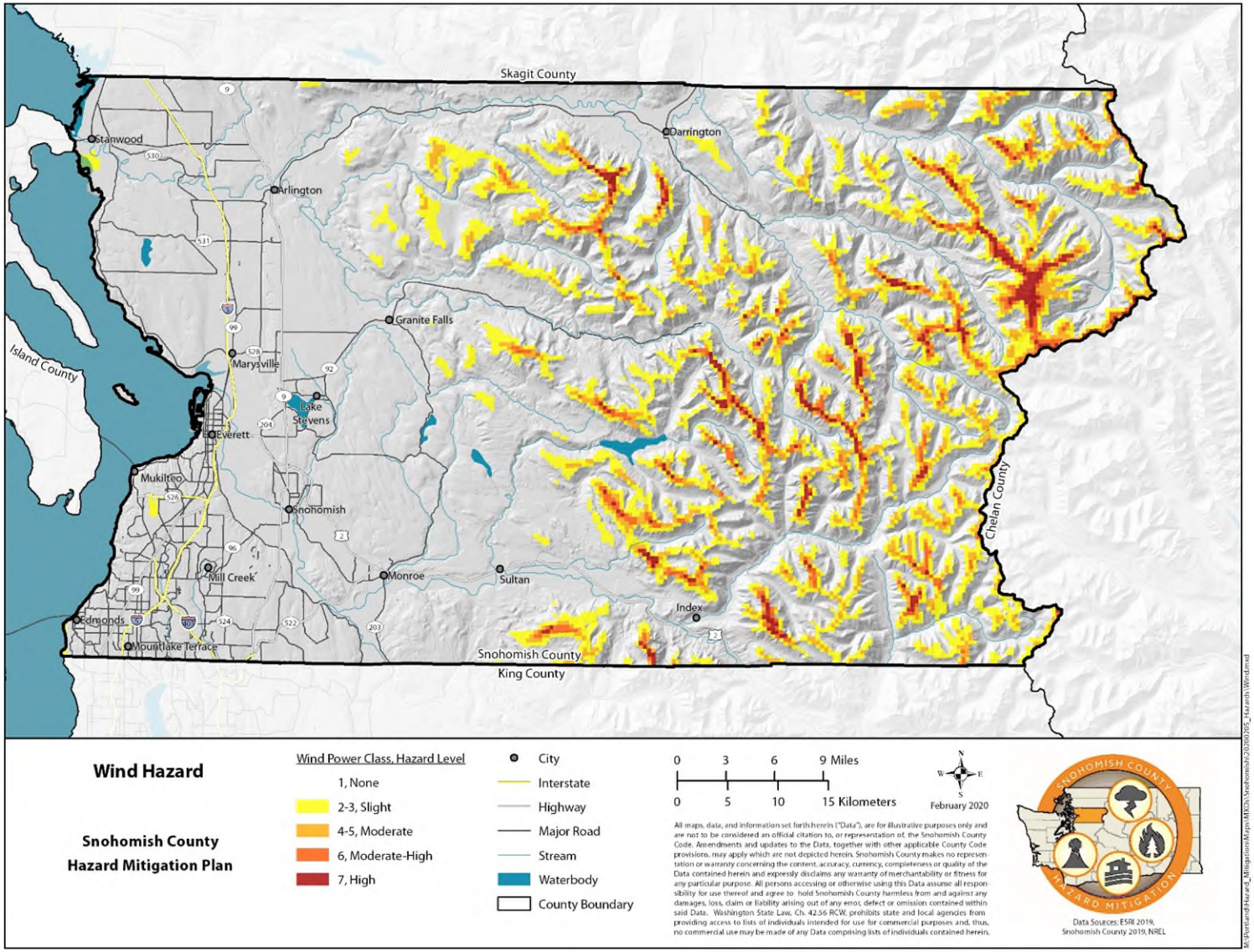
Map 17-1 Snohomish County Average Annual Precipitation



Map 17-2 Snohomish County Average Annual Minimum Temperature



Map 17-3 Snohomish County Average Annual Maximum Temperature



Map 17-4 Snohomish County Wind Hazard

18 Wildfire

18.1 General Background

A reportable wildland fire is any fire involving vegetative fuels, including a prescribed fire, that occurs in the wildland or urban-wildland interface areas, including those fires that threaten or consume structures. Most natural fires are caused by lightning. However, a small percentage of fires are caused by spontaneous combustion or other natural means. The majority of wildland fires are caused by human activity such as smoking, campfires, equipment use, and arson. Wildfires can happen every month of the year; drought, snowpack, and local weather conditions such as high winds can expand the length of the fire season (Snohomish County, n.d.). How a fire behaves depends on the following:

- Fuel – Fuel Load plays a factor along with mixed fuel types (e.g., vegetative underbrush under the canopy). Lighter fuels such as grasses, leaves, and needles quickly expel moisture and burn rapidly, while heavier fuels such as tree branches, logs, and trunks take longer to warm and ignite. Dead, dying, and diseased trees present a higher hazard (University of Washington 2015b).
- Weather – Strong, dry winds and relative humidity plays a large part in determining extreme fire conditions.
- Terrain – The topography of a region influences the amount and moisture of fuel, the impact of weather conditions (such as temperature and wind), potential barriers to fire spread (such as highways and lakes), and elevation and slop of land forms (uphill vs. downhill). South facing slopes, box canyons, and saddles can intensify fire spread.

18.1.1 Potential Damage from Wildfire

Fire hazards present a considerable risk to vegetation and wildlife habitats. Short-term loss caused by a wildfire can include destruction of timber, wildlife habitat, scenic vistas, and watersheds. Long-term effects include smaller timber harvests, reduced

DEFINITIONS

Conflagration—A fire that grows beyond its original source area to engulf adjoining regions. Wind, extremely dry or hazardous weather conditions, excessive fuel buildup, and explosions are usually the elements behind a wildfire conflagration.

Firestorm—A fire that expands to cover a large area, often more than a square mile. A firestorm usually occurs when many individual fires grow together into one. The area involved becomes so hot that all combustible materials ignite, even if they are not exposed to direct flame. Temperatures may exceed 1,000 degrees Celsius. Superheated air and hot gases of combustion rise over the fire zone, drawing surface winds in from all sides, often at velocities approaching 50 miles per hour. Although firestorms seldom spread because of the inward direction of the winds, once started, there is no known way of stopping them.

Interface Area—An area susceptible to wildfires and where wildland vegetation and urban or suburban development occur together. An example would be smaller urban areas and dispersed rural housing in forested areas.

Wildfire—Fires that result in uncontrolled destruction of forests, brush, field crops, grasslands, and real and personal property in non-urban areas. Because of their distance from firefighting resources, they can be difficult to contain and cause a great deal of destruction.

access to affected recreational areas, and destruction of cultural and economic resources and community infrastructure. Vulnerability to flooding increases through destruction of watersheds. The potential for significant damage to life and property exists in areas designated as wildland-urban interface (WUI) areas, where development is adjacent or among lands prone to wildland fire.

18.2 Snohomish County Hazard Profile

The wildland fire season in Snohomish County usually begins in May and ends in the fall with the rain, typically in September or October. However, fires have occurred in every month of the year in the county, influenced by drought, limited snowpack, and local weather conditions. Each year, human-caused fires damage on average more than 4,000 acres of state-protected lands in Washington.

Wildland fires historically were not considered a hazard, as fire is a normal part of most forest and range ecosystems in the temperate regions of the world. In Snohomish County, warm winds from the east create threatening conditions. These winds, sometimes referred to as synoptic winds, reduce humidity, dry out fuel, and can be sustained and move with great speed. These type of winds are associated with some of the Pacific Northwest's most catastrophic wildfires.

18.2.1 Hazard Ranking

The Steering Committee and Planning Team completed a hazard ranking survey during the Snohomish County 2020 HMP update process for a range of hazard-related factors based on worst case and most likely scenarios; definitions of the hazard ranking factors may be found in Table K-1 in Appendix K. The results of the survey were averaged together for each factor to generate a total average score and rank, enabling the prioritization of hazards by type. When compared against the other hazards included in the 2020 hazard ranking survey, wildfires were ranked as the seventh worst-case scenario and the fourteenth most likely scenario (see Table 18-1).

Table 18-1
Hazard Ranking Output

Severity (1=lowest, 5=highest)	Magnitude (1=lowest, 5=highest)	Frequency (1=lowest, 5=highest)	Onset (1=slowest, 5=fastest)	Duration (1=shortest, 5=longest)	Perceived Change in Risk	Average	Rank
Worst-case Scenario							
3.81	3.88	3.06	4.25	4.00	0.7	3.80	7
Most Likely Scenario							
1.56	1.88	2.00	2.81	2.94	0.7	2.24	14

18.2.2 Past Events

The county has seen only six wildland fires of more than 100 acres during the last 49 years (DNR 2019). The greatest potential danger zones are the WUI areas. There is no record of any large wildland fire (greater than 1,500 acres) in the county since 1900. The Washington Department of Natural Resources (DNR) has records of 977 wildland fire starts dating back to 1970.

There is one wildfire event in the NOAA Storm Events Database. A wildfire started in the Central Cascades and burned 848 acres across Snohomish and King Counties from September 4-15, 2017. It cost $4.5 million to suppress the fire (NOAA 2019b). There are no FEMA disaster declarations relating to wildfires.

18.2.3 Location

Map 18-2 shows WUI areas for Snohomish County as defined by DNR (2019).

WUI areas tend to be in the foothills and valleys east of Puget Sound stretching into the lower reaches of the Cascades, where people are present in semi-urban densities. Wildland fire analysis has been done using WUI area data created by DNR, which analyzed areas with population densities of at least 20 people per square mile, defensible space, access and ingress, water capabilities, fuel supply, weather and topography, and speed of response (University of Washington 2015b).

18.2.4 Frequency

Based on risk factors for the county and past occurrences, it is likely that wildland fires will continue. Changes in snowpack levels, precipitation patterns, and winds may contribute to more frequent and/or more severe fires. Wildland fires will continue to happen naturally and by human activities. Based on previous fire records, the average number of wildland fires is just under 20 per year.

18.2.5 Severity

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 the county. Given the potential for immediate response to reported fires, the likelihood of injuries and casualties can be minimal in these situations. However, there are isolated areas with limited ingress and egress options, increasing the potential for loss of life. Smoke and air pollution from fires can be a health hazard, especially for sensitive populations including children, the elderly, and those with respiratory and cardiovascular diseases. Wildland fire may also threaten the health and safety of those fighting the fires. First responders are exposed to the dangers from the initial incident and after-effects from smoke inhalation and heat stroke. In addition, wildland fire can lead to ancillary impacts, such as landslides in steep ravine areas and flooding due to the impacts of silt in the local watersheds.

18.2.6 Warning Time

Because wildland fires are typically caused by humans, there is no way to predict when one might break out. Dry lightning may also trigger wildland fires. Severe weather can be predicted, so special attention can be paid during weather events that may trigger wildland fires. If a fire does break out and spreads rapidly, residents may need to evacuate within hours or days. 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 rapid in most cases. The spread of cellular and two-way radio communications in recent years has further contributed to a significant improvement in warning time.

The National Weather Service (NWS) can issue a fire weather watch, when the potential for severe fire weather exists in the near future or is expected to develop. In addition, the NWS can issue a forecast warning called a red flag warning. This warning indicates that conditions are currently ideal for wildland fire combustion and rapid spread – warm temperatures, low humidity, and stronger winds. Firefighters and other emergency officials track these forecasts and watches to prepare for potential wildfires.

18.3 Cascading Impacts/Secondary Hazards

Wildland fires can cause cascading impacts that may be more widespread and have prolonged damage than the fire itself. Fires can cause direct economic losses in the reduction of harvestable timber and

indirect economic losses such as reduced tourism. Wildland fires cause the contamination of reservoirs (and sometimes drinking water), destroy transmission lines, and contribute to flooding. Fires strip slopes of vegetation, exposing them to greater amounts of runoff. This in turn can weaken soils and cause failures on slopes. Major landslides can occur several years after a fire. Most wildland fires burn hot and for long durations that can bake soils, especially those high in clay content, thus increasing the imperviousness to the ground. This increases the runoff generated by storm events, thus increasing the chance of flooding.

18.4 Potential Impacts from Future Climate Conditions

Fire in western ecosystems is determined by climate variability, local topography, and human intervention. Future climate conditions have the potential to affect multiple elements of the wildland fire system: fire behavior, ignitions, fire management, and vegetation fuels. Changes in winds (increased) may spread fires, threatening WUI areas. Additionally, future droughts may promote more or faster spreading wildland fires.

18.5 Exposure

18.5.1 Population

An estimated 8,740 people are living in WUI areas.

Population could not be examined by WUI areas because census block group areas do not coincide with the fire risk areas. However, population was estimated using the structure count of buildings in WUI areas and applying the census value of 2.49 persons per household for Snohomish County. Using this approach, it is estimated that the population living with WUI areas is 16,406.

18.5.1.1 Vulnerability

Vulnerable populations are assumed to be the same as described above. Smoke and air pollution from surrounding wildfires can be a health hazard to residents, especially for sensitive populations such as children, the elderly, and persons with respiratory and cardiovascular disease. Public health impacts associated with wildfires include difficulty breathing and reduction in visibility.

18.5.2 Property

18.5.2.1 Exposure and Vulnerability

Property damage from wildland fires can be severe and can significantly alter entire communities. The unincorporated county and the Cities of Arlington, Darrington, Edmonds, Granite Falls, Index, Lake Stevens, Monroe, Mukilteo, Stanwood, and Sultan all have assets exposed to wildland fire hazards. The total value of these assets is $1.2 billion, which represents 1.1 percent of the total assessed value of improvements in the county.

Table 18-2 displays the number of buildings exposed to the various wildfire hazard zones and their values within the planning area.

Table 18-2 Value of Property Exposed to At Least Moderate Wildland Fire Hazards				
Jurisdiction	Buildings Exposed	Assessed Value		
		Structure	Contents	Total
Arlington	4	$476,477	$238,239	$714,716
Darrington	4	$467,410	$467,410	$934,820
Edmonds	24	$8,720,620	$4,360,310	$13,080,930
Granite Falls	4	$567,510	$303,775	$871,285
Index	5	$321,400	$160,700	$482,100
Lake Stevens	27	$6,731,290	$3,365,645	$10,096,935
Marysville	20	$3,552,550	$1,776,275	$5,328,825
Monroe	6	$1,312,990	$656,495	$1,969,485
Mukilteo	50	$11,848,139	$7,022,319	$18,870,459
Stanwood	3	$352,299	$176,150	$528,449
Sultan	5	$794,478	$397,239	$1,191,716
Unincorporated	6437	$790,302,677	$412,856,198	$1,203,158,875
Grand Total	6589	$825,447,841	$431,780,754	$1,257,228,596

18.5.3 Critical Facilities

There are 51 critical facilities that are exposed to the wildland fire hazard in the County. Table 18-3 identifies facilities by category.

There are 27 registered Tier II hazardous material containment sites in WUI areas. During a wildland fire, these materials may release due to excessive heat and may add fuel to the fire. Releases may also harm the environment, saturating soils or seeping into waters leading to the Puget Sound.

Table 18-3 Critical Facilities Exposed to Wildland Fire Hazards (Moderate to Extreme)	
Bridge	39
Communication	1
Dam	1
Fire/EMS	3
Government	2
Natural Gas Facility	1
Police	1
School	3
Total	51

18.5.3.1 Vulnerability

There would likely be little damage to the majority of infrastructure. Most roads and railroads would be without damage in normal scenarios. Power lines are vulnerable due to the poles being made from wood. Bridges are usually not directly impacted; however, wildland fires can create conditions in which bridges are obstructed.

18.5.4 Environment

Wildland fires can cause severe environmental impacts:

- Damaged Fisheries – Critical trout, salmon, and steelhead fisheries in the Pacific Northwest can suffer from increased water temperatures, sedimentation, and changes in water quality.
- Soil Erosion – The protective covering provided by foliage and dead organic matter is removed, leaving the soil fully exposed to wind and water erosion. Accelerated soil erosion occurs, causing landslides and threatening aquatic habitats.
- Spread of Invasive Plant Species – Non-native woody plant species frequently invade burned areas.
- When weeds become established, they can dominate the plant cover over broad landscapes, and become difficult and costly to control.
- Disease and Insect Infestations—Unless diseased or insect-infested trees are swiftly removed, infestations and disease can spread to healthy forests and private lands. Timely active management actions are needed to remove diseased or infested trees.
- Destroyed Endangered Species Habitat – Catastrophic fires can have devastating consequences for endangered species.
- Soil Sterilization – Topsoil exposed to extreme heat can become water repellant, and soil nutrients may be lost. It can take decades or even centuries for ecosystems to recover from a fire. Some fires burn so hot that they can sterilize the soil.

18.6 Development Trends

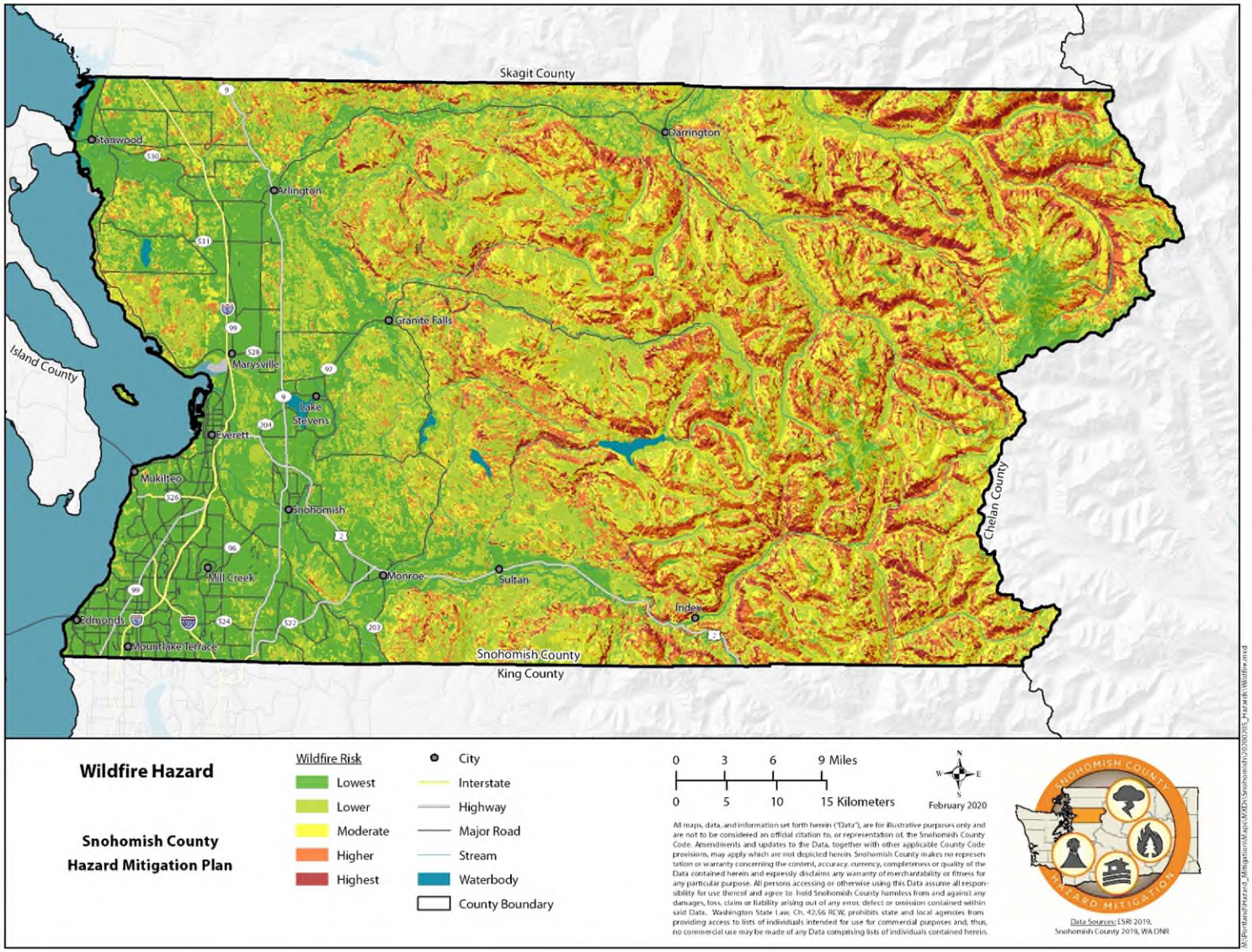
Per the state GMA, the county concentrates new development in urban areas, with limited development in rural areas—minimizing development that could increase incident risk from wildland fires. The development occurring in WUI areas can be managed with robust land use and building codes and effective enforcement of these codes.

18.7 Issues

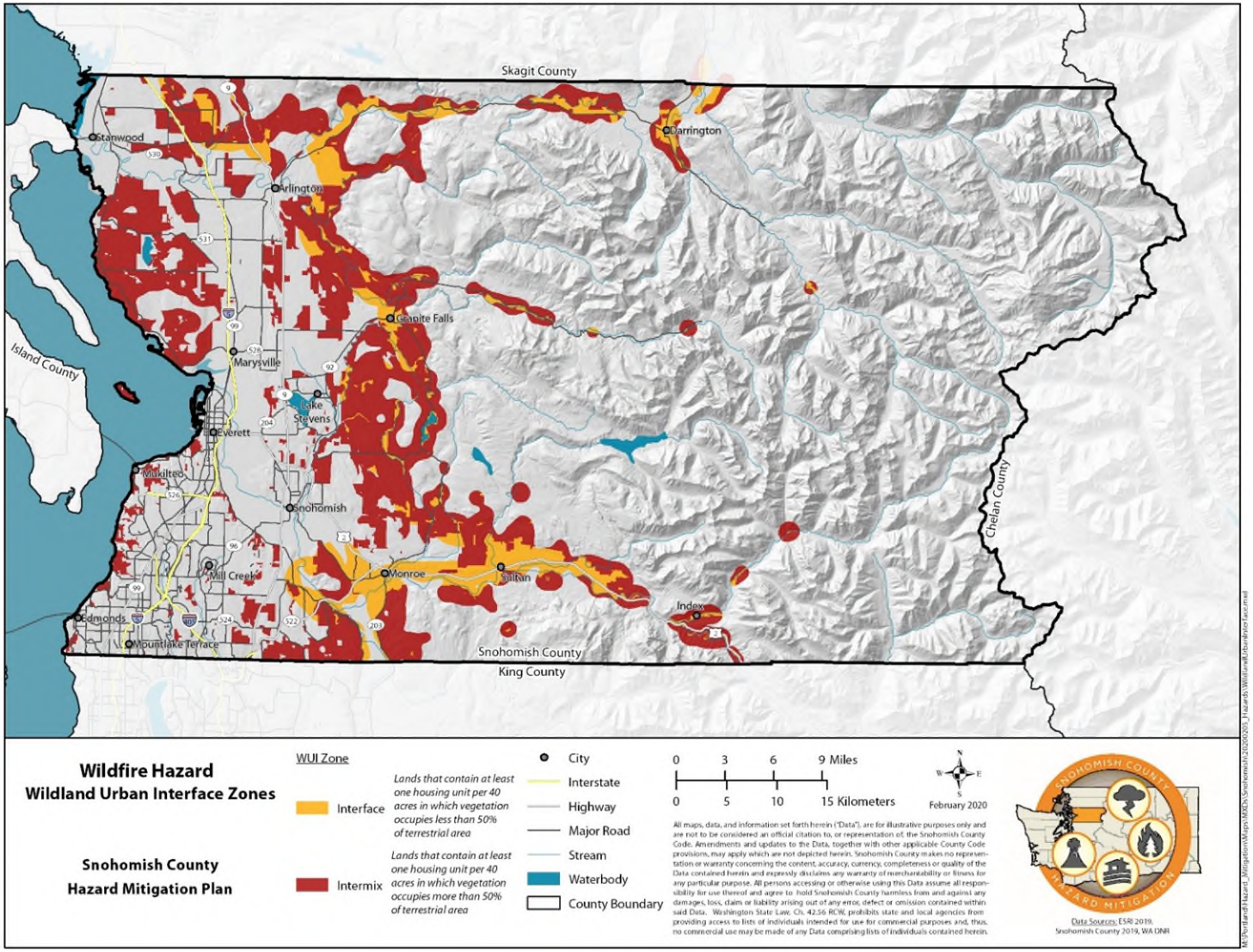
The major issues of for wildland fire are the following:

- Critical facilities and other structures that are wood-frame structures in wildland urban interface areas with combustible roofing materials.
- The perception of wildland fires as a high-risk hazard because a major event has not occurred within the planning area.
- Climate change could impact the risk exposure to this hazard in the future.
- There are a lack of fire hydrants and other water sources in county WUI areas, as well as a lack of air resources.
- A general lack of knowledge of safe fire practices within communities.
- There is a current lack of cohesive countywide fire response and fire districts that do not actively fight wildland fires, relying on mutual aid.

18.8 Hazard Maps



Map 18-1 Snohomish County Wildfire Hazard Map



Map 18-2 Snohomish County Wildland Urban Interface Zones

Snohomish County 2020 Hazard Mitigation Plan

Part 3: Mitigation Strategy

PART 3
Mitigation Strategy

19 Goals and Objectives

44 Code of Federal Regulations (CFR) Section 201.6(c)(3)(i) states that hazard mitigation plans (HMPs) shall describe mitigation goals to reduce or avoid long-term vulnerabilities to identified hazards. The Steering Committee reviewed and established a set of four goals and 16 measurable objectives for this plan based on data from the preliminary risk assessment and the results of public outreach. The goals and objectives informed plan development, mitigation-strategy identification, and prioritization, and are mutually reinforcing.

19.1 Goals and Objectives

The following tables list the goals and objectives that have been adopted by the Steering Committee. Achievement of these goals defines the effectiveness of a mitigation strategy. The goals are used to help establish mitigation strategy priorities for each jurisdiction. Each goal has a discrete set of objectives. Additionally, each objective will help measure the effectiveness of the mitigation initiatives and plan.

Goal 1 **Reduce Hazard and Threat-related Injury and Loss of Life**	
Item	Objectives
1.1	Develop and implement policies that integrate hazard and risk information into building codes and land use planning that promote resilient and safe development in high-risk areas.
1.2	Strengthen tools to remove threatened uses in hazardous areas and relocate them where risk reduction measures support development to a tolerable level.
1.3	Reduce the adverse impacts from and leverage the beneficial functions of natural hazards.
1.4	Develop continuity of operations plans and community-based continuity plans to mitigate the impacts of hazards becoming disasters, and support disaster preparedness, response, and recovery.
1.5	Develop, implement, and sustain programs that promote reliable, redundant, and resilient lifeline systems.

Goal 2 **Promote Resilient Communities, Resilient Economy, Sustainable Growth, and Hazard Prevention**	
Item	Objectives
2.1	Provide incentives that support the mitigation of impacts on critical business operations including small businesses and those located in high risk areas.
2.2	Increase the resilience of critical services, facilities, and infrastructure through applicable retrofits, sustainable funding programs, zoning and development changes, and reduce exposure/vulnerability to all hazards.

Goal 2 Promote Resilient Communities, Resilient Economy, Sustainable Growth, and Hazard Prevention	
Item	Objectives
2.3	Promote the ability of communities to mitigate, prepare for, respond to, and recover from an emergency or disaster through the strengthening of community networks and development of community-based emergency planning (e.g., evacuation zones and routes, and micro-infrastructure networks).

Goal 3 Consider Equity when Enhancing Public Awareness and Community Members' Ability to Mitigate, Prepare for, Respond to, and Recover from a Disaster	
Item	Objectives
3.1	Reduce the adverse impacts of disasters on vulnerable communities.
3.2	Create and enhance equitable public information programs and access to hazard information that promotes actionable preparedness and mitigation measures.
3.3	Identify and prioritize opportunities to increase capacity and redundancy for critical services, facilities, and infrastructure to vulnerable communities with special emphasis on communities that are at risk of isolation.

Goal 4 Make Decisions Through Regional Collaboration	
Item	Objectives
4.1	Support the alignment and integration of the 2020 Hazard Mitigation Plan goals, objectives, and strategies with other planning processes.
4.2	Develop a coordinated incentive program for eligible entities to adapt to risks through structural and nonstructural measures (e.g., acquisition program for homes or other uses located within high-risk hazard areas).
4.3	Use the best available science when developing new or updating existing plans to prepare for and adapt to climate impacts (e.g., update conservation requirements to minimize impacts of drought).
4.4	Support improved data collection, assessment, analysis, and implementation for all hazards.
4.5	Develop a coordinated flood mitigation strategy that leverages sustainable funding sources for flood control improvements and identifies opportunities for multi-agency collaboration.

20 Mitigation Alternatives

20.1 Mitigation Alternative Development

During the initial plan development, the project team developed a matrix of mitigation strategies based on past mitigation alternatives, Steering Committee-identified mitigation alternatives, and mitigation alternatives identified in the public survey. The strategy matrix represents the comprehensive range of alternatives considered by the planning partnership, in compliance with the requirements specified under 44 CFR Section 201.6(c)(3)(ii). During the plan update process, the Steering Committee reviewed the strategy matrix in conjunction with the findings of public outreach efforts, risk assessment results, and recommendations of the annual progress reports compiled during the initial performance period of the plan. The list of mitigation strategies was enhanced based on this review.

Each planning partner used the mitigation catalogs developed for the Snohomish County 2020 HMP, and/or the mitigation strategy matrix developed for this plan update, and the Federal Emergency Management Agency's (FEMA's) Social, Technical, Administrative, Political, Legal, Economic, and Environmental (STAPLEE) assessment methodology to select hazard mitigation initiatives. The STAPLEE assessment methodology evaluates proposed mitigation actions based on social, technical, administrative, political, legal, economic, and environmental criteria.

20.2 Mitigation Alternatives

Both the mitigation strategies matrix and the mitigation catalogs for the 2020 plan contain initiatives that could manipulate a hazard, reduce exposure to a hazard, reduce vulnerability to a hazard, or increase the ability to respond to or prepare for a hazard. The alternatives are categorized by responsibility for implementation (i.e., who would implement the initiative: individuals, businesses, or government). This list represents the comprehensive range of alternatives available for consideration by the planning partners.

The matrix was not exhaustive or site-specific. Its purpose was to provide each planning partner with a baseline of initiatives that were backed by a planning process, were consistent with the goals and objectives of the planning area and were within the capabilities of the partnership. Each planning partner could add to the matrix of alternatives if an initiative they desired was not included. Generally, alternatives in the catalog not selected by a planning partner were rejected based on one of the following:

- The alternative was beyond the jurisdiction's financial capabilities;
- Their jurisdiction was not vulnerable to the hazard; and
- The alternative had already been implemented.

See Appendix E to view the complete catalogs of mitigation alternatives developed for the 2020 plan update. Planning partners also retained the option to select mitigation strategies from the 2015 Catalogs of Mitigation Alternatives.

21 Plan Adoption

Section 201.6(c)(5) of 44 CFR requires documentation that the plan has been formally adopted by the governing body of the jurisdiction requesting federal approval of the plan. For multi-jurisdictional plans, each jurisdiction requesting approval must document that is has been formally adopted. This plan will be submitted for a pre-adoption review to both WA EMD and FEMA prior to adoption. Once pre-adoption approval has been provided by WA EMD and FEMA, all planning partners will formally adopt the plan update. All 37 partners understand that Disaster Mitigation Act of 2000 compliance and its benefits cannot be achieved until the plan is adopted. Copies of the resolutions adopting this plan for all planning partners are on file with Snohomish County Department of Emergency Management and are in Appendix J of this document.

22 Plan Implementation and Maintenance Strategy

22.1 Overview

44 CFR Section 201.6(c)(4) requires HMPs to outline a plan maintenance process that includes the following:

- The method and schedule of monitoring, evaluating, and updating the mitigation plan within a five-year cycle;
- A process by which local governments incorporate the requirements of the mitigation plan into other planning mechanisms, such as comprehensive or capital improvement plans, when appropriate; and
- A discussion of how the community will continue public participation in the plan maintenance process.

This chapter details the formal process that will ensure that the Snohomish County 2020 HMP will meet these requirements and remain an active and relevant document, and that the planning partnership maintains its eligibility for applicable funding sources. The plan's format allows the partnership to review and update sections when new information becomes available. New data can be easily incorporated as it becomes available, resulting in a plan that will remain current and relevant to the planning partnership.

22.2 Implementation

The effectiveness of the HMP depends on the implementation of the plan and incorporation of the outlined action items into existing partnership plans, policies, and programs. The updated plan includes a range of action items that, if implemented, would reduce losses from hazard events in the Snohomish County planning area. Together, the action items in the plan update provide the framework for activities that the partnership can choose to complete over the next five years. The Steering Committee and Planning Team have established goals and objectives that will be implemented through the development of new plans, existing plans, policies, and programs.

Snohomish County DEM will assume lead responsibility for planning and facilitating implementation and maintenance meetings. DEM will act as the county's point-of-contact for this plan. Although the DEM will have primary responsibility for convening these meetings, plan implementation and evaluation will be a shared responsibility among all planning partners and agencies identified as lead agencies in the mitigation action plans.

22.3 Steering Committee

The Steering Committee is made up of volunteers and paid staff who contributed greatly to the development of the updated plan. The purpose of this committee was to oversee the development of the plan update and make recommendations on key elements, including the maintenance strategy. It was the Steering Committee's position that an oversight committee with representation similar to that of the Steering Committee should have an active role in the maintenance strategy for this plan. Therefore, it is recommended that the Steering Committee remain as a viable body involved in key elements of the plan maintenance strategy.

The Steering Committee should include representatives of the planning partner organizations that submitted an annex, the residents of Snohomish County, and other stakeholders. The Steering Committee will convene to perform annual reviews at a place and time to be determined. The make-up of this committee can be dynamic, which will allow differing views and for participants to have a say in the implementation of the plan. The DEM will strive for true "stakeholder" representation on this committee. Individuals involved in this plan update process will be contacted and given the option to remain involved in the process.

The Steering Committee discussed ways to increase visibility and utilization of the plan and input into the annual progress report (see Section 22.4). The recommended venue for this process is through Snohomish County Tomorrow (SCT), specifically the Planning Advisory Committee (PAC) and Infrastructure Coordinating Committee (ICC). The PAC would provide visibility into the 2023 Comprehensive Plan update. The ICC will encourage coordinated use of the Snohomish County 2020 HMP when identifying and prioritizing infrastructure projects around the county. Using both the PAC and ICC would provide an opportunity for annual updates prior to jurisdiction budgeting, ensuring a chance to discuss inputs into the annual progress reports to encourage ongoing and regular mitigation discussions.

22.4 Annual Progress Report

The minimum task of the Steering Committee will be the evaluation of the progress of the plan. This review will include the following:

- Summary of any hazard events that occurred during the prior year and their impact on the planning area;
- A review of successful mitigation initiatives identified in the plan;
- A brief discussion about why targeted strategies were not completed;
- Re-evaluation of the action plans to determine if the timeline for identified projects needs to be amended (such as changing a long-term project to a short-term project because of funding availability);
- Recommendations for new projects;
- Changes in or potential for new funding options (grant opportunities); and
- Impact of any other planning programs or initiatives within the partnership that involve hazard mitigation.

For continuity, a mitigation strategy evaluation form will be used by each jurisdiction as a yearly progress report and submitted to the Steering Committee. The Mitigation Strategy Evaluation and Mitigation Action Evaluation forms are provided in Appendix F.

All planning partners will be responsible for submitting progress reports. From those progress reports, a formal annual report on the progress of the plan will be developed. This report will be used as follows:

- Posted on the website page dedicated to the Snohomish County 2020 HMP;
- Provided to the local media through a press release;
- Presented in the form of a council/board report to all participating jurisdictional governing bodies; and
- Provided as part of the Community Rating System annual re-certification package.

The CRS program requires a recertification submitted by October 1 of every calendar year for which the community has not received a formal audit. To meet this recertification timeline, the planning team will strive to complete this progress report process between June and September each year.

22.5 Plan Updates

44 CFR requires that local HMPs be reviewed, revised if appropriate, and resubmitted for approval in order to remain eligible for benefits under the Disaster Mitigation Act of 2000 (Section 201.6(d)(3)). The planning partnership intends to update the plan on a five-year cycle from the date of initial plan adoption. This cycle may be accelerated to less than five years based on the following triggers:

- A Presidential Disaster Declaration that impacts the Snohomish County planning area;
- A hazard event that causes loss of life; and
- A comprehensive update of the Snohomish County Comprehensive Plan or participating city's comprehensive plan.

It will not be the intent of this update process to start from scratch and develop a new HMP for the Snohomish County planning area. Based on needs identified by the planning team, this update will, at a minimum, include the elements below:

- The update process will be convened through the Steering Committee;
- The hazard risk assessment will be reviewed and, if necessary, updated using best available information and technologies;
- The action plans will be reviewed and revised to account for any initiatives completed, dropped, or changed and to account for changes in the risk assessment or new partnership policies identified under other planning mechanisms, as appropriate (such as the general plan);
- The draft update will be sent to appropriate agencies and organizations for comment;
- The public will be given an opportunity to comment on the update prior to adoption; and
- The planning partnership governing bodies will adopt their respective portions of the updated plan.

22.6 Continuing Public Involvement

The public will be regularly updated on the status of hazard mitigation actions through the Snohomish County website, and county-operated social media platforms such as Facebook and Twitter. Copies of the HMP annual progress reports will be distributed to stakeholders and the media, where appropriate, and hard copies of the Snohomish County 2020 HMP will be available to the public within the Sno-Isle Library System. The county also maintains an interactive Natural Hazard Viewer (i.e., digital map) to engage the public and help them better understand and manage natural hazard risks.

Additionally, a new public involvement strategy will be initiated based on guidance from the Steering Committee each time the plan is updated. This strategy will be based on the needs and capabilities of Snohomish County at the time of the update. At a minimum, this strategy will include the use of local media outlets within the planning area and social media.

22.7 Incorporation into Other Planning Mechanisms

The information on hazard, risk, vulnerability, and mitigation contained in this plan update is based on the best science and technology currently available. This information can be invaluable in making decisions required through other planning efforts, such as critical areas planning, growth management planning, and capital facilities planning. All partners will use information from this updated plan as the best available science and data on natural hazards impacting Snohomish County. Information in the updated plan can be used as a tool in other programs, such as the following:

- Land use planning;
- Critical areas regulation;
- Growth management;
- Capital improvements;
- Water Resource Inventory Area planning; and
- Basin planning.

As information becomes available from other planning mechanisms that can enhance this plan, it will be incorporated via the update process.