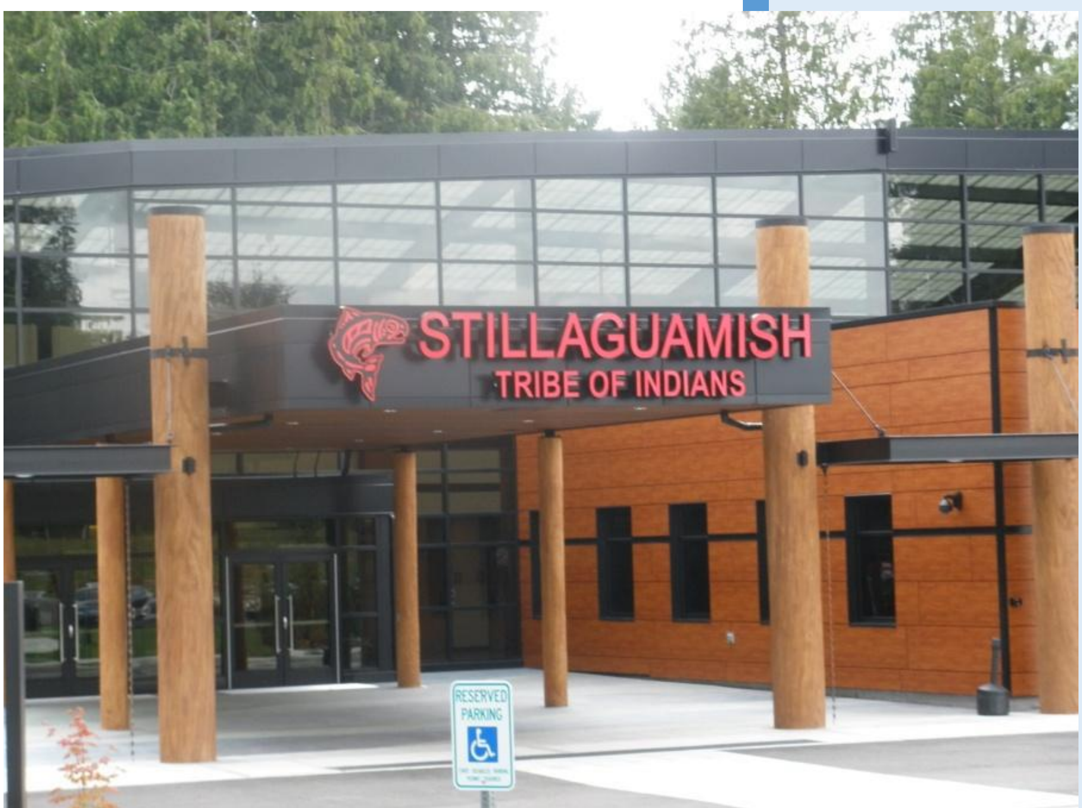
2020

Stillaguamish Tribe of Indians Hazard Mitigation Plan Update



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The Stillaguamish Tribe of Indians
HAZARD MITIGATION PLAN UPDATE

STILLAGUAMISH
TRIBE OF INDIANS

JUNE 2020

Prepared for:
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EXECUTIVE SUMMARY

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The Disaster Mitigation Act (DMA; Public Law 106-390) is the latest federal legislation enacted to encourage and promote proactive, pre-disaster planning as a condition of receiving financial assistance under the Robert T. Stafford Act. The DMA emphasizes planning for disasters before they occur. Under the DMA, a pre-disaster hazard mitigation program and requirements for the national post-disaster hazard mitigation grant program were established.

In recognition of tribal sovereignty and the government-to-government relationship that currently exists between FEMA and Indian Tribal governments, FEMA amended 44 CFR 201 at 72 Fed. Reg. 61720 on October 31, 2007, and provided further amendments on September 16, 2009, amending 74 Fed. Reg. 47471 to consolidate and clarify the requirements for Indian Tribal governments. These amendments established protocol for Tribal Hazard Mitigation Plans to be separate from State and Local Mitigation Plans. It also finalized the Mitigation Planning Guidelines, which became effective March 2010. It is under those guidelines which this Tribal Hazard Mitigation Plan was developed. At the time the previous Hazard Mitigation Plan was developed, Tribal standards were based to a great extent to those requirements of a State-level plan as there was no other guidance in place specific to tribes. To the greatest extent possible, information from the 2015 plan has been incorporated into this document.

For consistency, 44 CFR 201.2 defines *Indian Tribal Government* as any Federally recognized governing body of an Indian or Alaska Native tribe, band, nation, pueblo, village, or community that the Secretary of Interior acknowledges to exist as an Indian Tribe under the Federally Recognized Indian Tribe List Act of 1994, 25 U.S.C. 479a.

The DMA encourages tribes, states, and local authorities to work together on pre-disaster planning, and it promotes sustainability as a strategy for disaster resistance. “Sustainable hazard mitigation” 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 accurate needs for mitigation, resulting in faster allocation of funding and more cost-effective risk reduction projects.

Embracing this initiative as a foundation for proactive planning as well as FEMA’s “whole community approach,” the Stillaguamish Tribe of Indians has developed its first stand-alone Hazard Mitigation Plan (HMP) in an effort to reduce loss of life and property resulting from disasters. While it is impossible to predict exactly when and where disasters will occur, or the extent to which they will impact the Tribe, with careful planning and collaboration among the relevant parties, it is possible to minimize losses that can occur from disasters. This has been and will continue to be the driving force behind this plan development. Utilizing the three primary characteristics of mitigation efforts to retreat, accommodate, or protect,

> “**Whole Community** is an approach to emergency management that reinforces the fact that FEMA is only one part of our nation’s emergency management team; that we must leverage all of the resources of our collective team in preparing for, protecting against, responding to, recovering from and mitigating against all hazards; and that collectively we must meet the needs of the entire community in each of these areas. This larger collective emergency management team includes, not only FEMA and its partners at the federal level, but also local, tribal, state and territorial partners; non-governmental organizations like faith-based and non-profit groups and private sector industry; to individuals, families and communities, who continue to be the nation’s most important assets as first responders during a disaster.”
>
> *–FEMA*
>
> http://www.fema.gov/whole-community

the Stillaguamish Tribe of Indians will develop techniques and practices that will contribute to the environment by developing non-regret actions which create multiple positive outcomes.

For planning purposes, *Hazard Mitigation* is defined as *a way to reduce or alleviate the loss of life, personal injury, and property damage that can result from a disaster through long-term strategies.* It involves strategies such as planning, policy changes, programs, projects, and other activities that can mitigate the impacts of hazards on the Stillaguamish Tribe of Indians. It recognizes that the responsibility for hazard mitigation lies with many, including private property owners; business and industry; and Tribal, local, state, and federal governments.

Many elements went into making this Tribal Mitigation plan a success. The Tribe's Planning Team was instrumental in providing ideas, concepts, historical data and information, discussions, and support needed to develop this plan. Development of the update was completed in coordination with the Planning Team members and the Tribe's consultant, Bridgeview Consulting, LLC.

PLAN DEVELOPMENT METHODOLOGY

Development of the hazard mitigation plan included five phases:

- Phase 1—Organize and review
- Phase 2—Risk assessment
- Phase 3—Engage the public
- Phase 4—Assemble the plan
- Phase 5—Plan adoption

Phase 1—Organize and Review

Under this phase, the Hazard Mitigation Planning Team (hereinafter Planning Team) was assembled to oversee the development of the plan update. The Planning Team consisted of Tribal staff and Tribal members, other stakeholders in the planning area, and a consultant who provided technical support to the Planning Team. Coordination with other tribal, county, state, and federal agencies involved in hazard mitigation occurred from the onset of this plan's development through its completion. A multi-media public involvement strategy which centered on a hazard preparedness questionnaire/survey was developed during Phase 1, as well as identification of public presentations at various events which were scheduled to occur during the plan's development. Also occurring during Phase 1 was a comprehensive review of the Tribe's previous annex to the Snohomish County Hazard Mitigation Plans (2015, 2020), Washington State's Enhanced Hazard Mitigation Plan (2018), and a comprehensive review of existing programs within the planning area that may support or enhance hazard mitigation actions. A key function of the Planning Team was to review and update existing goals as appropriate, and to develop measurable objectives for the 2020 update.

For future planning purposes, the Hazard Mitigation Planning Team adopted December 31, 2018 as the end date for incidents, information, and data incorporated in this plan. Future planning efforts shall commence with incidents and information beginning January 1, 2019 forward.

Phase 2—Risk Assessment

Risk assessment is the process of measuring the potential loss of life, personal injury, economic injury, and property damage resulting from natural hazards. This process assesses the vulnerability of people, buildings, cultural resources, and infrastructure to natural hazards. It focuses on the following parameters:

- Hazard identification and profiling
- Identification of Cultural resources
- The impact of hazards on physical, cultural, social and economic assets
- Vulnerability identification
- Estimates of the cost of damage or costs that can be avoided through mitigation.

The risk assessment for this hazard mitigation plan meets the requirements outlined in Chapter 44 of the Code of Federal Regulations (44 CFR). Phase 2 occurred simultaneously with Phase 1, with the two efforts using information generated by one another to generate valid data, supported by sound analysis.

Phase 3—Engage the Public

Specific to Tribal plans, 44 CFR 201.7 states that Tribal governments may define who they feel constitute "public" within the planning realm, as many Tribal members have difficulty or apprehension about how to honor traditional beliefs and cultural attributes while still fully participating in the mitigation planning process.

Under this phase, a public involvement strategy was developed by the Planning Team that maximized the capabilities of the Tribe, while still maintaining their cultural beliefs and responsibilities to the Elements. The Planning Team provided information necessary for inclusion within the document. One of the first steps taken was the development of a contact list which included individuals whose input was needed to complete this plan to its fullest capacity. Additionally, the strategy also included: Tribal Council Government updates; public meetings to review the draft plan; distribution of the draft plan to planning committee members; utilization of a hazard mitigation survey; use of the Tribe's existing website dedicated to the plan, and media releases throughout various stages in the process. Public engagement also included information from the counties in the geographic area of the Tribe – Snohomish and Skagit Counties. Throughout the course of this project, numerous meetings were held, in addition to briefings provided to various stakeholders involved in this effort. This strategy was deemed by the Hazard Mitigation Planning Team as a key function in the success of this planning effort.

Phase 4—Assemble the Plan

The Planning Team assembled key information from Phases 1 and 2 into a document to meet the DMA requirements. Under 44 CFR 201.7, a Tribal Hazards Mitigation Plan must include the following:

- A description of the Planning process
- Risk assessment
- Mitigation Strategy
  - Goals
  - Review of alternatives
  - Prioritized "action plan"
- Plan Maintenance section
- Documentation of Adoption

Phase 5—Plan Adoption and Maintenance

The Project Manager was tasked with briefing the Tribal Business Council on the plan prior to its adoption after the Tribe received FEMA Approval Pending Adoption notice. A copy of the Adoption Resolution is included in Chapter 16.

This document, as written, includes a plan implementation and maintenance section that details the formal process for ensuring that the plan remains an active and relevant document. The plan maintenance process includes a schedule for monitoring and evaluating the plan's progress annually and producing a plan revision every 5 years. This process seeks to keep a steering body that meets the criteria of the original Hazard Mitigation Planning Team intact to perform this annual review, albeit it will be referred to as a planning team. This phase includes strategies for continued public involvement and incorporation of the recommendations of this plan into other planning mechanisms of the Tribe, such as the comprehensive plan, capital improvement plan, building code, and development design guidelines.

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CHAPTER 1.
GENERAL INFORMATION

1.1 PURPOSE AND AUTHORITY

The federal Disaster Mitigation Act (DMA) emphasizes the importance of planning for disasters before they occur by requiring tribes, states, and local governments to develop hazard mitigation plans as a condition for federal grant assistance. The DMA (Public Law 106-390; approved by Congress October 10, 2000), amended the Stafford Disaster Relief and Emergency Assistance Act by repealing its previous mitigation planning provisions and replacing them with a new set of requirements that emphasize the need to closely coordinate mitigation planning and implementation.

Hazard Mitigation Plan Requirements for Indian Tribal Governments

Requirements for Indian Tribal governments were consolidated and clarified when the U.S. Federal Emergency Management Agency (FEMA) amended Title 44 of the Code of Federal Regulations (44 CFR; Section 201) on October 31, 2007 (72 Fed. Reg. 61720) and again on September 16, 2009 (74 Fed. Reg. 47471). These amendments were made in recognition of the status of tribal sovereignty and the government-to-government relationship between FEMA and Indian Tribal governments. They established a protocol for Tribal hazard mitigation plans to be separate from state and local mitigation plans. Final mitigation planning guidelines became effective March 2010. Tribal hazard mitigation plan requirements differ from local hazard mitigation plan requirements and are more like the requirements for a state-level type plan. This Hazard Mitigation Plan (HMP) for the Stillaguamish Tribe of Indians was developed under those guidelines. The federal statutes define *Indian Tribal Government* as "any Federally recognized governing body of an Indian or Alaska Native tribe, band, nation, pueblo, village, or community that the Secretary of Interior acknowledges to exist as an Indian Tribe under the Federally Recognized Indian Tribe List Act of 1994, 25 U.S.C. 479(a)" (44 CFR 201.2).

1.1.1 The Stillaguamish Tribe of Indians' Response to DMA

Underlying Principles of the DMA

The intent behind hazard mitigation is to reduce or alleviate loss of life, personal injury, property, and environmental damage that can result from a disaster through long- and short-term strategies. It involves 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, industry, and local, state, and federal government. The DMA encourages tribes, states, and local authorities to work together on pre-disaster planning, promoting sustainability for disaster resistance. *Sustainable hazard mitigation* includes the sound management of cultural and 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 tribes and governments articulate accurate needs for mitigation, resulting in faster allocation of funding, and more cost-effective risk reduction projects.

In an effort to support the underlying principles of the DMA, the Stillaguamish Tribe of Indians developed their first Hazard Mitigation Plan as an annex to the Snohomish County Hazard Mitigation Plan. Utilizing that as a starting point, the Tribe has now developed its first stand-alone plan -- the *Stillaguamish Tribe of Indians' 2020 Hazard Mitigation Plan,* which demonstrates the Tribe's continued efforts to ensure the safety of their Tribal members, staff, and visitors to the Tribal Planning Area, while continuing to be a good stewards to the environment by practicing sound and sensible mitigation efforts.

This 2020 plan has been developed in accordance with requirements of the DMA, including criteria addressing the planning process, risk assessment, mitigation strategy, plan maintenance, and the adoption process. To the greatest extent possible, data from the previous plan has been incorporated into this document; however, as planning requirements, guidance and data have changed significantly, there are new additions to this document which were previously not addressed. Likewise, some materials from the previous plan were considered no longer relevant, accurate, or applicable, and were therefore removed. Throughout this document, reflection to the previous plan is made when data was incorporated. The previous plan was utilized as a starting point and was fully reviewed during this update process by all Hazard Mitigation Planning Team Members.

1.1.2 Progress Report of 2015 Hazard Mitigation Plan

Since the 2015 Hazard Mitigation Plan (HMP) was approved, the Stillaguamish Tribe of Indians has completed many initiatives identified throughout this document in an attempt to serve the population and increase economic growth throughout the Tribal Planning Area. Chapter 15 identifies the current status of the strategies contained in the previous plan. Snohomish County's 2015 plan maintenance strategy identified an annual meeting with all planning partners as its method of tracking project completion and identification of hazard impact. Such meetings did not occur. The Tribe, however, does feel that such strategy remains effective, and has developed a similar process for their use as discussed in Plan Maintenance portion of this document.

In addition to implementation of some of the 2015 mitigation strategies, the Tribe has developed a number of different plans and completed several studies, all of which have enhanced the Tribe's ability to support mitigation-friendly infrastructure development. During development of these various planning efforts, data from the previous Hazard Mitigation Plan were integrated to the greatest extent possible, with the HMP data serving as a starting point. A detailed list of the various efforts which support mitigation is contained within the Capability Matrix (Chapter 5).

Integrating mitigation efforts into the daily practices has become commonplace to a large extent. A number of Tribal Departments' daily practices support mitigation, including: the Planning Department, Natural Resources Department, Culture & Heritage Department, and the Tribal Fisheries Program, among others. These departments, as well as others, have continued to incorporate mitigation activities into various day-to-day functions. A few examples of those efforts include: land use development projects emphasizing smart planning by utilizing the risk data to assist in selecting site locations; building materials and standards based on recommended codes, and overall assessment of the communities' usage of new construction to determine if multiple purposes exist, such as a community center which can also be used as a shelter.

During planning stages, project development includes prioritizing mitigation efforts based on impact (positive and negative), such as the project's proximity to 100-year floodplain; landslide risk and assessing the impact of climate change. An excellent example of this relates to climate change. During the planning stages for the Tribe's water system, a major consideration was the year-round flow levels, which have been, and will continue to be, impacted by climate change and potential drought conditions which have persisted throughout the area. The water system was built with limited negative impact to the aquatic habitat.

The updated version of the hazard mitigation action plan is a key element of this plan. For the purpose of this document, mitigation action items are defined as: *activities designed to reduce or eliminate losses resulting from the impacts of natural hazards of concern*. It is through the implementation of the action plan that the Tribe can strive to become disaster-resilient through sustainable hazard mitigation. Although one of the driving influences for preparing this plan was grant funding eligibility, that is not the focus of this plan, but rather, an added benefit. It was important to the Tribe that it examine initiatives that would work through all phases of emergency management and that contribute to, rather than remove from, the environment. It was significant to the Tribal Members that the mitigation efforts include mainstreaming adaptive, 'no-regrets' strategies which improved their abilities to live with the hazards of concern, while not adversely impacting their beliefs and culture. They have adopted a philosophy of *accommodate, retreat, or protect* when developing their mitigation strategies. As such, some of the initiatives outlined in this plan are not grant-eligible, and grant eligibility was not the focus of the selection. Rather, the focus was on the initiatives' effectiveness in achieving the goals of the plan, and whether or not they are within the Tribe's capabilities. Detailed descriptions for these actions can be found in Chapter 15.

1.1.3 Funding Sources

Once the 2020 Hazard Mitigation Plan is approved by FEMA, the Tribe will continue to be eligible for funding under the Stafford Act. FEMA grant programs provide various funding opportunities to support mitigation planning and projects to reduce potential disaster damages. It is the intent of the Tribe to pursue grant opportunities in the future to assist in mitigating against the Tribe's hazards of concern. Some of those current grant opportunities available which support mitigation efforts are delineated in Table 1-1. Additional funding sources are identified within the Strategy section of this document.

TABLE 1-1
GRANT OPPORTUNITIES

Program	Enabling Legislation	Funding Authorization	Hazard Mitigation Plan Requirement	
			Grantee	Sub-Grantee
Public Assistance, Categories A-B (e.g., debris removal, emergency protective measures)	Stafford Act	Presidential Disaster Declaration	☑	☑
Public Assistance, Categories C-G (e.g., repair of damaged infrastructure, publicly owned buildings)	Stafford Act	Presidential Disaster Declaration	☑	☑
Individual Assistance (IA)	Stafford Act	Presidential Disaster Declaration	☑	☑
Fire Management Assistance Grants	Stafford Act	Fire Management Assistance Declaration	☑	□
Hazard Mitigation Grant Program (HMGP) Planning and Project Grant	Stafford Act	Presidential Disaster Declaration	☑	☑
Pre-Disaster Mitigation (PDM) Planning Grant	Stafford Act	Annual Appropriation	☑	☑
PDM Project Grant	Stafford Act	Annual Appropriation	☑	☑
Flood Mitigation Assistance (FMA)	National Flood Insurance Act	Annual Appropriation	☑	☑
Severe Repetitive Loss (SRL)	National Flood Insurance Act	Annual Appropriation	☑	□
Repetitive Flood Claims (RFC)	National Flood Insurance Act	Annual Appropriation	☑	□
Tribal Homeland Security	Dept. of Homeland Security	Annual Appropriation	☑	□

☑ = Tribal Hazard Mitigation Plan Required
□ = No Tribal Hazard Mitigation Plan Required

1.2 IMPLEMENTATION AND ASSURANCES

Full implementation of the recommendations of this plan will require time and resources. This plan reflects an adaptive management approach in that specific recommendations and plan review protocols are provided to evaluate changes in vulnerability and action plan prioritization after the plan is adopted. The true measure of the plan's success will be its ability to adapt to the ever-changing climate of hazard mitigation. Funding resources are always evolving, as are programmatic changes based on new mandates. The Stillaguamish Tribe has a long-standing tradition of proactive response to issues that may impact its members. The Tribe is forward thinking and strives whenever possible to improve the lives of its members, and the residents living in the Tribal Planning Area. This tradition is reflected in the development of this plan, as it is not an easy task to accomplish. The Tribal Board of Directors will assume responsibility for adopting the recommendations of this plan and committing Tribal resources towards its implementation. The framework established by this plan will help identify a strategy that maximizes the potential for implementation based on available and potential resources. It commits the Tribe to pursue initiatives when the benefits of a project exceed its costs, and adequate resources are available. Most important, the Tribe developed this plan with community input. These techniques will set the stage for successful implementation of the recommendations in this plan.

As established within 44 CFR 13.11(c), the Tribal Board of Directors will continue to comply with all applicable federal statutes and regulations in effect, including those periods during which the Tribe receives grant funding to ensure grant contract compliance, and scheduled project closeouts as identified and required within each specific grant. In compliance with 44 CFR 13.11(d), the Tribe, whenever necessary, will reflect new or revised federal statutes or regulations, or any material changes in Tribal policy or operation. It is understood that the Tribe will submit those amendments for review and approval in coordination with FEMA Region X.

1.3 WHO WILL BENEFIT FROM THIS PLAN?

All tribal members and businesses of the Stillaguamish Tribe of Indians are the ultimate beneficiaries of this hazard mitigation plan. The plan reduces risk for those who live in, work in, and visit the Tribal Planning Area. It provides a viable planning framework for all foreseeable natural hazards. Participation in development of the plan by Tribal Hazard Mitigation Planning Team Members (and outside stakeholders as requested by the Tribe) helped ensure that outcomes will be mutually beneficial. The plan's goals and recommendations can lay groundwork for the development and implementation of local mitigation activities and partnerships.

1.4 HOW TO USE THIS PLAN

This hazard mitigation plan is organized into four primary parts, each of which includes elements required under federal guidelines to attain plan approval:

- Part 1— Introduction
- Part 2— The Planning Process
- Part 3— Community Profile
- Part 4— Risk Assessment
- Part 5—Mitigation Strategy.

The following appendices provided at the end of the plan include information or explanations to support the main content of the plan:

- Appendix A—A glossary of acronyms and definitions.

- Appendix B—An example template for progress reports to be completed as this plan is implemented.

1.5 CHANGES BETWEEN THE 2015 AND 2020 PLAN UPDATE

Significant differences exist between the 2015 Hazard Mitigation Plan Annex and the 2020 Plan. This is the Stillaguamish Tribe's first stand-alone Hazard Mitigation Plan. As such, the plan has been expanded to meet all planning requirements identified within 44 CFR 201.7. All materials identified in the previous annex template to the Snohomish County Hazard Mitigation Plan (HMP) have been incorporated and updated as appropriate. The 2015 Snohomish County HMP has also been utilized to help identify relevant historical information as it related to the Stillaguamish Tribe. That data and information has been updated within the current Stillaguamish plan. This document is also intended to meet the mitigation plan requirements for the 2017 Tribal Declarations Pilot Guidance.

For planning purposes, all incidents occurring since completion of the previous plan through December 31, 2018 have been recorded and included in this plan. The Tribe's next update should commence with incidents and information occurring January 1, 2019 forward.

The plan itself is a comprehensive update of all data and includes best available science which has been enhanced since completion of the previous plan. New studies, reports, and scientific data has been reviewed, and all risk data has been updated to the greatest extent possible with that new data (discussed in detail in the profiles).

Hazards previously identified in the 2015 plan were reviewed and carried over as determined appropriate by the Hazard Mitigation Planning Team. Some of the weather events were re-grouped into a "Severe Weather" chapter. Non-natural were not addressed, with the exception of hazardous materials sites.

Based on the risk assessment, all maps, charts, graphics, and associated data has been updated to reflect current findings. Specific methodology for how each assessment was completed is included in Chapter 6.

A different method was utilized for the risk ranking of the hazards of concern, discussed in Chapter 14. The approach utilized is simplistic in nature and will make future updates less difficult. Social Vulnerability is also addressed in greater detail in this plan, as well as information concerning programs and efforts in place to help address issues associated with social vulnerability.

Structure data was modified to include only tribal structures, adding new structures and land mass acquired by the Tribe since completion of the last plan. This will more accurately reflect the actual losses which the Tribe can potentially experience as a result of hazard impact.

Census data was updated with the most current data available; however, there are limitations with respect to US Census data, as only very limited information was available specific to the Tribe. Such are indicated.

The Capabilities Assessment was greatly enhanced to include a clearer perspective as to the capabilities of the Tribe, while also demonstrating areas on which focus must be given with respect to deficiencies which exist. In many instances, those deficiencies were identified as potential action items/strategies within Chapter 155. The previous goals and objectives were reviewed and updated as appropriate.

Specific strategies and action items identified previously have been discussed in detail in Chapter 15. Those strategies carried over to the 2020 plan are identified, and new strategies and action items are identified. Specific focus was placed on new construction, as the Tribe is actively expanding. Additional items which reflect differences between the previous and current plan update are referenced throughout the plan itself where appropriate and significant.

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CHAPTER 2.
PLANNING PROCESS

2.1 PLANNING RESOURCE ORGANIZATION

The process followed to develop the Stillaguamish Tribe's Hazard Mitigation Plan had the following primary objectives, which are discussed in detail in the following sections:

- Secure grant funding
- Define the planning area
- Establish a planning team
- Coordinate with other agencies
- Review existing programs
- Engage the public (as defined by the Tribe)

2.1.1 Funding of the 2020 Hazard Mitigation Plan

This planning effort was supplemented by a grant from the Federal Emergency Management Agency (FEMA). The Tribe applied for a grant in 2018, and funding was appropriated. The grant provided funding for 75 percent of the cost associated with development of the Hazard Mitigation Plan, with the Tribe providing 25 percent through in-kind contributions.

2.1.2 Defining the Planning Area

This document constitutes a Tribal Hazard Mitigation Plan for the Stillaguamish Tribe of Indians. The Plan covers the lands within the boundaries of the Reservation, as well as additional areas that include Tribal trust and fee lands located outside of its identified boundary. Limited locations or items of cultural significance have been identified within this document in an effort to protect the areas and items; however, they have been considered within this planning process and risk assessment analysis, as well as strategy development.

The Stillaguamish Tribe generally considers its local community to encompass the Stillaguamish Watershed and Port Susan, and the people living in it. Tribal traditional cultural and religious practices, and as well as Tribal co-management of certain natural and cultural resources may extend beyond these geographic boundaries. Although the Stillaguamish Tribe does not own all of the land within the area of analysis, the Tribe maintains treaty-reserved property rights not only to Reservation lands, but also lands for hunting, fishing, trapping, and gathering rights. Collectively, these areas are referred to throughout this plan as the *Tribal Planning Area*. Where the "Reservation" is referenced, it should be assumed that the analysis includes all areas in which the Tribe owns lands, and on which it has identified critical facilities. While the Tribe owns additional lands throughout Snohomish County, the focus for this initial plan was on identifying impact to critical assets and facilities.

The entire Reservation is considered to be of cultural significance, as are additional areas within the Tribal Planning Area. The primary tribal membership population centers are within Snohomish County. As such, this process includes all of the people, property, infrastructure, and natural environment within the entire Tribal Planning Area.

2.1.3 Formation of the Tribal Hazard Mitigation Planning Team

Hazard mitigation planning enhances collaboration and support among diverse parties whose interests can be affected by hazard losses. A Tribal Hazard Mitigation Planning Team (hereinafter may be referred to as Planning Team) made up of various Tribal staff was formed to help provide information and input into the plan development and lead the effort with respect to the actual drafting of the plan. The members of this team included key Tribal staff, planners, and Tribal Members. Other stakeholders from within the planning area were also identified by Tribal Staff to provide relevant information. The Stillaguamish Tribe of Indians also retained Bridgeview Consulting, LLC., to assist with development and implementation of the plan. The Bridgeview Consulting project manager, Beverly O'Dea, assumed the role of the lead planner, reporting directly to the Tribe's Project Manager, Cpt. Andy Mosalsky. Table 2-1 lists the members of the team.

2.1.4 Planning Team Meetings

The Planning Team agreed to meet as needed throughout the course of the plan's development in workshop type settings. These meetings occurred in person, via emails, webinar meetings, and conference calls. The Planning Team addressed a set of objectives based on the work plan established for the plan. Various members met beginning June 2019 through the plan's completion, soliciting subject matter expertise from team members as needed depending on the issue being addressed. Meeting agendas, notes and attendance logs are available for review upon request to the Tribe's Project Manager.

TABLE 2-1
PLANNING MEMBERSHIP

Name	Position	Planning Task
Cpt. Andy Mosalsky	Stillaguamish Police Department	Project Manager; coordinated all meetings; meeting attendance; provided data; reviewed documents; public outreach; presentation to Board of Directors
Carole Kirk	Land Management Liaison	Assisted with the development of the critical facilities list; provided mapping assistance; provided assistance with respect to tribal capabilities; historic background
Danielle Zimmermann	Grants and Contracts Administrator	Conducted grants management; assisted with assimilation of data and information; maintained data; research
Kerry Lyste	THPO/GIS Database Administrator	Assist with GIS requests and data layers as available;
Casey Stevens	Planning Director	Assisted with data gathering; provided several reports for review and inclusion in the plan; identified transportation related information; assisted with strategy development; provided several reports, historical documentation, and information, including Climate Change Adaptation;

TABLE 2-1
PLANNING MEMBERSHIP

Name	Position	Planning Task
Franchesca Perez	Natural Resources	Provided information concerning previous plan edition; provided various reports related to tribal natural resources; assisted with data gathering and review; conducted plan review;
Tom Dietz	Transportation Planner	Provided general information needed for plan development; identified previous impact areas of concern;
Deidre Shipley	Cultural	Provided information concerning various cultural resources of the tribe; provided background information concerning previous impact; risk assessment review and input;
Nate Brown	Angle of the Winds Casino	Provided information with respect to critical infrastructure for the Angle of the Winds Casino and Hotel.
Audie Calvert	Angle of the Winds Casino	Provided information with respect to critical infrastructure for the Angle of the Winds Casino and Hotel.
Patrick Stevenson	Natural Resources	Provided hazard data information and review of profiles;
Jeremy Smith	Facilities	Provided information concerning facilities.
Jason Anderson	Riparian Ecologist	Provided hazard data and information; provided information on streamside landownership and habitat; reviewed draft plan;
Maggie Taylor	Natural Resources	Provided information concerning hazards of concern and general background data; reviewed draft hazard profiles and plan.
Jody Brown	Water Resources Program Manager	Provided landslide and floodplain data; reviewed draft plan.
Jason Griffith	Natural Resources Biologist	Provided landslide data and GIS layer; hazard profile and draft plan review
Sam Barr	Tribal Historic Preservation Office – Cultural Resource Specialist	Provided information on structures, cultural resources, and tribal historic information; plan review.
Scott Rockwell	Forest and Fisheries Biologist	Provided wildfire history data; plan review.
Beverly O'Dea,	Bridgeview Consulting, LLC	Project Manager and Lead Planner
David O'Dea,	Bridgeview Consulting LLC	Senior Strategic Analyst, Facilitator, Research, Q&A
Cathy Walker	Bridgeview Consulting, LLC	Senior GIS Analyst

2.1.5 Coordination with Other Agencies

Opportunities for involvement in the planning process must be provided to neighboring communities, local and regional agencies involved in hazard mitigation, agencies with authority to regulate development, businesses, academia, and other private and nonprofit interests (44 CFR, Section 201.7(b)). This task was accomplished by the planning team as follows:

- **Planning Team Involvement**—Tribal department and various agency representatives were invited to participate on the Planning Team.
- **Agency Notification and/or Use of Information**—The following agencies were notified of the planning effort, provided relevant data, invited to participate in the plan development process, or were kept apprised of plan development milestones. These notifications took place via email or telephonic contact:
  - FEMA Region X
  - Snohomish County (various departments)
  - Washington State Office of Emergency Management
  - Washington State Department of Natural Resources (various divisions)
  - Washington State Department of Ecology (various divisions)

  These agencies received meeting announcements, meeting agendas, and meeting minutes by e-mail throughout the plan development process. These agencies supported the effort by attending meetings or providing feedback on issues.
- **Pre-Adoption Review**— Agencies listed above were provided an opportunity to review and comment on this plan, primarily through the Tribe's website, which was utilized for the hazard mitigation plan update. E-mails were distributed containing informing concerning draft review, as well as a link to download the plan if desired.
- **Newsletters—**In addition to the above, the Tribe distributes a regular newsletter, which announced plan development and milestones. The newsletter also directed Tribal members to the newly developed website, and the on-line survey.
- **Press Release –** The Tribe also distributed a press release which announced the planning effort, and provided the address to the *Hazard Mitigation Survey*, asking citizens to complete the document.

Some of the various stakeholders and their respective areas of participation are identified in Table 2-2. This list is not all-inclusive, but does demonstrate the various topics and agencies utilized/contacted.

TABLE 2-2
STAKEHOLDERS AND AREAS OF PARTICIPATION

Stakeholders			Data and Information Provided
Gi-Choul Ahn, GIS Analyst Snohomish County	Stormwater		Provided Hazus HPR files for flood Hazus Runs for review.
Bureau of Indian Affairs			Tribal Boundary
FEMA Region X	John Schelling, Mitigation		Risk Report (Skagit)

TABLE 2-2 STAKEHOLDERS AND AREAS OF PARTICIPATION			
Stakeholders			**Data and Information Provided**
	Program Manager		
WA DNR	Daniel Eungard, PE		Tsunami Hazard
WA DOE	Jerry Franklin, Risk Map Coordinator		Flood data, SRL and CRS data and information; Coastal Zone Atlas (unstable slopes)
WA DOE	Diane Fowler, Community Right to Know Coordinator		Reporting Hazmat sites in county
WA DOE	Bobbak Talebi, Coastal Planner	George Kaminsky, PhD	Coastal Erosion data and information
USGS			Earthquake and Tsunami Data

2.1.6 Review of Existing Information

Chapter 55 of this plan provides a detailed overview of existing information, laws, and ordinances in effect within the planning area that can affect hazard mitigation initiatives. As a whole, hazard mitigation planning must include review and incorporation, if appropriate, of existing plans, studies, reports, and technical information (44 CFR, Section 201.7(c)(1)(iii)), such as those identified below, many of which can affect mitigation within the planning area:

- Stillaguamish Tribe Constitution
- Stillaguamish Tribe 2015 Hazard Mitigation Plan
- Stillaguamish Tribe Comprehensive Emergency Management Plan (draft format)
- Stillaguamish Tribe 2015 Safety Plan
- Stillaguamish Tribe 2017 Transportation Plan
- Stillaguamish Tribe Natural Resources Department Climate Change Adaptation Plan (2017)
- Snohomish and Skagit Counties Hazard Mitigation Plans
- Snohomish County Comprehensive Plan
- State of Washington Enhanced Multi-Hazard Mitigation Plan (2018)
- Various watershed restoration project reports
- Various papers and studies concerning the impacts of climate change

- Interpretive Map Series: Earthquake Hazard Maps and Seismic Risk Assessment for Washington
- Various FEMA damage assessment documents and reports concerning damages from Oso Landslide.

An assessment of all Tribe's regulatory, technical, and financial capabilities to implement hazard mitigation initiatives is presented in Chapter 4. Many of these relevant plans, studies and regulations are cited in the capability assessment.

2.1.7 Public Involvement

Broad public participation in the planning process helps ensure that diverse points of view about the planning area's needs are considered and addressed. The public must have opportunities to comment on disaster mitigation plans during the drafting stages and prior to plan approval (44 CFR Section 201.7(b), 201.7(c)(1)(i) and 201.7(c)(1)(ii)). For this planning effort, "public" is defined as tribal members, tribal employees, the contractor, and some members of surrounding jurisdictions. While surrounding jurisdictions and governmental agencies had some involvement in the planning effort, the Planning Team was limited to Tribal government, Tribal members, Tribal employees, and the contractor. Part of the reason for this decision was to preserve information concerning the Tribe's cultural resources.

The Tribe did extensive outreach and used different methods to increase involvement, such as pairing meetings with existing Tribal Board meetings, providing Web-based data, and scheduling conference calls that allowed participation by agencies and individuals. Interviews were also conducted with individuals and specialists from outside organizations. Those interviews identified common concerns related to natural and manmade hazards, and key long- and short-term activities to reduce risk.

The Planning Team developed a comprehensive public involvement strategy using websites, media sources, and utilized existing meetings to gain input on the process. The Tribe utilized their website to post announcements and draft plan materials wherein notices and survey links were posted. During meetings (both Tribal and non-tribal meetings) Planning Team Members discussed the planning effort and directed interested parties to the website to gain better insight of the Tribe's endeavors, and to solicit input. Planning Team Members also identified non-tribal stakeholders who possessed relevant information, which were queried for specific data for inclusion in the plan update. During the development of this plan update, Snohomish County was also in the process of developing its 2020 update to their Hazard Mitigation Plan, and as such, information and data exchange between the County and the Tribe assisted in the development of both plans, including public outreach efforts.

During the final stage of the Plan's development, the COVID-19 Pandemic prohibited group gatherings. As such, the Tribe elected to utilize existing email distribution lists and the Tribe's website to gain public input.

Strategy

The strategy for involving the public in this plan emphasized the following elements:

- Include Tribal Members and Tribal Staff on the planning team. Including Tribal Staff would include members who are not Tribal.
- Use a questionnaire/survey to determine general perceptions of risk and support for hazard mitigation and to solicit direction on alternatives. The questionnaire was available to anyone wishing to respond via the website, as well as distributed by hand. The Tribe also posted a news release in the Tribal Newsletter, seeking response and input.

- Utilize the Tribe's Public Information Officer to serve as lead public outreach facilitator to distribute mitigation-related information and efforts.
- Utilize existing distribution lists to disseminate and capture relevant information. These lists historically have reached both tribal and non-tribal members.
- Identify and involve planning area stakeholders (non-tribal).

Planning Team Input

The majority of the members of the Planning Team live or work in the tribal planning area. The make-up of the Planning Team proved to be integral in the success of this planning effort. This helped to add a historical perspective to this committee that proved to be valuable in identifying direction for the plan development process. Members of the existing team were also on the original team, which provided additional historic knowledge which supported the update process as review and intent of the old plan was discussed, and update options applied.

Survey

A Hazard Mitigation Survey was developed by the Planning Team Members. The survey, distributed throughout the planning area, was designed to help identify vulnerable areas; to gauge household preparedness, and to identify the level of knowledge of tools and techniques that assist in reducing risk and loss from hazards. The answers helped guide the Planning Team in selecting goals, objectives, and mitigation strategies. The survey was disseminated throughout the planning area by multiple means, including hard-copy distribution of the surveys at council meetings. Additionally, a web-based version of the survey was made available on the hazard mitigation plan website. Surveys were also made available at Tribal office locations in hardcopy format. The Stillaguamish Tribe's Newsletter, which is distributed electronically and hardcopy to tribal members, was also utilized during this process to regularly to provide information concerning on-going efforts with respect to the survey, and on-going planning effort. By engaging the public through the public involvement strategy, the concept of mitigation was introduced to the public, and the Planning Team received feedback that was used in developing the components of the plan.

Response to the survey indicate that: ……. (Will be inserted after public review to capture any additional survey responses)

Public Information Officer

The Tribe's Public Information Officer served as one of the lead public outreach facilitators, using existing email lists (E-Blast lists) which reached an estimated 500 tribal members nationwide, as well as employees and local area residents.

Public Meetings

The public outreach events which occurred allowed attendees to examine information and have direct conversations with project staff. Reasons for planning and information generated for the risk assessment were shared with attendees. Maps, charts, and data were provided for the primary hazards to which the planning area is most vulnerable. Planning Team Members were available to answer questions, with email addresses provided to which questions and comments were also directed. Citizen and tribal members were asked to complete the on-line survey if they had not yet done so, and each was given an opportunity to provide written comments to the Planning Team. The Planning Team also erected flyers along various public hallways, providing information on the project, provided the Tribe's website address on which all information was maintained, including the link to the survey. Additional specific details of outreach events are identified in Table 2-2.

Comments received were reviewed and vetted through the Planning Team Members, and data incorporated as appropriate. During May 2020, the initial draft plan was reviewed by the Planning Team Members. After comments and information gathered during the review process were incorporated, the final draft plan was again distributed for review by all tribal members. Copies of the plan were made available via the Tribe's Mitigation webpage. A hard copy was also available for review and comment. The draft plan was available from May 26 – June 11, 2020.

The final public meeting was held on xxxxx, during which time the plan was presented to the Tribal Board of Directors, and at which time the Board approved and adopted the plan.

INSERT

Figure 2-1 Tribal Website

News Releases / Newsletters

A news release was also published to draw attention to the Tribe's planning effort and survey. The Tribe's regularly distributed newsletter was used to disseminate information through the planning process, including regular updates and notice of the draft review period. Notices were distributed in October 2019 and May 2020.

Internet and Board of Director's Meetings

At the beginning of the plan development process, information was added to the Tribe's website to inform and keep the public advised on plan development milestones and to solicit relevant input. Discussions during Tribal Board of Director's Meetings also occurred, during which the Tribe's Project Manager, Cpt. Andrew Mosalsky, provided status updates on the process, solicited information from meeting attendees, and advised of the various project milestones. In addition, the Tribal Grant Coordinator for this effort also discussed the various steps taken throughout the process and project milestones. Tribal leaders, directors, and tribal members attended the meetings, which are regularly scheduled meetings, open to the public.

During February and May 2020, the risk assessment was made available for review and comment, including on the Tribe's website (as well as in person). In addition, an E-Blast was sent out using the Tribe's existing distribution lists. At the completion of the initial draft plan, the plan was provided via a file-transfer site, which allowed for the download of the plan for review.

The Tribe's website address was publicized in all press releases, mailings, questionnaires, and public meetings. Information on the plan development process, the planning team, the questionnaire, and phased drafts of the plan were made available to the public on the site. The Tribe intends to keep their website active after the plan's completion to keep the public informed about successful mitigation projects and future plan updates.

2.1.8 Plan Development Chronology/Milestones

Table 2-3 summarizes some of the important milestones in the development of the plan, including public outreach events.

TABLE 2-3
PLAN DEVELOPMENT MILESTONES

Date	Group	Description	Attendance
2018			
2018	Submit grant application	Seek funding for plan development process	N/A
2018	Receive notice of grant award	Funding secured.	N/A
2019			
April	Initiate consultant procurement	Seek a planning expert to facilitate the process	N/A
June	Select Bridgeview Consulting, LLC to facilitate plan development	Facilitation contractor secured	N/A
July	Identify planning team	Formation of the planning team. Began review of existing plan and existing documentation supporting effort (e.g., studies, other planning documents, etc.) General plan information was distributed to team in preparation of initial planning team/kick-off meeting. Identified potential public outreach strategy for presentation at kick-off meeting. Will use existing Facebook, Twitter, and email distribution lists, which reach tribal and non-tribal members.	N/A
Aug	Planning Meeting/ Information gathering session	General information gathering concerning previous plan documentation; GIS data; general Tribal information to identify data gaps.	5
Sept	Public Outreach	Press release distributed; notice of process posted on website of planning process kick-off.	NA
Oct	Planning Meeting	The planning team met to review the HMP update process; review existing plan; confirm hazards of concern; review and update goals; identify objectives; define critical facilities; identify public outreach strategy	15
Oct	Public Outreach	Deployed Survey via web, erected posters with survey location at internal employee lunch/break rooms, and distributed information in the Tribe’s Newsletter. Email distributions were also made to tribal members and tribal staff.	NA
Dec	Planning Meeting	Updated data provided concerning structure data; maps refined for internal planning team review. Survey link again distributed internally.	7
2020			
Jan	Planning Meeting	Risk assessment data, CPRI and building impact data provided to planning team for review and comment.	10

TABLE 2-3
PLAN DEVELOPMENT MILESTONES

Date	Group	Description	Attendance
Feb	Planning Meeting	Review of risk assessment and methodology used to conduct the analysis; confirmation of risk analysis and ranking; strategy development; identified method for prioritization; review of grant opportunities for funding; confirm public outreach for presentation of risk via posters. Planning Team Members and Tribal Staff provide strategies for inclusion in the HMP update.	7
Feb/ March	Internal Draft Plan Review	Internal review of portions of the draft plan by planning team members commenced.	All
March 23		COVID Response - Per Tribal Board of Directors, no public meetings	
May 6-13	Public Outreach	Presentation of hazard information, maps, survey questions; announcement of upcoming open review process for HMP. Notices erected in open public facilities (staff only); email distribution to all tribal employees and enrolled tribal members.	
May 6	Draft Plan	Draft provided to Planning Team for review and comment until May 18, 2020.	All
May 26	Public Comment Period began	Initial public comment period of draft plan opens. Draft plan provided electronically to all planning members, both tribal and non-tribal, as well as the plan being made available at the Administrative Office for Review.	N/A
June 12	Plan Submittal	Draft Plan submitted to FEMA Region X for review.	
July XXX	Public Outreach – Presentation at Tribal Council, Adoption	Final public meeting on Plan presented at Tribal Council Meeting. Tribal Council adopted plan. Resolution forwarded to FEMA.	XX
	Plan Approval	Final plan approved by FEMA	N/A

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CHAPTER 3.
STILLAGUAMISH TRIBE OF INDIANS PROFILE

The Stillaguamish Tribe is composed of descendants of the Stoluck-wa-mish River Tribe. In 1855 the population resided on the main branch of the Stillaguamish River, its estuary, and marine shorelines, as well as along the North and South Forks of the river. The name Stillaguamish, under various spellings, has been used since around 1850 to refer to those Indians who lived along the Stillaguamish River and camped along its tributaries. They were a party to the Treaty of Point Elliott of January 22, 1855. No separate reservation was established for the Stoluck-wa-mish Indians. Some moved to the Tulalip Reservation, but the majority remained in the aboriginal area along the Stillaguamish River and delta. Tribal headquarters are located in Arlington, Washington. In 2014, what is currently identified as the Stillaguamish Tribe of Indians Reservation was established.

3.1 LOCATION AND GEOGRAPHY

The Stillaguamish Tribal community is located in northern Snohomish County near Arlington, Washington. It is located between the Cascade Mountains and Puget Sound in the temperate Puget sound basin. The Stillaguamish Tribe's trust lands are located in Snohomish County, Washington. The Stillaguamish Tribe generally considers its local community to encompass the Stillaguamish Watershed and Port Susan, and the people living in it.

Currently, the Tribe has approximately 64 acres of reservation land, an additional 592 acres of property in Tribal trust, and 1,214 acres of Tribally owned lands dispersed throughout the Stillaguamish watershed. The Tribe also maintains rights to Usual and Accustomed Fishing and Hunting Grounds. Combined, those areas are referred to as the Tribal Planning Area (for planning purposes, the reference to the "Reservation" shall include the Federal designation, as well as all Tribal properties as appropriate). Figure 3-1 identifies the Stillaguamish landownership throughout Snohomish County (2018). Figure 3-2 identifies the Stillaguamish watershed. Figure 3-3 identifies the Stillaguamish River estuary. Traditional cultural and religious practices, and as well as Tribal co-management of certain natural and cultural resources extend beyond these geographic boundaries. Figure 3-4 identifies the location of the reservation within the watershed.

The Stillaguamish Usual and Accustomed (U&A) area comprises the historical region in which finfish, shellfish, and other natural resources were collected by the Stillaguamish people. Current adjudicated U&A includes the geographic areas within the Stillaguamish River watershed. The Stillaguamish River is the fifth largest tributary to Puget Sound. The watershed drains an area of approximately 700 square miles and includes more than 3,112 miles of river, stream, and marine shore habitat. Elevations in the watershed range from sea level to about 6,854 feet on Three Fingers Mountain. The river enters Puget Sound at Stanwood, 16 miles north of Everett in northwestern Snohomish County. The watershed drains into both Port Susan and Skagit Bay, depending on tides. It is also part of the Whidbey Basin, which includes Skagit Bay, Saratoga Passage, Port Susan, and Deception Pass.

The Stillaguamish watershed can be divided into three general regions: the North Fork, the South Fork, and the Lower Mainstem. The two forks join in Arlington, 18 rivers miles from the mouth. Pilchuck, Deer, Boulder, and Canyon Creeks are the four largest tributaries to the Stillaguamish River system. The watershed includes land governed by Snohomish County and Skagit County, the cities of Arlington, Stanwood, Granite Falls, and the Stillaguamish and Tulalip Tribes.

Much of the area is rural, with urban development concentrated significantly along the I-5 corridor. Population centers are focused in the Arlington, Stanwood, Granite Falls, and the Stillaguamish and Tulalip Tribes.

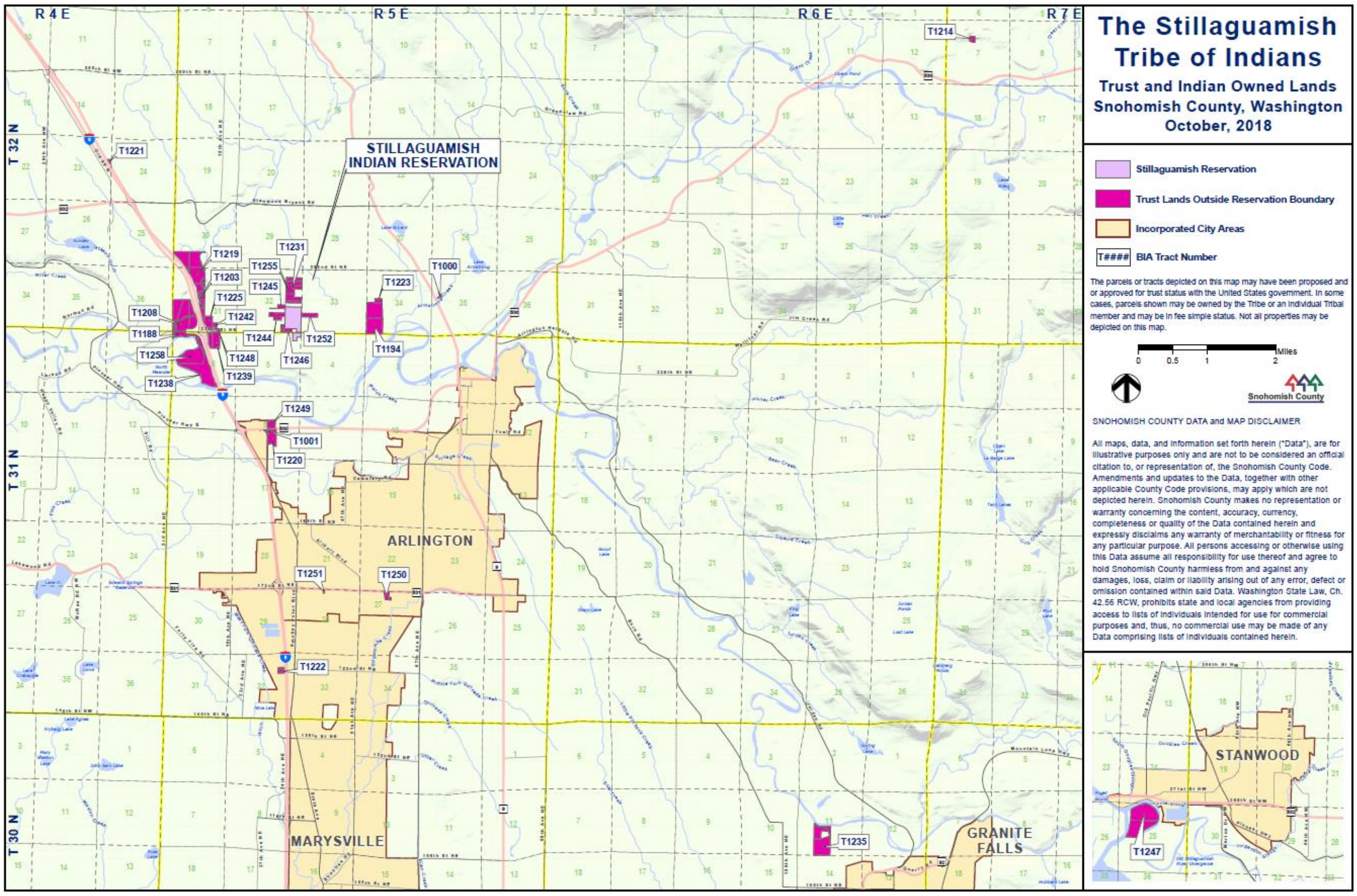

Figure 3-1 Trust and Indian Owned Lands within Snohomish County, WA

Figure 3-2 Stillaguamish Watershed

Figure 3-3 Stillaguamish River and Estuary
Source: WA DOE Photo ID Number 000924-114848

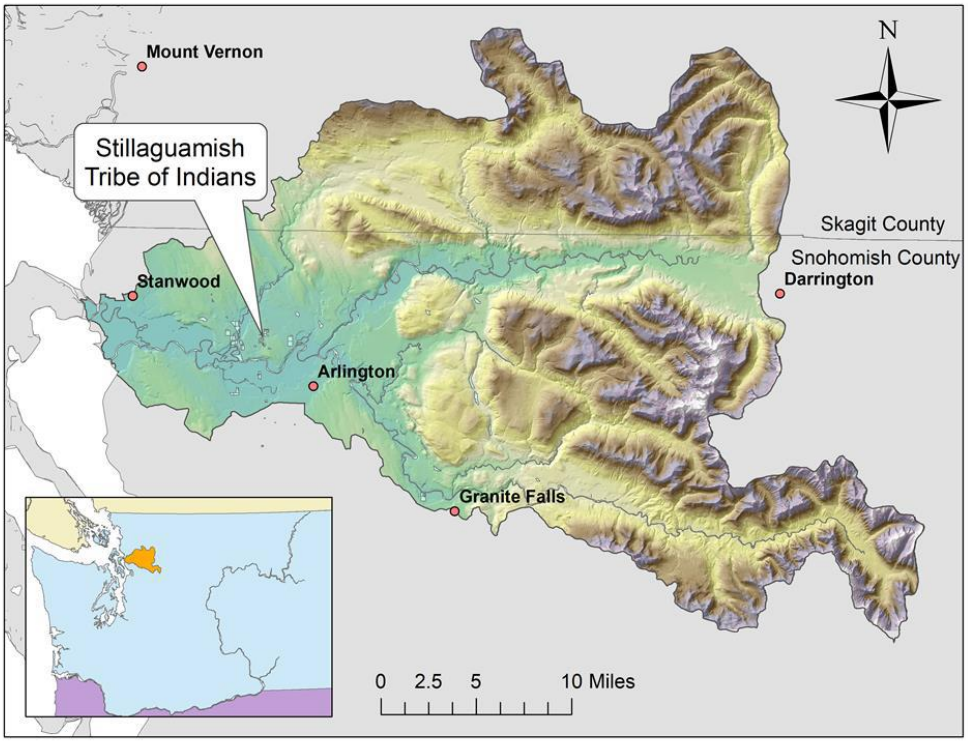

Figure 3-4 Stillaguamish Watershed

3.2 TRIBAL GOVERNANCE

The Tribe's constitution, approved by the Tribal council on January 31, 1953 and amended most recently in 2012, provides for the administration responsibilities of Tribal government to be handled by the popularly elected six-member Stillaguamish Board of Directors, sometimes also referred to as the Tribal Council. The Tribe petitioned the Secretary of Interior to acknowledge them for recognition as an Indian Tribe in 1974. The Board of Directors is composed of a Chairman, a Vice Chairman, a Secretary, a Treasurer, and two Members. A Board of Directors serve staggered terms of three years; every year an election is held for two of the seats on the Board of Directors.

On February 7, 1979, the Stillaguamish Tribe was listed in the Federal Register as eligible for Indian Health Service care and became part of the service population served by the Puget Sound Service Unit.

The Stillaguamish Tribe maintains in excess of 10 departments within its structure of government, all of which have been established to serve Tribal needs within the Tribal Planning Area and its Tribal Members. Several of the various departments are identified within this document as having a significant role in mitigating the impact of hazards of concern, while enhancing the resilience and sustainability of the Tribe and their People. At present, there are approximately 1,345 employees working for the Tribe, including Government/Enterprise, Tribal Member Services, and Casino and Hotel personnel. Some of these positions are 24/7 operations.

3.3 CLIMATE

The local climate is typically maritime with cool, wet winters and mild summers. Rainfall is highly variable throughout the watershed, with average annual rainfall ranging from 30 inches per year in the western lowlands of the watershed to 150 inches per year at higher elevations in the eastern portion of the watershed. Approximately 75% of the precipitation falls between October and March. Precipitation and stream flows are highest in late autumn and winter as a result of rainstorms and rapid snowmelt during warmer rainstorms, called rain-on-snow events. The lowest flows usually occur during the summer dry period from July through September.

3.4 DEMOGRAPHICS, DEVELOPMENT AND REGULATION

Knowledge of the composition of the population and how it has changed in the past and how it may change in the future is needed for making informed decisions about the future. Information about population is a critical part of planning because it directly relates to land needs such as housing, industry, stores, public facilities and services, and transportation. Population changes are useful socio-economic indicators. A growing population generally indicates a growing economy, while a decreasing population signifies economic decline.

3.4.1 Tribal Membership and Population

The enrolled tribal population is approximately 330. The majority of enrolled members live near the reservation, although members reside in all areas of the world. The Tribe does anticipate a continued increase in population, with more tribal members returning to the area of the reservation.

The reservation currently has no housing units within its boundaries, but single-family residential structures for the elderly (duplex style) are currently under planning and development. That housing, once complete, will also include living space for caregivers to assist the elders. The Tribe does maintain additional housing within close proximity to the reservation within Snohomish County.

At present, the Tribe owns limited housing for use by tribal members off the reservation. It does own 15 additional rental properties which are not considered critical assets. Those structures were not included in the risk assessment process as they are scattered throughout Snohomish and Skagit Counties.

The Tribe does maintain a multi-plex unit off the reservation which provides housing for youth. The Tribe does consider that structure as a critical facility, and it is included within this risk assessment.

According to the Snohomish County Tomorrow 2016 Growth Monitoring Report, it is anticipated that the population for the area will continue to increase over the life cycle of this plan, particularly in the areas of the Urban Growth Areas. Historic data has shown that while King County has grown at a faster rate, Snohomish County and the surrounding Urban Growth Areas are expected to continue to grow at the rate of 1.4 percent annually (down from the 1.5 percent projected during the 2010-2013 reporting period).[1] Even though the Stillaguamish Tribe's population is ~330, it is estimated that the area of the County containing the Tribal Reservation and various trust and fee lands will increase by similar ratios.

U.S. Census data reviewed for the Stillaguamish Tribe and the Off-Reservation area inaccurately illustrates the number of tribal members living on or near the reservation (identified as 11), and therefore provides no additional information of value with respect to projected population growth.[2]

3.4.2 Age Distribution

No age distribution data is available from the US Census data, and the Tribe does not track the ages of Tribal members in a manner applicable to this planning document. However, in general, as a group, the

[1] https://snohomishcountywa.gov/DocumentCenter/View/44885/GMR_2016_complete_final_reducedsize_Apr-12-2017updt?bidId=

[2] My Tribal Area. Accessed 22 Nov 2019. Available online at: https://www.census.gov/tribal/?st=53&aianihh=4000

elderly (65 and over) are more apt to lack the physical and economic resources necessary for response to hazard events and are more likely to suffer health-related consequences making recovery slower. They are more likely to be vision, hearing, and/or mobility impaired, and more likely to experience mental impairment or dementia. Additionally, the elderly are more likely to live in assisted-living facilities where emergency preparedness occurs at the discretion of facility operators. Elderly residents living in their own homes may have more difficulty evacuating their homes and could be stranded in dangerous situations. This population group is more likely to need special medical attention, which may not be readily available during natural disasters due to isolation caused by the event. Specific planning attention for the elderly is an important consideration given the current aging of the American population.

Children under 5 are also particularly vulnerable to disaster events because of their young age and dependence on others for basic necessities. Very young children may additionally be vulnerable to injury or sickness; 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.

3.4.3 Income

In the United States, individual households are expected to use private resources to prepare for, respond to and recover from disasters to some extent. This means that households living in poverty are automatically disadvantaged when confronting hazards. Additionally, the poor typically occupy more poorly built and inadequately maintained housing. Mobile or modular homes, for example, are more susceptible to damage in earthquakes and floods than other types of housing. In urban areas, the poor often live in older houses and apartment complexes, which are more likely to be made of un-reinforced masonry, a building type that is particularly susceptible to damage during earthquakes. Furthermore, residents below the poverty level are less likely to have insurance to compensate for losses incurred from natural disasters. This means that residents below the poverty level have a great deal to lose during an event and are the least prepared to deal with potential losses. Personal household economics significantly impact people's decisions on evacuation: those who cannot afford gas for their cars will likely decide not to evacuate.

U.S. Census Bureau data does not provide information specific to the Tribal membership. The Tribe does not maintain this type of data.

3.4.4 Disabled Populations

The 2010 U.S. Census Bureau estimates 54 million (non-institutionalized) Americans with disabilities in the U.S. This equates to about one-in-five persons. People with disabilities are more likely to have difficulty responding to a hazard event than the general population. Knowing that local government is the first level of response to assist individuals, coordination of efforts to meet the access and functional needs of individuals with disabilities is paramount to life safety efforts. In this respect, it is important for emergency managers to distinguish the differences between *functional* and *medical* needs to allow them to plan accordingly for incidents which require evacuations and sheltering needs. Pre-determining the percentage of population impacted with a disability will provide emergency management personnel and first responders the information necessary to pre-plan by having individuals available who can provide those services necessary to meet the requirements of those with access and functional needs.

The 2010 Census does not provide data on individuals with disabilities specific to the Stillaguamish Tribe, nor does the Washington State Office of Financial Management.[3]

[3] https://www.ofm.wa.gov/sites/default/files/public/legacy/pop/census2010/sf1/data/tribal/wa_2010_sf1_tribal_28000US67967.pdf

3.4.5 Economy

The Business Development Department is the economic development arm of the Stillaguamish Tribe, which is responsible for maintaining current tribally owned businesses as well as planning future investments, businesses and initiatives, and for the economic benefit of the Stillaguamish Tribe.

The Tribe currently oversee the following businesses:

- The Angel of the Winds Casino and Hotel
- The Banksavers Nursery & Landscaping
- The River Rock Smoke Shops
- The River Rock Tobacco & Fuel Convenience Store
- Stillaguamish Outdoor Media
- River Rock Smoke Shop
- Digital billboards
- Tesla Charging Station

The Angle of the Winds Casino is the Tribe's largest employer. Other major industries in the area not owned by the tribe include aircraft manufacturing (Boeing), wood products, food processing, electronics, and software.

3.5 MAJOR PAST HAZARD EVENTS

Presidential disaster declarations are typically issued for hazard events that cause more damage than tribal governments can handle without assistance from the federal government, although no specific dollar loss threshold has been established for these declarations. A presidential disaster declaration puts federal recovery programs into motion to help disaster victims, businesses, tribal and public entities. In some instances, grant funding from disaster declarations are also matched by state programs and funds, for which the Tribe may be eligible.

Table 3-1identifies all Federal Disaster Declarations which have occurred in Snohomish County since 1964 for which presidential disaster declarations were issued, or in the case of fire, where the fire management was issued. As the Tribe owns properties off of the reservation boundaries, the Planning Team felt it was relevant to illustrate impact from disasters not just on the reservation boundaries, but the entire county. Those disasters which have directly impacted the Stillaguamish Tribe, or which are tribally declared events are indicated as such. Review of these events helps identify targets for risk reduction and ways to increase a community's capability to avoid large-scale events in the future. The table also identifies two emergency declarations, one for the Oso Landslide (2014) declaration at the local level prior to the Presidential Declaration occurring, and one for the Hurricane Katrina Evacuations (2005) in preparation of evacuees.

Unfortunately, many natural hazard events do not trigger or rise to the level of a federal disaster declaration, but nonetheless have significant impacts on their communities. These events are also important to consider in establishing recurrence intervals for hazards of concern. Limited dollar loss data is available to identify impact to the Tribe. The Tribe has identified the capture of such loss data as a strategy for future planning efforts, as well as to support grant opportunities.

TABLE 3-1 STILLAGUAMISH TRIBE DISASTER HISTORY 1970-2018					
Disaster Number	**Declaration Date**	**Incident Type**	**Title**	**Incident Begin Date**	**Incident End Date**
4418	3/4/2019	Severe Storm(s)	Severe Winter Storms, Straight-Line Winds, Flooding, Landslides, Mudslides, and Tornado	12/10/2018	12/24/2018
4249	1/15/2016	Severe Storm(s)	Severe Storms, Straight-Line Winds, Flooding, Landslides, and Mudslides	11/12/2015	11/21/2015
4242	10/15/2015	Severe Storm(s)	Severe Windstorm	8/29/2015	8/29/2015
4168*	4/2/2014	Mud/Landslide	Flooding and Mudslides	3/22/2014	4/28/2014
3370**	3/24/2014	Mud/Landslide	Flooding and Mudslides	3/22/2014	4/28/2014
4056	3/5/2012	Severe Storm(s)	Severe Winter Storm, Flooding, Landslides, and Mudslides	1/14/2012	1/23/2012
1963*	3/25/11	Severe Winter Storm	Severe Winter Storm, Flooding, Landslides and Mudslides.	1/11/2011	1/21/2012
1825	3/2/2009	Severe Storm(s)	Severe Winter Storm and Record And Near Record Snow	12/12/2008	1/5/2009
1817	1/30/2009	Flood	Severe Winter Storm, Landslides, Mudslides, and Flooding	1/6/2009	1/16/2009
1734	12/8/2007	Severe Storm(s)	Severe Storms, Flooding, Landslides, and Mudslides	12/1/2007	12/17/2007
1682	2/14/2007	Severe Storm(s)	Severe Winter Storm, Landslides, and Mudslides	12/14/2006	12/15/2006
1671	12/12/2006	Severe Storm(s)	Severe Storms, Flooding, Landslides, and Mudslides	11/2/2006	11/11/2006
1641	5/17/2006	Severe Storm(s)	Severe Storms, Flooding, Tidal Surge, Landslides, and Mudslides	1/27/2006	2/4/2006
3227**	9/7/2005	Coastal Storm	Hurricane Katrina Evacuation	8/29/2005	10/1/2005
1499	11/7/2003	Severe Storm(s)	Severe Storms and Flooding	10/15/2003	10/23/2003
1361	3/1/2001	Earthquake	Earthquake	2/28/2001	3/16/2001
1172	4/2/1997	Flood	Heavy Rains, Snow Melt, Flooding, Land and Mud Slides	3/18/1997	3/28/1997

TABLE 3-1 STILLAGUAMISH TRIBE DISASTER HISTORY 1970-2018					
Disaster Number	**Declaration Date**	**Incident Type**	**Title**	**Incident Begin Date**	**Incident End Date**
1159	1/17/1997	Severe Storm(s)	Severe Winter Storms, Land and Mud Slides, Flooding	12/26/1996	2/10/1997
1100	2/9/1996	Flood	High Winds, Severe Storms and Flooding	1/26/1996	2/23/1996
1079	1/3/1996	Severe Storm(s)	Severe Storms, High Wind, and Flooding	11/7/1995	12/18/1995
981	3/4/1993	Severe Storm(s)	Severe Storms and High Wind	1/20/1993	1/21/1993
896	3/8/1991	Flood	Severe Storms and High Tides	12/20/1990	12/31/1990
883	11/26/1990	Flood	Severe Storms and Flooding	11/9/1990	12/20/1990
784	12/15/1986	Flood	Severe Storms and Flooding	11/22/1986	11/29/1986
623	5/21/1980	Volcano	Volcanic Eruption, Mt. St. Helens	5/21/1980	5/21/1980
612	12/31/1979	Flood	Storms, High Tides, Mudslides and Flooding	12/31/1979	12/31/1979
545	12/10/1977	Flood	Severe Storms, Mudslides, and Flooding	12/10/1977	12/10/1977
492	12/13/1975	Flood	Severe Storms and Flooding	12/13/1975	12/13/1975
196	5/11/1965	Earthquake	Earthquake	5/11/1965	5/11/1965
185	12/29/1964	Flood	Heavy Rains and Flooding	12/29/1964	12/29/1964
*Tribal Declaration **Emergency Declaration (Oso Landslide and Hurricane Katrina Evacuation)					

CHAPTER 4.
LAND USE PROFILE

As a sovereign nation, decisions on land use are governed by Tribal Government, who maintain legislative and policy-making authority. The Tribe does have land use rules and regulations in place and is an avid steward of protecting the natural resources of the tribal planning area.

Once complete, this 2020 Update to the Hazard Mitigation Plan, along with existing land use regulations will be utilized to support land use development in the future by providing vital information on the risk associated with natural hazards in the planning area. The Tribe will incorporate by reference the Hazard Mitigation Plan in its comprehensive plans as updated or completed. This will assure that all future trends in development can be established with the benefits of the information on risk and vulnerability to natural hazards identified in this plan, as well as continue to protect the natural environment.

4.1.1 Current Land Use and Future Development Trends

Currently, the Tribe has approximately 64 acres of reservation land, an additional 592 acres of property in Tribal trust, and 1,214 acres of Tribally owned lands dispersed throughout the Stillaguamish watershed. The Tribe also maintains rights to Usual and Accustomed Fishing and Hunting Grounds. Combined, those areas are referred to as the Tribal Planning Area. Land use within the watershed is 61% forestry, 22% rural, 15% agriculture, and 2% urban. Federal, state, and private forest land uses occupy the majority of the watershed.

Infrastructure (both social and economic) on the Reservation is somewhat limited in nature, and consists primarily of administration of the tribe, community center (which serves as a congregate meal site and provides some education programs), natural resources, and several business enterprises, in addition to the elder housing. Individual tribal members own residential structures within the surrounding areas off the reservation, but in many cases, the land on which the structures are placed is trust land. Common land use on the reservation include residential (forthcoming in 2020), governmental operations, and commercial/business.

The Tribe does not administer user fees and is without a tax base. Gaming and tourism provide its primary business revenue through Angels of the Wind Casino and Hotel. On average, the Casino and Hotel host in excess of 400,000 visitors annually. The Tribe is actively seeking new industries and commercial ventures. The Tribe does have a medical facility on the reservation and provides social service programs to all federally recognized tribal members. There is also a fish hatchery on the reservation to help in the protection of salmon spawning.

At present, new buildings funded with Federal dollars are required to be built to minimum International Building Code (IBC) standards. The Tribe is not required to obtain building permits for construction on Tribal Land. Buildings constructed prior to land being placed in trust are permitted through Snohomish County. For construction on trust land, the Tribe does contract with plan reviewers and inspectors, as well as the Fire Marshall.

Future Development

The Tribe does have specific areas identified for various types of land-use designations for development on areas of the reservation. The Tribe does adhere to zoning regulations in areas not on reservation. Figure 4-1 identifies the current land use as it exists now, and for future development phases on the reservation.

Currently, the Tribe does intend to build additional residential structures on the reservation, including a multi-story structure (apartment style). The Tribe is also looking at construction of a new police facility, which will also serve as the Tribe's Emergency Operations Center. In addition to those items identified, the Tribe also is considering the development of an RV Park.

The Tribe, through its Natural Resource Division, also identifies and prioritize wetlands to restore, conserve and protect properties throughout the Stillaguamish watershed. Such actions not only positively influence and preserve the natural environment, but also act as natural flood reduction buffer, allowing water to naturally accumulate and disburse, while preserving the natural resource.

As that land use development occurs, this mitigation plan will be utilized to help identify potential areas of risk to ensure construction in those areas are limited, or developed in such a way as to reduce the impact of the hazards on the Tribal members and visitors to the planning area.

All tribal lands are considered culturally sacred; however, there are specific areas which are particularly more significant, such as burial grounds and areas designated for archaeological preservation. These factors reduce the amount of land available for economic development and community facilities and are areas which any type of land development is either totally restricted, or highly monitored. In addition, the Tribe's cultural resource protection program provides protection to ancestral and sacred sites and landscapes in cooperation with federal, state and local land management agencies, private developers, and landowners. Cultural and sacred sites were considered during development of this mitigation plan, although none were identified by location.

The Tribe continues to work with the surrounding municipalities to ensure that land use development as it occurs minimally impacts the vulnerability of the people, property, and natural environment of the Tribe. In some instances, such as development along the various waterways, development has negatively impacted the Tribe from an environmental aspect by increased contamination, sediment, and fish habitat, among others. Increased vulnerability with respect to impact on the tribal population at risk is limited in nature as a result of land use development restricting construction in high risk areas, as well as policies and regulatory authority in place, such as building and zoning codes.

The impact to the natural environment is of significant concern to the Tribe and is one of the primary reasons why the Tribe has purchased land in areas frequently flooded, to allow for such areas to return to their natural state. Such effort is identified as a strategy in this plan, and the Tribe will continue such efforts in their attempt to mitigate negative land use development.

4.1.2 Age and Type of Building Stock

The year of construction is significant in determining the potential impact from various hazards due to construction standards in place at the time. Structures built pre-1972 historically have maintained lower building standards than current codes in place. New construction is built to higher standards.

The majority of all tribal structures on the Reservation itself are newer in nature. One structure was built in 1959 (medical facility); two in the 1970's (medical facility and multi-family housing); three in the 1980's (government operations); two in the 1990's (protective); and the remainder from 2000 forward.

Residential land use generally consists of duplex-type dwellings, including those converted to an office/administrative building for maintenance. According to Tribal data, there are currently six (6) housing units (primarily Elder housing), and a youth apartment complex off the reservation in the Tribal Planning Area. There are several commercial locations on the Reservation, including the Angle of the Winds Casino and Hotel, the Tesla charging station, and medical and health facilities, among others. The Tribe does intend to continue construction of a planned assisted living-type housing development on the Reservation during the life cycle of this plan for additional elder support. When such development occurs, it will be built to the highest standards, in areas of low-hazard risk to ensure public safety.

Figure 4-1 Land Use Distribution on Reservation

4.1.3 Critical Facilities and Infrastructure

Critical facilities and infrastructure are those that are essential to the health and welfare of the population. These become especially important after a hazard event. Critical facilities typically include police and fire stations, schools, and emergency operations centers. Critical infrastructure can include the roads and bridges that provide ingress and egress and allow emergency vehicles access to 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. As defined for this hazard mitigation plan, critical facilities are focused on tribal-owned facilities.

As the Tribe is somewhat limited in their structure base, loss of any structure would significantly impact the Tribe, especially if such a structure fell within FEMA/DHS' customary definition of critical facility. Losing any structure could result in a negative economic impact or force a tribal member to leave the area if a housing structure was involved. As such, the planning team determined that critical facilities for the purposes of this planning effort include, but are not limited to the following:

- Tribal owned facilities such as department, agency, council facilities, and administrative offices that provide essential services to the Stillaguamish People.
- Emergency response facilities needed for disaster response and recovery, including, but not limited to: public safety buildings; emergency services buildings; emergency operations centers; emergency supply storage facilities, and low income, emergency shelter(s), and tribally owned residential structures.
- Medical and health facilities used during both emergency response or in the normal course of business.
- Facilities that may be used to house or shelter disaster victims, such as: schools, gymnasiums, churches, senior, or community centers.
- Utilities and infrastructure vital to maintaining or restoring normal services to the areas damaged by the disaster.
- Community gathering places, including culturally significant areas, parks, community centers, gymnasiums, and meeting halls.
- Structures or facilities that produce, use, or store highly volatile, flammable, explosive, toxic, and/or water-reactive materials.
- Elder and youth housing (tribal owned).

Cultural sites or facilities that are vitally important to maintaining the Tribe's cultural history, language, and traditions, such as burial grounds, archaeological sites, and artifact storage facilities.

The Planning Team developed a detailed list of those structures meeting the identified definition, which was utilized as the primary source of risk assessment during this process.

In addition to the critical facilities, as indicated, the Tribe also owns 15 residential structures used as rentals; none of those structures are on the reservation and are scattered throughout Snohomish County, and not identified as critical structures within this planning process, although they do provide rental income. Single family and duplex-style residential structures owned by tribal members were also not included in this risk assessment, as they also are not on the actual reservation itself, but within Snohomish and Skagit Counties. Similar to the rental units the tribe maintains, impact to those structures in general are encompassed within the local jurisdiction's Hazard Mitigation Plan as part of the general building stock of the County. Economic loss impact data is therefore not included for those residential structures.

It should be noted that due to the lack of available municipal water, the Tribe does construct extensive water purification and storage facilities in conjunction with all new construction to ensure an adequate and safe water supply system exists.

The critical facilities identified for this plan update included ~36 structures, including culturally significant structures. The list itself is not provided within this document and is considered confidential in nature. The Tribe will continue to rely on the Snohomish County Hazard Mitigation Plan to identify critical or essential facilities which are not owned or managed by the Tribe which are at risk to the hazards of concern. Building structure and content values (estimated at 50% building value) total in excess of $326 million. Table 4-1 and Figure 4-2 illustrate the critical facilities in the Tribal Planning Area.

TABLE 4-1
CRITICAL FACILITIES

Critical Facilities Types	Count	Building	Content	Total
Casino, Hotel, Parking Garage, Charging Station	4	$121,942,000	$61,201,000	$183,143,000
Commercial	2	$9,656,700	$4,828,350	$14,485,050
Cultural	4	$3,405,950	$1,702,975	$5,108,925
Government/Administration	3	$7,450,000	$3,725,000	$11,175,000
HazMat (Casino Gas station; value included in Casino/Hotel)	1	-	-	-
Industrial	1	$400,000	$200,000	$600,000
Medical	4	$18,053,000	$9,026,500	$27,079,500
Natural Resource	1	$520,000	$260,000	$780,000
Protective	6	$21,200,000	$10,600,000	$31,800,000
Residential Single and Multi-Family	4	$14,500,000	$7,250,000	$21,750,000
School	1	$6,500,000	$3,250,000	$9,750,000
Wastewater	1	$7,500,000	$3,750,000	$11,250,000
Water	4	$6,231,785	$3,115,893	$9,347,678
Totals	**36**	$217,359,435	$108,909,718	$326,269,153

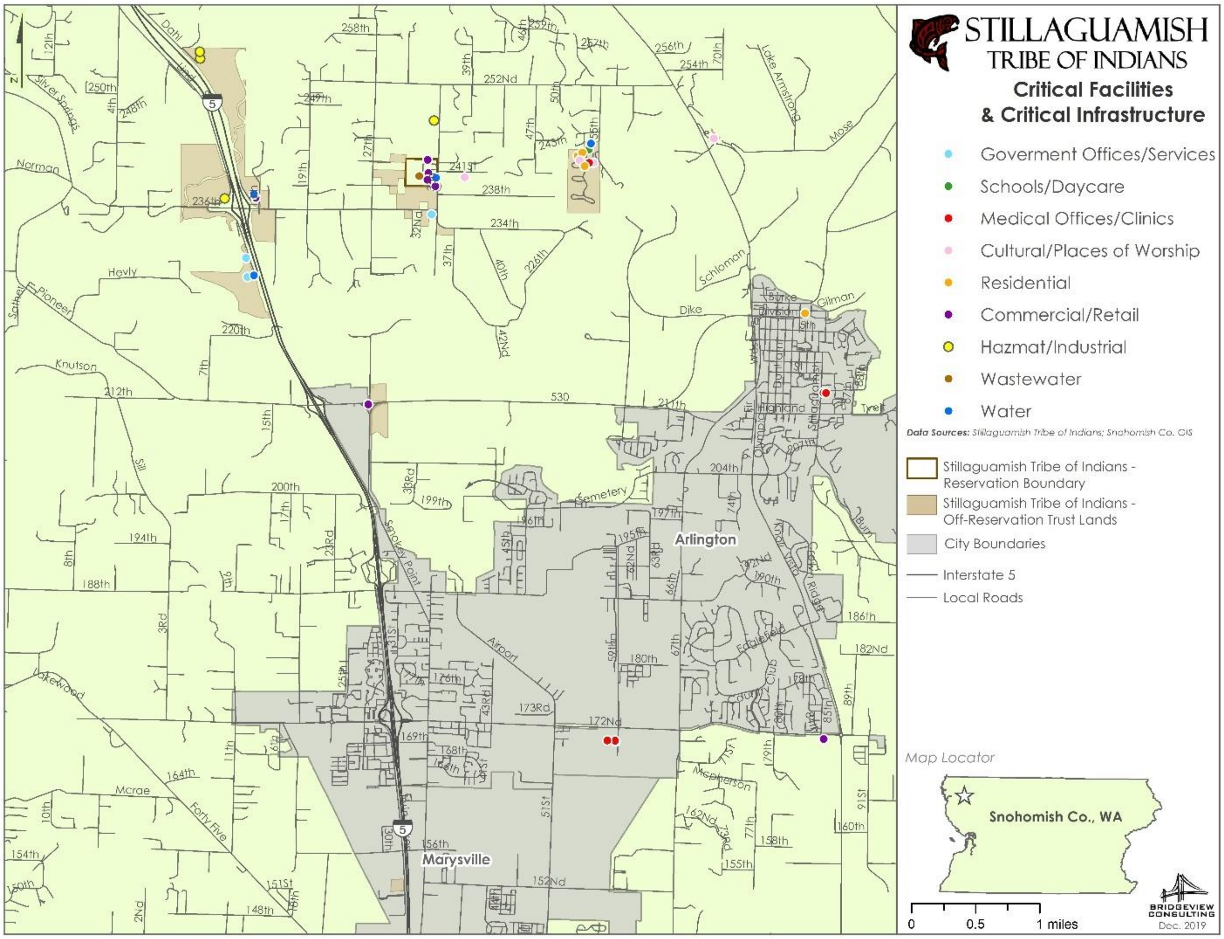

Figure 4-2 Tribal Critical Facilities (both on and off Reservation)

4.1.4 Roadways

The majority of major roadways in the region are owned and maintained either by local, state or federal agencies. Within the Reservation, the Tribe does construct and maintain a network of roadways. The Tribe also provides financial assistance and support for federal, state and county roadways in the area and leading onto the Reservation.

4.1.5 Transportation

The Stillaguamish Tribal Transit Services and Vanpool/Rideshare Program currently oversees the public transportation needs on the reservation. The Stillaguamish Tribe began offering a Tribally owned and operated Demand-Response transit service in 2006. The Stillaguamish Tribe currently offers two transportation services, a Demand-Response service, and a Vanpool/Rideshare Program. The Demand-Response service is open to Tribal members and non-tribal community members meeting economic, medical, educational, cultural, and recreational needs. The Vanpool/Rideshare Program began in November 2009 and offers employees a low cost, shared ride system to get to work.

The Tribe commissioned a transportation report, which was adopted in 2017. That report identifies the need for transportation on the reservation to approximately 47,000 commuters annually to ensure access for all tribal members (whether a registered member of the Stillaguamish Tribe or any other federally recognized tribe) to the health and social services provided by the Stillaguamish Tribe and other surrounding tribes.

Transportation becomes a factor within the disaster realm for individuals who cannot evacuate due to the lack of transportation, which is one of the vulnerabilities associated with impact. The Tribe does have the ability to provide assistance to individuals on the reservation should such a need arise utilizing transportation resources.

4.1.6 Rail

No rail lines exist on the reservation; however, they do traverse Snohomish County. Impact from a chemical release within the tribal planning area of the Stillaguamish Watershed would also impact the tribe. Ingress and egress could also be impacted if a rail accident occurred along a major arterial within the County.

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CHAPTER 5. CAPABILITY ASSESSMENT

The planning team performed an inventory and analysis of existing authorities and capabilities called a "capability assessment." A capability assessment creates an inventory of the Tribe's mission, programs, and policies, and evaluates its capacity to carry them out. Table 5-1 summarizes the legal and regulatory capabilities of the Tribe. Table 5-2 summarizes the administrative and technical capability. Table 5-3 summarizes fiscal capability.

Table 5-4 On-Going Mitigation Efforts

identifies mitigation efforts which are on-going in the Tribal Planning Area.

TABLE 5-1
LEGAL AND REGULATORY CAPABILITY

	Tribal Authority or Program in Place	Other Jurisdictional Authority	State Mandated	Comments
Codes, Ordinances & Requirements				
Building Code IBC 2015 Standards Adopted	Y		Y	The State and County consistently adopt the most current standards established. The Tribe also adheres to those same standards. When construction occurs off trust land, permitting occurs through the County and all IBC standards are met accordingly. The Tribe also has standards established which it must meet at the Federal level for all federally funded projects.
Floodplain Ordinance				The Tribe is not an NFIP community, and therefore is not required to have a floodplain ordinance; however, when constructing facilities, particularly when federal grant funds are utilized, the tribe does adhere to federal standards, which require adherence to floodplain regulations.
Stormwater Management	N	Y		Snohomish County and EPA
Growth Management	NA			The Tribe is not required to address growth management in the same manner as counties and cities in the state of Washington.
Site Plan Review	Y			Contracted Services

TABLE 5-1
LEGAL AND REGULATORY CAPABILITY

	Tribal Authority or Program in Place	Other Jurisdictional Authority	State Mandated	Comments
Public Health and Safety	Y	Y	Y	Public Health and Safety is addressed to a large extent by Tribal Health. For some matters, the County also provides this data, as does the State Dept. of Health.
Climate Change Adaptation	Y		Y	The Tribe is very actively engaged in various climate change issues through, among other departments, Natural Resources. The Climate Impacts Group also completed a Vulnerability Assessment for the Tribe in 2015. In May 2017, the Tribe adopted its Adaptation Plan.
Natural Hazard Specific Ordinance (stormwater, steep slope, wildfire, etc.)	Y			The Tribe works diligently within the Stillaguamish Watershed to ensure no, or at least very low adverse impacts throughout the community, and has taken extensive measures and established programs to specifically address this issue. See also the Stillaguamish Tribe of Indians Natural Resources Climate Adaptation Plan.
Environmental Protection	Y			Tribal programs as well as EPA regulated programs.
Dam Safety	NA		Y	Washington State Department of Ecology
Forestland-Urban Interface Fire Protection Act	Y			The Tribe works closely with its local fire protection service entities and enlists the aid of property owners toward the goal of turning properties into less volatile zones, enhancing firefighter safety and effectiveness. While not mandated, the Tribe is actively involved in forestland protection activities.
Planning Documents				
General or Comprehensive Plan	Y			
Floodplain or Basin Plans or Activities	Y			The Tribe actively engages in maintaining the natural environment for watershed protection.

TABLE 5-1
LEGAL AND REGULATORY CAPABILITY

	Tribal Authority or Program in Place	Other Jurisdictional Authority	State Mandated	Comments
Capital Improvement Plan	Y			The Tribe has a plan in place for future development and enhancement of existing structures.
Habitat Conservation Plan	Y			Yes. See Climate Change Adaptation Plan, among others.
Community Wildfire Protection Plan	N	Y	Y	Some jurisdictions within the planning region are part of the Firewise program. Snohomish and Skagit Counties, the surrounding municipalities to the Tribe, do have a current CWPPs in place, both under current development. The Tribe itself does participate in those planning initiatives, working with the local fire suppression organizations to provide information to Tribal Members concerning reducing fire risk, and have been part of the planning process in developing the CWPPs.
Transportation Plan	Y			The Tribe has a Transportation Plan, adopted in 2017.
Response/Recovery Planning				
Comprehensive Emergency Management Plan	Y			
Threat and Hazard Identification and Risk Assessment	N			
Post-Disaster Recovery Plan	Y			The Tribe has various plans in place to address disaster impact.
Continuity of Operations Plan				
Administration, Boards, and Commission				
Mitigation Planning Committee	Y			An HMP Committee was established to develop this plan. Those members will remain on the Committee during the lifecycle of this plan and will conduct the annual reviews as identified in the plan maintenance section.
Maintenance programs to reduce risk (e.g., tree trimming, clearing drainage systems, chipping, etc.)	Y			

TABLE 5-1
LEGAL AND REGULATORY CAPABILITY

	Tribal Authority or Program in Place	Other Jurisdictional Authority	State Mandated	Comments
Mutual Aid Agreements / Memorandums of Understanding	Y	With County and other Tribes in the area	N	The Tribe has MOUs with various entities to provide various services.

TABLE 5-2
ADMINISTRATIVE AND TECHNICAL CAPABILITY

Staff/Personnel Resources	Available?	Department/Agency/Position
Planners or engineers with knowledge of land development and land management practices	Yes	Planning Department Staff
Professionals trained in building or infrastructure construction practices (building officials, fire inspectors, etc.)	Yes	Contracted services through County
Engineers or inspectors specializing in construction practices?	Yes	Contracted services
Planners or engineers with an understanding of natural hazards	Yes	Several in various Tribal Departments.
Staff with training in benefit/cost analysis	Yes	Tribe has performed BCAs.
Surveyors	Yes	Contracted services as needed.
Personnel skilled or trained in GIS applications	Yes	
Personnel skilled or trained in Hazus use	No	
Scientist familiar with natural hazards in local area	Yes	Foresters, Geologists,
Emergency Manager	Yes	Police Captain serves as the designated EM
Grant writers	Yes	On staff.
Warning Systems/Services	Yes	Through County services
Hazard data and information available to public	Yes	Risk assessment maps are available for review in person and on website.
Maintain Elevation Certificates	No	

TABLE 5-3
FISCAL CAPABILITIES

Financial Resources	**Accessible or Eligible to Use?**
1. Community Development Block Grants	Yes
2. Capital Improvements Project Funding	Yes

TABLE 5-3
FISCAL CAPABILITIES

Financial Resources	Accessible or Eligible to Use?
3. Authority to Levy Taxes for Specific Purposes	Authority, but never executed.
4. User Fees For Water, Sewer, Gas or Electric Service	No
5. Impact Fees for Buyers or Developers of New Development/Homes (Not at present, but potentially may occur during life cycle of HMP)	No
6. Incur Debt through General Obligation Bonds	Yes
7. Incur Debt through Special Tax Bonds	Yes
8. Incur Debt through Private Activity Bonds	Yes
9. Could Withhold Public Expenditures in Hazard-Prone Areas	No
10. State-Sponsored Grant Programs	Yes
11. Bureau of Indian Affairs Sponsored Grant	Yes
12. Indian Health Services Grant	Yes
13. U.S. Dept. of Agriculture, Rural Development Agency	Yes
14. U.S. Environmental Protection Agency	Yes
15. U.S. Fire Administration	Yes
16. Tribal Homeland Security Grants	Yes
18. Stafford Act Grants	Yes
19. Healthy Forest Restoration Act	Provides funding to reduce or eliminate hazardous fuels; aims to create fuel breaks by reducing density of vegetation and trees; improve forest fighting capabilities, and research new methods to reduce the impact of invasive insets.

TABLE 5-4
ON-GOING MITIGATION EFFORTS

Mitigation Effort	Available? Yes/No	Department/Agency/Position
Hazardous Vegetation Abatement Program	Y	Through various partnerships with the Forest Service
Fire Safe Councils or Fire Wise Community	Y	While the Tribe itself is not a Fire Wise Community, surrounding jurisdictions are and the Tribe actively participates in CWPP development through the County.
Chipper program	N	
Defensible space inspections program	N	
Creek, stream, culvert, or storm drain maintenance or cleaning program	Y	Actively involved in management on the Reservation and throughout the watershed.

Stream restoration program	Y	Various on-going efforts as well as several completed efforts.
Erosion or sediment control program	Y	Actively involved in various restoration projects throughout the watershed in support of erosion and sediment control efforts.
Address signage for property addresses	Y	
Other		

5.1 EXISTING REGULATIONS

Pertinent federal laws are described below. It should be noted that as a sovereign nation, the Tribe is not required to adhere to any local or state planning regulations; however, in an effort to be a good steward and neighbor, the Tribe does strive to plan in consideration of state and local requirements. The Tribe must comply with applicable federal regulations for construction and maintenance of facilities, such as those administered by HUD and EPA, as well as other federal agencies. This places a significant burden upon the Tribe as it is doubly impacted in their efforts when developing land use authority and other regulatory statutes.

5.1.1 Federal

Disaster Mitigation Act

The DMA is the current federal legislation addressing hazard mitigation planning. It emphasizes planning for disasters before they occur. It specifically addresses planning at the local level, requiring plans to be in place before Hazard Mitigation Grant Program funds are available to communities. This plan is designed to meet the requirements of DMA, improving eligibility for future hazard mitigation funds.

Endangered Species Act

The federal Endangered Species Act (ESA) was enacted in 1973 to conserve species facing depletion or extinction and the ecosystems that support them. The act sets forth a process for determining which species are threatened and endangered and requires the conservation of the critical habitat in which those species live. The ESA provides broad protection for species of fish, wildlife and plants that are listed as threatened or endangered. Provisions are made for listing species, as well as for recovery plans and the designation of critical habitat for listed species. The ESA outlines procedures for federal agencies to follow when taking actions that may jeopardize listed species and contains exceptions and exemptions. Criminal and civil penalties are provided for violations of the ESA.

Federal agencies must seek to conserve endangered and threatened species and use their authorities in furtherance of the ESA’s purposes. The ESA defines three fundamental terms:

- **Endangered** means that a species of fish, animal or plant is “in danger of extinction throughout all or a significant portion of its range.” (For salmon and other vertebrate species, this may include subspecies and distinct population segments.)
- **Threatened** means that a species “is likely to become endangered within the foreseeable future.” Regulations may be less restrictive for threatened species than for endangered species.
- **Critical habitat** means “specific geographical areas that are…essential for the conservation and management of a listed species, whether occupied by the species or not.”

Clean Water Act

The federal Clean Water Act (CWA) employs regulatory and non-regulatory tools to reduce direct pollutant discharges into waterways, finance municipal wastewater treatment facilities, and manage polluted runoff. These tools are employed to achieve the broader goal of restoring and maintaining the chemical, physical, and biological integrity of the nation's surface waters so that they can support "the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water."

Evolution of CWA programs over the last decade has included a shift from a program-by-program, source-by-source, pollutant-by-pollutant approach to more holistic watershed-based strategies. Under the watershed approach, equal emphasis is placed on protecting healthy waters and restoring impaired ones. A full array of issues are addressed, not just those subject to CWA regulatory authority. Involvement of stakeholder groups in the development and implementation of strategies for achieving and maintaining water quality and other environmental goals is a hallmark of this approach.

The EPA recognizes that Indian Tribes face serious human health and environmental problems and are working with the Indian Tribes to protect the health and environment of waters in Indian Country. Presently, the Stillaguamish Tribe has partnered with other entities to assist with several watershed restoration projects in its efforts to return the watersheds to a healthy state.

Presidential Disaster Declarations

Presidentially declared disasters are disaster events that cause more damage than state and local governments/resources can handle without federal assistance. There is not generally a specific dollar threshold that must be met. A Presidential Major Disaster Declaration puts into motion long-term federal recovery programs, some of which are matched by state programs, and designed to help disaster victims, businesses, and public entities. A Presidential Emergency Declaration can also be declared, but assistance is limited to specific emergency needs.

Non-FEMA Disaster Declarations

Unique to Tribes is the fact that disaster declarations can also be granted by other federal agencies other than FEMA, such as the Department of Housing and Urban Development and the Bureau of Indian Affairs. In such cases, similar to a Presidentially Declared event, funds are designated to help the Tribes recover from the impact of disaster events, and customarily carry a match requirement. Those funds are limited to specific needs and are limited in nature.

5.1.2 State-Level Planning Initiatives

The Tribe must comply with all applicable Federal regulations, which many times are much more stringent than those regulations which state or local jurisdictions must address, placing a much heavier burden on the Tribe as they continue to grow and develop tribal lands. As a sovereign nation, the Tribe is not subject to state or local requirements; however, in the spirit of being a good neighbor and in partnership with the surrounding jurisdictions, the Tribe does consider its local communities in all of its planning initiatives. Some Tribal planning initiatives which the Tribe is undertaking also coincide with the following state planning initiatives:

- Guidelines for Greenhouse Gas Emissions
- Washington State Building Code
- Washington State Enhanced Hazard Mitigation Planning
- Snohomish and Skagit County Hazard Mitigation Planning

5.1.3 General Public Safety Information

Emergency Management:

Emergency management functions are the responsibility of the Tribal Police Department, but duties for emergency management planning are shared throughout several departments. The various Tribal departments have taken proactive steps to enhance the Tribe's capabilities with respect to emergency response and recovery efforts for both pre-and post-disaster efforts as discussed throughout this plan.

While many of these activities (such as this mitigation plan) have been grant funded through various federal programs, policy development to enhance resilience of the Tribe has been funded through other Tribal Funds, demonstrating the Tribe's commitment to developing a robust and applicable *all hazards* emergency management program. During the life cycle of this plan, the Tribe will continue to seek funds to assist in the development of various response plans, including potentially a: Comprehensive Emergency Management Plan (update); Continuity of Operation's Plan, and a Recovery Plan, which will further enhance the Tribe's resiliency to disasters.

National Incident Management System (NIMS):

The Tribe has adopted the National Incident Management System (NIMS) as its operating structure for emergency events.

Schools, Community Centers, and Shelters:

There are no elementary, middle, or high schools owned or operated by the Tribe on the Reservation; however, there is a day care facility, which is located in the community center. That facility also provides daily meals for seniors and does have a kitchen facility. There is also the Long House Pavilion, which is a culturally significant site on the reservation. If needed, those facilities could provide emergency shelters for cooling, warming, or feeding purposes, although they have not yet been designated in that capacity, nor ever used in that manner to date. The community center does have a generator, but the Long House Pavilion does not.

The Tribe does not own a designated Red Cross Shelter; however, in times of emergencies, the Angle of the Winds Casino Resort hotel could also be utilized as such for Tribal members as it is wholly self-sustaining, with its own water and power supply (generators), and is ADA compliant.

Evacuation Policy:

Currently the Tribe has no evacuation policy in place. Once the Hazard Mitigation Plan has been completed, the Tribe will utilize the data in the future for potential evacuation planning.

Disaster Declaration Policy:

The Tribe does have an established Disaster Declaration Policy which allows it to request disaster assistance directly to FEMA (and others). The Tribe does have the capacity to administer its own grant and recovery program and would be able to establish an Administrative Plan to administer and track any such grants it receives as a result of any disaster. The Tribe has previously gone directly to FEMA for disaster declarations, such as with the Oso Landslide. Completion of this mitigation plan is a required step in meeting the requirements for that effort.

Law Enforcement:

Law Enforcement services are provided by the Stillaguamish Police Department, who also provide assistance off the reservation to Snohomish County Sheriff's Department. The Tribe has no jail or holding facilities.

Gaming (Gambling) Enforcement

Gaming enforcement at the Angle of the Winds Casino is provided by Casino Security, with support from tribal police as needed.

Fish and Wildlife Enforcement

There is hunting and fishing enforcement by two Fish and Wildlife officers.

Tribal Court:

There is a Court facility housing a Court of General Jurisdiction, dealing with child welfare, delinquency, housing, and some domestic issues, as well as criminal court.

Hospital, Medical, Ambulance, Emergency Medical and Assisted Living Capabilities:

There is no hospital facility on the reservation, although they do have a medical clinic. Elder housing exists, which does provide for some assisted living space within each duplex (both single and two-bedroom units) by family members to the elders. The Tribe is in the development phase of additional elder housing, which will include additional space for individual care givers. Ambulance and emergency medical services are provided by the County and local fire district; the Casino does have emergency medical technicians on staff that are fully trained to provide emergency services as needed.

Fire Services:

Fire services are contracted through Snohomish County. The Tribe does have an excellent relationship with its fire service partners. Currently, the Tribe does have staff / tribal members trained in firefighting techniques.

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CHAPTER 6.
HAZARD IDENTIFICATION AND RISK ASSESSMENT METHODOLOGY

6.1 OVERIEW

The DMA requires measuring potential losses to critical facilities and property resulting from natural hazards. A hazard is an act or phenomenon that has the potential to produce harm or other undesirable consequences to a person or thing. Natural hazards can exist with or without the presence of people and land development. However, hazards can be exacerbated by societal behavior and practice, such as building in a floodplain, along a sea cliff, or on an earthquake fault. Natural disasters are inevitable, but the impacts of natural hazards can, at a minimum, be mitigated or, in some instances, prevented entirely. It should be noted that occurring simultaneous with this plan development is the COVID-19 Pandemic. During the final review phase, the Planning Team did identify the potential inclusion of a Global Virus in future plan updates.

The goal of the risk assessment is to determine which hazards present the greatest risk and what areas are the most vulnerable to hazards. The Stillaguamish Tribe is exposed to many natural and other hazards. The risk assessment and vulnerability analysis helps identify where mitigation measures could reduce loss of life or damage to property in the planning region. Each hazard-specific risk assessment provides risk-based information to assist the Tribe in determining priorities for implementing mitigation measures.

The risk assessment approach used for this plan entailed using geographic information system (GIS), Hazus hazard-modeling software, and hazard-impact data to develop vulnerability models for people, structures and critical facilities, and evaluating those vulnerabilities in relation to hazard profiles that model where hazards exist. This approach is dependent on the detail and accuracy of the data used. In all instances, this assessment used Best Available Science and data to ensure the highest level of accuracy possible.

This risk assessment is broken down into three phases, as follows:

> The first phase, hazard identification, involves the identification of the geographic extent of a hazard, its intensity, and its probability of occurrence (discussed below). This level of assessment typically involves producing a map. The outputs from this phase can be used for land use planning, management, and development of regulatory authority; public awareness and education; identifying areas which require further study; and identifying properties or structures appropriate for mitigation efforts, such as acquisition or relocation.
>
> The second phase, the vulnerability assessment, combines the information from the hazard identification with an inventory of the existing (or planned) property and population exposed to the hazard. It then attempts to predict how different types of property and population groups will be impacted or affected by the hazard of concern. This step assists in justifying changes to building codes or regulatory authority, property acquisition programs, such as those available through various granting opportunities; developing or modifying policies concerning critical or essential facilities, and public awareness and education.

The third phase, the risk analysis, involves estimating the damage, injuries, and costs likely to be incurred in the geographic area of concern over a period of time. Risk has two measurable components:

1. The magnitude of the harm that may result, defined through the vulnerability assessment; and
2. The likelihood or probability of harm occurring.

Utilizing those three phases of assessment, information was developed which identifies the hazards that affect the planning area, the likely location of natural hazard impact, the severity of the impact, previous occurrences, and the probability of future hazard events. That data, once complete, is utilized to complete the Risk Ranking process described in Chapter 14, which applies all of the data capture to the Calculated Priority Risk Index (CPRI).

The following is provided as the foundation for the standardized risk terminology utilized in this effort:

- Hazard: Natural, human caused or technological source or cause of harm or damage, demonstrated as actual (deterministic/historical events) or potential (probabilistic) events.
- Risk: The potential for an unwanted outcome resulting from a hazard event, as determined by its likelihood and associated consequences. For this plan, when possible, risk includes potential future losses based on probability, severity and vulnerability, expressed in dollar losses. In some instances, dollar losses are based on actual demonstrated impact, such as through the use of the Hazus model. In other cases, losses are demonstrated through exposure analysis due to the inability to determine the extent to which a structure is impacted.
- Extent and Location: The area of potential or demonstrated impact within the area in which the analysis is being conducted. In some instances, the area of impact is within a geographically defined area, such as a floodplain. In other instances, such as for severe weather, there is no established geographic boundary associated with the hazard, as it can impact the entire area.
- Severity/Magnitude: The extent or magnitude on which a hazard is ranked, demonstrated in various means, e.g., Richter Scale.
- Vulnerability: The degree of damage, e.g., building damage or the number of people injured.
- Probability of Occurrence and Return Intervals: These terms are used as a synonym for likelihood, or the estimation of the potential of an incident to occur.

6.2 HAZARD IDENTIFICATION AND PROFILES

For this plan, the planning partners and stakeholders considered the full range of natural hazards that could impact the planning area. The process incorporated review of state and local hazard planning documents, as well as information on the frequency, magnitude and costs associated with hazards that have impacted or could impact the planning area. Anecdotal information regarding natural hazards and the perceived vulnerability of the planning area's assets to them was also used. Based on the review, the planning team, at its kick-off meeting, identified the following natural hazards that this plan addresses as the hazards of concern:

- Earthquake
- Flood / Dam
- Landslide

- Severe Weather
- Volcano
- Wildfire

The list of hazards remain consistent with the previous plan, with slight modifications to expand Severe Weather, and to include discussion on Climate Change within each profile. Based on the full spectrum of hazards addressed, it is the intent of the Tribe to use this risk assessment in lieu of preparing a separate hazard identification and vulnerability assessment for other planning efforts which may require same.

The hazard profiles describe the risks associated with identified hazards of concern. Each chapter describes the hazard, the planning area's vulnerabilities, and, when possible, probable event scenarios. The following steps were used to define the risk of each hazard:

Identify and profile the following information for each hazard:

- General overview and description of hazard;
- Identification of previous occurrences;
- Geographic areas most affected by the hazard;
- Event frequency estimates;
- Severity estimates;
- Warning time likely to be available for response;
- Risk and vulnerability assessment, which includes identification of impact on people, property, economy, and the environment.

6.3 RISK ASSESSMENT PROCESS AND TOOLS

The hazard profiles and risk assessments describe the risks associated with each identified hazard of concern. Each chapter describes the hazard, the planning area's vulnerabilities, and probable event scenarios. Chapter 144 summarizes all of the analysis completed by way of completion of the Calculated Priority Risk Index (CPRI) for hazard ranking.

Once the profiles were completed, the following steps were used to define the risk vulnerability of each hazard:

- Determine exposure to each hazard—Exposure was determined by overlaying hazard maps with an inventory of structures, facilities, and systems to determine which of them would be exposed to each hazard.
- Assess the vulnerability of exposed facilities—Vulnerability of 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 Hazus (discussed below) were used in this assessment.
- Where specific quantitative assessments could not be completed, vulnerability was measured in general, qualitative term, summarizing the potential impact based on past occurrences, spatial extent, and subjective damage and casualty potential. Those items were categorized utilizing the criteria established in the CPRI (see below).

- The final step in the process was to assign a significance level determined by review of the results of vulnerability based on the CPRI schedule, assigning a final qualitative assessment based on the following classifications:
  - Extremely Low—The occurrence and potential cost of damage to life and property is very minimal to nonexistent.
  - Low—Minimal potential impact. The occurrence and potential cost of damage to life and property is minimal.
  - Medium—Moderate potential impact. This ranking carries a moderate threat level to the general population and/or built environment. Here the potential damage is more isolated and less costly than a more widespread disaster.
  - High—Widespread potential impact. This ranking carries a high threat to the general population and/or built environment. The potential for damage is widespread. Hazards in this category may have occurred in the past.
  - Extremely High—Very widespread with catastrophic impact.

6.3.1 Calculated Priority Risk Index Scoring Criteria

For the 2020 update, the Planning Team utilized a Calculated Priority Risk Index Score for each hazard of concern, addressing impact primarily at the reservation level. In some cases, this may include areas off the reservation, but vulnerabilities are focused on tribal-owned structures. Vulnerabilities are described in terms of critical facilities, structures, population, economic values, and functionality of government which can be affected by the hazard event as identified in the below tables. Hazard impact areas describe the geographic extent a hazard can impact the tribe and are uniquely defined on a hazard-by-hazard basis. Mapping of the hazards, where spatial differences exist, allows for hazard analysis by geographic location. Some hazards can have varying levels of risk based on location. Other hazards cover larger geographic areas and affect the area uniformly. Therefore, a system must be established which addresses all elements (people, property, economy, continuity of government) in order to rate each hazard consistently. The use of the Calculated Priority Risk Index allows such application, based on established criteria of application to determine the risk factor. For identification purposes, the six criteria on which the CPRI is based are probability, magnitude, geographic extent and location, warning time/speed of onset, and duration of the event. Those elements are further defined as follows:

Probability

Probability of a hazard event occurring in the future was assessed based on hazard frequency over a 100-year period (where available). Hazard frequency was based on the number of times the hazard event occurred divided by the period of record. If the hazard lacked a definitive historical record, the probability was assessed qualitatively based on regional history and other contributing factors. Probability of occurrence was assigned a 40% weighting factor, and was broken down as follows:

Rating	Likelihood	Frequency of Occurrence
1	Unlikely	Less than 1% probability in the next 100 years.
2	Possible	Between 1% and 10% probability in the next year, or at least one chance in the next 100 years.
3	Likely	Between 10% and 100% probability in next year, or at least one chance in the next 10 years.
4	Highly Likely	Greater than 1 event per year (frequency greater than 1).

Magnitude

The magnitude of potential hazard events was evaluated for each hazard. Magnitude is a measure of the strength of a hazard event and is usually determined using technical measures specific to the hazard. Magnitude was calculated for each hazard where property damage data was available and was assigned a 25% weighting factor. Magnitude calculation was determined using the following: *Property Damage / Number of Incidents) / $ of Building Stock Exposure = Magnitude.* In some cases, the Hazus model provided specific people/dollar impact data. For other hazards, a GIS exposure analysis was conducted. Magnitude was broken down as follows:

Rating	Magnitude	Percentage of People and Property Affected
1	Negligible	Less than 5% Very minor impact to people, property, economy, and continuity of government at 90%.
2	Limited	6% to 24% Injuries or illnesses minor in nature, with only slight property damage and minimal loss associated with economic impact; continuity of government only slightly impacted, with 80% functionality.
3	Critical	25% to 49% Injuries result in some permanent disability; 25-49% of population impacted; moderate property damage ; moderate impact to economy, with loss of revenue and facility impact; government at 50% operational capacity with service disruption more than one week, but less than a month.
4	Catastrophic	More than 50% Injuries and illness resulting in permanent disability and death to more than 50% of the population; severe property damage greater than 50%; economy significantly impacted as a result of loss of buildings, content, inventory; government significantly impacted; limited services provided, with disruption anticipated to last beyond one month.

Extent and Location

The measure of the percentage of the people and property within the planning area impacted by the event, and the extent (degree) to which they are impacted. Extent and location were assigned a weighting factor of 20%, and broken down as follows:

Rating	Magnitude	Percentage of People and Property Affected
1	Negligible	Less than 10% Few if any injuries or illness. Minor quality of life lost with little or no property damage. Brief interruption of essential facilities and services for less than four hours.
2	Limited	10% to 24% Minor injuries and illness. Minor, short term property damage that does not threaten structural stability. Shutdown of essential facilities and services for 4 to 24 hours.
3	Critical	25% to 49% Serious injury and illness. Major or long-term property damage, that threatens structural stability. Shutdown of essential facilities and services for 24 to 72 hours.
4	Catastrophic	More than 50% Multiple deaths Property destroyed or damaged beyond repair Complete shutdown of essential facilities and services for 3 days or more.

Warning Time/Speed of Onset

The rate at which a hazard occurs, or the time provided in advance of a situation occurring (e.g., notice of a cold front approaching or a potential hurricane, etc.) provides the time necessary to prepare for such an event. Sudden-impact hazards with no advanced warning are of greater concern. Warning Time/Speed of onset was assigned a 10% weighting factor, and broken down as follows:

Rating	Probable amount of warning time
1	More than 24 hours warning time.
2	12-24 hours warning time.
3	5-12 hours warning time.
4	Minimal or no warning time.

Duration

The time span associated with an event was also considered, the concept being the longer an event occurs, the greater the threat or potential for injuries and damages. Duration was assigned a weighting factor of 5%, and was broken down as follows:

Rating	Duration of Event
1	6-24 hours
2	More than 24 hours
3	Less than 1 week
4	More than 1 week

Chapter 14 summarizes all of the analysis conducted by way of completion of the Calculated Priority Risk Index (CPRI) for hazard ranking.

6.3.2 Hazus and GIS Applications

Earthquake and Flood Modeling Overview

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, with new models for estimating potential losses from hurricanes and floods.

Hazus 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 facility, transportation and utility lifeline, and 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 as mitigation planning efforts evolve.
- Facilitates the review of mitigation plans because it helps to ensure that FEMA methodologies are incorporated.
- Supports grant applications by calculating benefits using FEMA definitions and terminology.

- Produces hazard data and loss estimates that can be used in communication with local stakeholders.
- Is administered by the tribal or local government and can be used to manage and update a hazard mitigation plan throughout its implementation.

Levels of Detail for Evaluation

HAZUS provides default data for inventory, vulnerability, and hazards; this default data can be supplemented with local data to provide a more refined analysis. 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 requires detailed engineering and geotechnical information to customize it for the planning area.

Building Inventory

A User Defined Facility approach was used to model exposure and vulnerability to the critical infrastructure identified during this process. GIS building data utilizing detailed structure information for tribal facilities was loaded into the GIS and Hazus model. Building information was developed using best available Tribal data, including building address points, aerial imagery, and Tribal staff resources. Building and content replacement values were estimated using values from various sources, including valuation by Tribal staff.

Hazus Application for This Plan

The following methods were used to assess specific hazards for this plan:

- **Flood**—A Hazus Level 2 analysis was performed. Analysis was based on current FEMA regulatory 100- and 500-year flood hazard data. The 2019 Snohomish County FIRM and the 1989 Skagit County FIRM was utilized for this analysis. Based on review of that data, there are two Tribal structures exposed to the flood hazard as identified in the FIRMs.
- **Earthquake**—A Hazus Level 2 analysis was performed to assess earthquake risk and exposure. Earthquake shake maps prepared by the U.S. Geological Survey (USGS) were used for the analysis of this hazard. A modified version of the National Earthquake Hazard Reduction Program (NEHRP) soils inventory was used. One scenario event was modeled:
  - The scenario events utilized were the Devils Mountain M7.5 Earthquake and the Cascadia M9.0 Earthquake.

Drought, Landslide, Severe Weather, Volcano, and Wildfire

For drought, landslide, severe weather and wildfire, historical data is not adequate to model future losses as no specific damage functions have been developed. However, GIS is able to map hazard areas and calculate exposure if geographic information is available with respect to the location of the hazard and inventory data. Areas and inventory susceptible to some of the hazards of concern were mapped and exposure was evaluated. For other hazards, a qualitative analysis was conducted using the best available data and professional judgment. Locally relevant information was gathered from a variety of sources. Frequency and severity indicators include past events and the expert opinions of geologists, tribal staff, emergency management personnel and others. The primary data source was Tribal staff, including various GIS data sets, augmented with county, state, and federal datasets. Additional data sources for specific hazards were as follows:

Drought—The risk assessment methodologies used for this plan focus on damage to structures. Because drought does not impact structures, the risk assessment for drought was more limited and qualitative than the assessment for the other hazards of concern. The impact from drought also references fish loss associated with the negative impact of climate change on water levels, and sedimentation issues resulting from drought situations.

Landslide—Historic landslide hazard data was used to assess exposure to landslides using Washington State Department of Ecology Landslide Susceptibility data. This data depicts landslide susceptibility at a 10-meter resolution across the state of Washington. Utilizing elevation data and WA DNR identified slope susceptibility at anything greater than 40 percent slope, a 100' buffer was used to identify potential critical facilities falling within these potential landslide hazard areas. It should be noted that *this data is for mitigation planning purposes only, and should not be considered for life safety matters.* No landslide hazard analysis was conducted, but rather, only reprojection of existing data. Additional landslide data is available at: http://www.dnr.wa.gov/programs-and-services/geology/geologic-hazards/landslides

Severe Weather—Severe weather data was downloaded from various sources, including the Natural Resources Conservation Service and the National Climatic Data Center, PRISM, Tornado Project, and other sources as referenced. A lack of data separating severe weather damage from flooding, windstorms, and landslide damage prevented a detailed analysis for exposure and vulnerability, as well as the fact that there is no generally accepted damage functions for the hazard. For planning purposes, it is assumed that the entire planning area is exposed to some extent to severe weather. Certain areas are more exposed due to geographic location and local weather patterns, as well as the response capabilities of local first responders.

Volcano - There are currently no generally accepted damage functions for volcanic hazards in risk assessment platforms such as Hazus or any GIS system for the ash fall associated with the hazard. There would also be too many variables to associate with any type of plume modeling for ash. No historical data was available specifically for the Tribe with respect to impact and losses associated with the eruption of Mount St. Helens on which impact could be based. Therefore, for planning purposes, it is assumed that the entire planning area is exposed to some extent to ash accumulations from eruption of either Mt. Baker or Glacier Peak. Those structures would be vulnerable to the excessive weight of tephra and rainfall. Certain areas are more exposed to ash accumulations due to geographic location and local weather patterns, as well as the response capabilities of local first responders. In addition to the ashfall, Lahar inundation zones were also identified, with identification of the area and critical facilities impacted.

Wildfire— There is currently no validated damage function available to support wildfire mitigation planning because no such damage functions have been generated. Instead, dollar loss estimates were developed by calculating the value of exposed structures identified utilizing the various LANDFIRE Fire Regime (1-5) datasets. Information on wildfire analysis was captured from various sources, including Washington State Department of Natural Resources, Wildfire Protection data,, US Forest Service data, LAND FIRE data, and Wildland Urban Interface Zone data, among other sources as available for the tribal planning area.

6.3.3 Probability of Occurrence and Return Intervals

Natural hazard events with relatively long return periods, such as a 100-year flood or a 500-year earthquake, are often thought to be very unlikely. In reality, the probability that such events occur over the next 30 or 50 years is relatively high.

Natural hazard events with very long return periods, such as 100 or 500 or 1,000 years, have significant probabilities of occurring during the lifetime of a building:

- Hazard events with return periods of 100 years have probabilities of occurring in the next 30 or 50 years of about 26 percent and about 40 percent, respectively.
- Hazard events with return periods of 500 years have about a 6 percent and about a 10 percent chance of occurring over the next 30 or 50 years, respectively.
- Hazard events with return periods of 1,000 years have about a 3 percent chance and about a 5 percent chance of occurring over the next 30 or 50 years, respectively.

For life safety considerations, even natural hazard events with return periods of more than 1,000 years are often deemed significant if the consequences of the event happening are very severe (extremely high damage and/or substantial loss of life). For example, the seismic design requirements for new construction are based on the level of ground shaking with a return period of 2,475 years (2 percent probability in 50 years). Providing life safety for this level of ground shaking is deemed necessary for seismic design of new buildings to minimize life safety risk. Of course, a hazard event with a relatively long return period may occur tomorrow, next year, or within a few years. Return periods of 100 years, 500 years or 1,000 years mean that such events have a 1 percent, a 0.2 percent or a 0.1 percent chance of occurring in any given year.

6.4 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 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 for planning purposes; not life-safety measures.*

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CHAPTER 7. DROUGHT

7.1 GENERAL BACKGROUND

DEFINITIONS

Drought—The cumulative impacts of several dry years on water users and agricultural producers. It can include deficiencies in surface and subsurface water supplies and cause impacts to health, well-being, and quality of life.

Hydrological Drought—Deficiencies in surface and subsurface water supplies.

Socioeconomic Drought—Drought impacts on health, well-being, and quality of life.

Droughts originate from a deficiency of precipitation resulting from an unusual weather pattern. If the weather pattern lasts a short time (a few weeks or a couple of months), the drought is considered short-term. If the weather pattern becomes entrenched and the precipitation deficits last for several months or years, the drought is considered long-term. It is possible for a region to experience a long-term circulation pattern that produces drought, and to have short-term changes in this long-term pattern that result in short-term wet spells. Likewise, it is possible for a long-term wet circulation pattern to be interrupted by short-term weather spells that result in short-term drought.

Drought is a prolonged period of dryness severe enough to reduce soil moisture, water, and snow levels below the minimum necessary for sustaining plant, animal, and economic systems. Droughts are a natural part of the climate cycle. For this plan, the County has elected to use Washington's statutory definition of drought (RCW Chapter 43.83B.400), which is based on both of the following conditions occurring:

- The water supply for the area is below 75 percent of normal.
- Water uses and users in the area will likely incur undue hardships because of the water shortage.

7.2 HAZARD PROFILE

7.2.1 Extent and Location

Drought can have a widespread impact on the environment and the economy, depending upon its severity, although it typically does not result in loss of life or damage to property, as do other natural disasters. The National Drought Mitigation Center uses three categories to describe likely drought impacts:

- Agricultural—Drought threatens crops that rely on natural precipitation, while also increasing the potential for infestation.
- Water supply—Drought threatens supplies of water for irrigated crops, for communities and for fish and salmon and other species of wildlife.
- Fire hazard—Drought increases the threat of wildfires from dry conditions in forest and rangelands.

In Washington, where hydroelectric power plants generate nearly three-quarters of the electricity produced, drought also threatens the supply of electricity. Unlike most disasters, droughts normally occur slowly but last a long time. Drought conditions occur every few years in Washington. The droughts of 1977 and 2001 (discussed below), the worst and second worst in state history, provide good examples of how drought can affect the state.

On average, the nationwide annual impacts of drought are greater than the impacts of any other natural hazard. They are estimated to be between $6 billion and $8 billion annually in the United States and occur primarily in the agriculture, transportation, recreation and tourism, forestry, and energy sectors. Social and environmental impacts are also significant, although it is difficult to put a precise cost on these impacts.

Drought affects groundwater sources, but generally not as quickly as surface water supplies, although groundwater supplies generally take longer to recover. Reduced precipitation during a drought means that groundwater supplies are not replenished at a normal rate. This can lead to a reduction in groundwater levels and problems such as reduced pumping capacity or wells going dry. Shallow wells are more susceptible than deep wells. About 16,000 drinking water systems in Washington get water from the ground; these systems serve about 5.2 million people. Reduced replenishment of groundwater affects streams. Much of the flow in streams comes from groundwater, especially during the summer when there is less precipitation and after snowmelt ends. Reduced groundwater levels mean that even less water will enter streams when steam flows are lowest. Reduced water levels in wells also means that the wells are subject to saltwater intrusion.

The area’s drinking water on the reservation comes from the local watersheds and is provided from privately-owned wells. Drought conditions within the planning area may increase pressure on local aquifers, with increased pumping potentially resulting in saltwater intrusion into freshwater aquifers. This, in turn, could cause restrictions on economic growth and development, impacting the economy.

7.2.2 Previous Occurrences

In the past century, Washington has experienced a number of drought episodes, including several that lasted for more than a single season—1928 to 1932, 1992 to 1994, and 1996 to 1997. Table 7-1 identifies additional drought occurrences in the state. The 1977 drought was the worst on record, but the 2001 drought came close to surpassing it in some respects. Table 7-2 has data on how the two droughts affected Washington by late September of their respective years.

TABLE 7-1
DROUGHT OCCURRENCES

July-August 1902	No measurable rainfall in Western Washington
August 1919	Drought and hot weather occurred in Western Washington
July – August 1921	Drought in all agricultural sections.
June-August 1922	The statewide precipitation averaged 0.10 inches.
March – August 1924	Lack of soil moisture retarded germination of spring wheat.
July 1925	Drought occurred in Washington
July 21-August 25, 1926	Little or no rainfall was reported.
June 1928-March 1929	Most stations averaged less than 20 percent of normal rainfall for August and September and less than 60 percent for nine months.
July – August 1930	Drought affected the entire state. Most weather stations averaged 10 percent or less of normal precipitation.
April 1934-March 1937	The longest drought in the region’s history – the driest periods were April-August 1934, September-December 1935, and July-January 1936-1937.
May – September 1938	Driest growing season in Western Washington.
1952	Every month was below normal precipitation except June. The hardest hit areas were Puget Sound and the central Cascades.

TABLE 7-1
DROUGHT OCCURRENCES

January – May 1964	Drought covered the southwestern part of the state. Precipitation was less than 40 percent of normal.
Spring 1966	Drought throughout Washington
June – August 1967	Drought throughout Washington
January – August 1973	Dry in the Cascades.
October 1976 – September 1977	Worst drought in Pacific Northwest history. Below normal precipitation in Olympia, Seattle, and Yakima. Crop yields were below normal and ski resorts closed for much of the 1976-77 season. The 1977 drought led to widespread water shortages and severe water conservation measures throughout Washington. More than 70 public and private drinking-water operations reported water-supply problems. Wheat and cattle were the most seriously affected agricultural products in the state. The Federal Power Commission ordered public utilities on the Columbia River to release water to help fish survive. Agriculture experienced drought-related losses of more than $400 million.
2001	Governor declared statewide Stage 2 drought in response to severe dry spell.
June – September 2003	Federal disaster number 1499 assigned to 15 counties. The original disaster was for flooding, but several jurisdictions were included because of previous drought conditions. The 2001 drought came on fairly rapidly. Between November 2000 and March 2001, most of the state's rainfall and snowpack totals were only about 60 percent of normal. The 2001 event was a result of warm weather melting snowpack into streams a month earlier than normal. Nine large utility companies statewide advised the Washington State Department of Health that they were highly vulnerable to the drought. Washington declared a statewide drought emergency on March 14, 2001. As a result of the 2001 drought, 90,000 acres of agricultural land were taken out of production; thousands of acres of orchards were unused, and the sugar beet industry was out of production.
March 10, 2005 Governor Declared Drought	Precipitation levels was below or much below the average from November through February, with extremely warm fall and winter months, adversely affecting the state's mountain snowpack. A warm mid-January removed much of the remaining snowpack, with March projections at 66 percent of normal, indicating that Washington might be facing a drought as bad as, or worse, than the 1977 drought. Late March rains filled reservoirs to about 95 percent. State legislature approved $12 million supplemental budget that provided funds to buy water, improve wells, and implement other emergency water supply projects. Wildfires numbers was about 75 percent of previous five years, but acreage burned was three times greater.

TABLE 7-1 DROUGHT OCCURRENCES	
2015	2015 was the year of the "snowpack drought." Washington State had normal or near-normal precipitation over the 2014-2015 winter season. However, October through March the average statewide temperature was 40.5 degrees Fahrenheit, 4.7 degrees above the 20th century long-term average and ranking as the warmest October through March on record. Washington experienced record low snowpack because mountain precipitation that normally fell as snow instead fell as rain. The snowpack deficit then was compounded as precipitation began to lag behind normal levels in early spring and into the summer. With record spring and summer temperatures, and little to no precipitation over many parts of the state, the snowpack drought morphed into a traditional precipitation drought, causing injury to crop and aquatic species. Many rivers and streams experienced record low flows. (See Figure 6-1.)
2019	As of May 20, 2019, Governor Jay Inslee issued an emergency drought declaration in 24 watersheds statewide (see Figure 7-2). According to the Washington State Department of Ecology, very dry conditions over the past several months and a diminished snowpack impacted streamflow, which were identified to be well below normal conditions across most of the state (see Figure 6-3).[4] Watersheds west of the Cascades crest, which are more rain dependent than rivers on the east side, flowed at much below normal levels. Some rivers set record daily lows for historic May flows. Statewide, at the time the declaration was ordered, only four (4) percent of rivers were flowing at levels above normal. Streamflows were strong in the southeast corner of the state. Twenty-seven out of 62 watersheds were declared for drought as of May 20, 2019. Skagit County and several of its watersheds were among the Counties identified as having a drought emergency. On August 29, 2019, the USDA designated Skagit County as one of the four areas identified as sustaining a natural disaster due to the drought.

[4] Source: https://waterwatch.usgs.gov/?m=real&r=wa

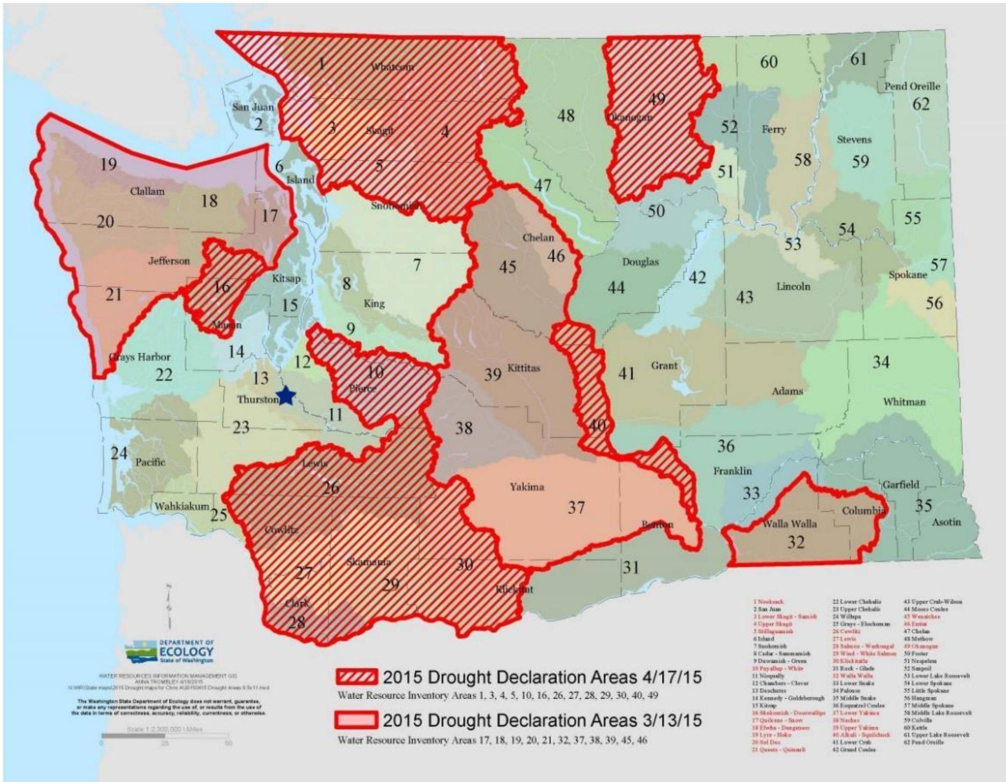

Figure 7-1 Washington State Department of Ecology 2015 Drought Map

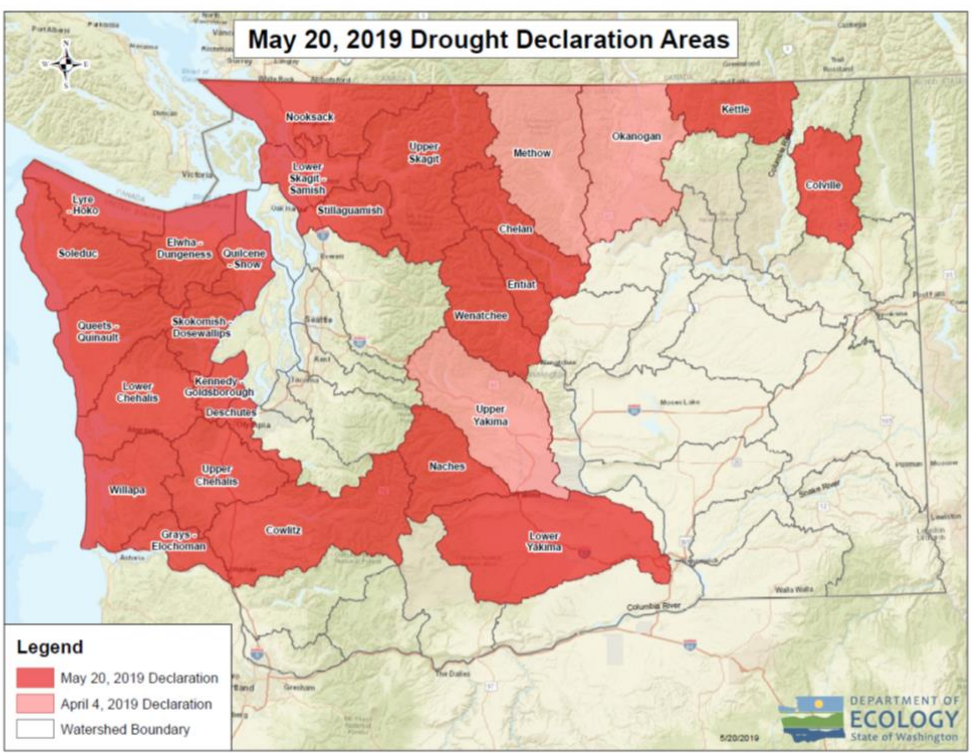

Figure 7-2 Washington State Department of Ecology May 2019 Drought Declaration Areas

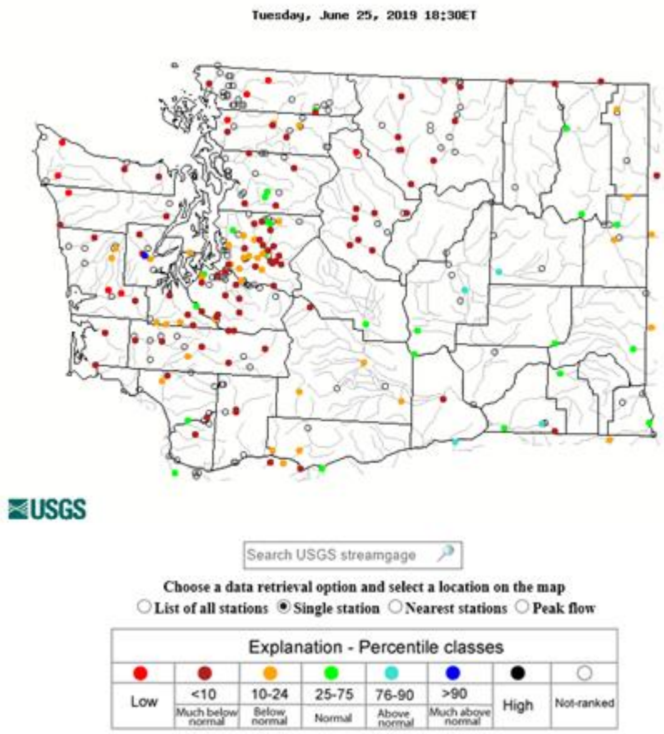

Figure 7-3 USGS Streamflow Comparison for Day of Year

TABLE 7-2
COMPARISON OF IMPACTS OF 1977 DROUGHT TO 2001 DROUGHT

Impact	1977 Drought	2001 Drought
Precipitation	Precipitation at most locations ranged from 50 to 75% of normal levels, and in parts of Eastern Washington as low as 42 to 45% of normal.	Precipitation was 56 to 74% of normal. U.S. Bureau of Reclamation – Yakima Project irrigators received only 37% of their normal entitlements. At the end of the irrigation season, the Bureau of Reclamation's five reservoirs stored only 50,000 acre-feet of water compared with 300,000 acre-feet typically in storage.
Wildland Fire	1,319 wildland fires burned 10,800 acres. State fire-fighting activities involved more than 7,000 man-hours and cost more than $1.5 million.	1,162 wildland fires burned 223,857 acres. Firefighting efforts cost the state $38 million and various local, regional, and federal agencies another $100 million.
Fish	In August and September 1977, water levels at the Goldendale and Spokane trout hatcheries were down. Fish had difficulties passing through Kendall Creek, a tributary to the north fork of the Nooksack River in Whatcom County.	A dozen state hatcheries took a series of drought-related measures, including installing equipment at North Toutle and Puyallup hatcheries to address low water flow problems.

TABLE 7-2
COMPARISON OF IMPACTS OF 1977 DROUGHT TO 2001 DROUGHT

Impact	1977 Drought	2001 Drought
Emergency Water Permits	Department of Ecology issued 517 temporary groundwater permits to help farmers and communities drill more wells.	Department of Ecology issued 172 temporary emergency water-right permits and changes to existing water rights.
Economic Impacts	The state's economy lost an estimated $410 million over a two-year period. The drought hit the aluminum industry hardest. Major losses in agriculture and service industries included a $5 million loss in the ski industry. 13,000 jobs were lost because of layoffs in the aluminum industry and in agriculture.	The Bonneville Power Administration paid more than $400 million to electricity-intensive industries to shut down and remain closed for the duration of the drought. Thousands lost their jobs for months, including 2,000-3,000 workers at the Kaiser and Vanalco plants. Federal agencies provided more than $10.1 million in disaster aid to growers. More than $7.9 million in state funds paid for drought-related projects; these projects enabled the state to provide irrigation water to farmers with junior water rights and to increase water in fish-bearing streams.

7.2.3 Severity

In 1989, the Washington State Legislature gave permanent drought relief authority to the Department of Ecology and enabled them to issue orders declaring drought emergencies. (RCW 43.83B.400-430 and Chapter 173-166 WAC). In Washington State, the statutory criteria for drought is a water supply below 75% of normal and a shortage expected to create undue hardship for some water users.

While droughts customarily do not directly impact structures, droughts do impact individuals (farmers, laborers, etc.), the agricultural and natural resource industries, and other precipitation-dependent sectors. Lack of snowpack has forced ski resorts into bankruptcy. There is increased danger of forest /wildland fires. Millions of board feet of timber have been lost. Loss of forests and trees increases erosion, causing damage to aquatic life, irrigation, and power development by heavy silting of streams, reservoirs, and rivers. The health of forests is also a concern with respect to infestation associated with weakened trees due to drought.

Nearly all areas of Washington are vulnerable to drought. The coastal areas of Washington, the Olympic Peninsula, and areas in Central Washington just east of the Cascades are particularly vulnerable. High quality agricultural soils exist in Snohomish County. These areas sustain crops that are dependent upon moisture through the winter and spring and dryer conditions in the summer.

The severity of a drought depends on the degree of moisture deficiency, the duration, and the size and location of the affected area. The longer the duration of the drought and the larger the area impacted, the more severe the potential impacts. Droughts are not usually associated with direct impacts on people or property, but they can have significant impacts on agriculture, wildlife, and fishing, which can impact people indirectly. When measuring the severity of droughts, analysts typically look at economic impacts.

A drought lasting for more than one season would most likely reduce the annual snowpack accumulated at high elevations in the Cascade Mountains, thereby reducing normal stream flows in local rivers and creeks. Should an extreme, long-term drought occur, a large portion of the population of area would be impacted. As of this 2019 writing, many areas of the state are experiencing drought conditions. Many have instituted voluntary water conservation measures, particularly those communities which receive water supplies from the depleted watersheds.

The water supply for the planning area is obtained from the Stillaguamish River or large creeks with reliable, glacial sources. The effects of an extreme, long-term drought could result in inadequate streams flows and ground water recharge, thereby resulting in the implementation of strict water conservation measures. A severe drought may result in large numbers of wells going dry. Residents and guests to the Reservation rely on private wells or private water systems for their domestic water supply.

A substantial reduction in stream flows could severely impact the generation of electricity from the hydro-electric dams. A reduction in hydro-electric generation will result in increased electricity rates or could also result in brown outs.

The National Oceanic and Atmospheric Administration (NOAA) has developed several indices to measure drought impacts and severity to map their extent and locations. The Palmer Drought Severity Index (PDSI) and Crop Moisture Index (CMI) are indices of the relative dryness or wetness effecting water sensitive economies. The PDSI indicates the prolonged and abnormal moisture deficiency or excess. The CMI gives the short-term or current status of purely agricultural drought or moisture surplus and can change rapidly from week to week. Both indices indicate general conditions and not local variations caused by isolated rain. Input to the calculations include the weekly precipitation total and average temperature, division constants (water capacity of the soil, etc.) and previous history of the indices.

The PDSI is an important climatological tool for evaluating the scope, severity, and frequency of prolonged periods of abnormally dry or wet weather. It can be used to help delineate disaster areas and indicate the availability of irrigation water supplies, reservoir levels, range conditions, amount of stock water, and potential intensity of forest fires. The CMI can be used to measure the status of dryness or wetness affecting warm season crops and field activities.

What follow are a series of maps indicating current conditions as it relates to Drought. These maps change very frequently and are intended to demonstrate information available to viewers. Additional information and current monthly data are available from the NOAA website: http://www.ncdc.noaa.gov/oa/climate/research/prelim/drought/palmer.html

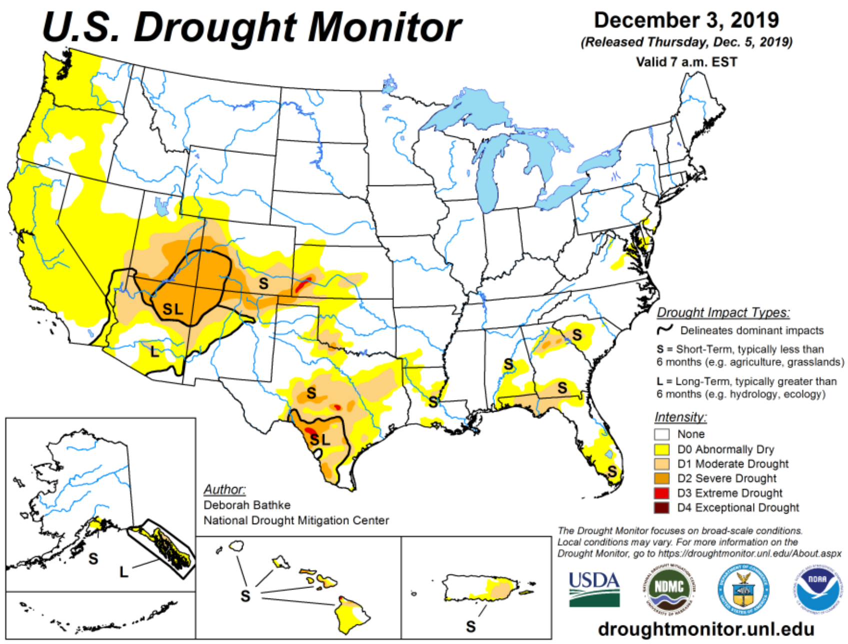

Figure 7-4 December 2019 Washington Drought Monitor

Source: NOAA http://go.usa.gov/3eZGd

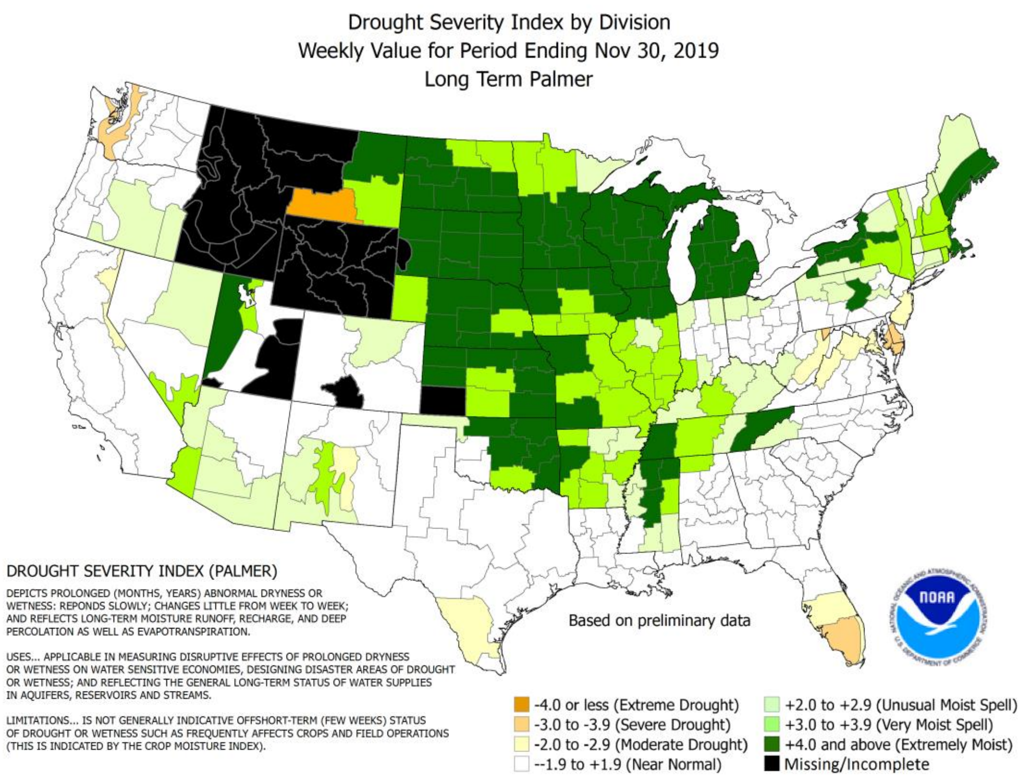

Figure 7-5 Palmer Drought Severity Index - November 2019

The ***Palmer Crop Moisture Index*** measures short-term drought on a weekly scale and is used to quantify drought's impacts on agriculture during the growing season. See figure below for the current information available as of this update.

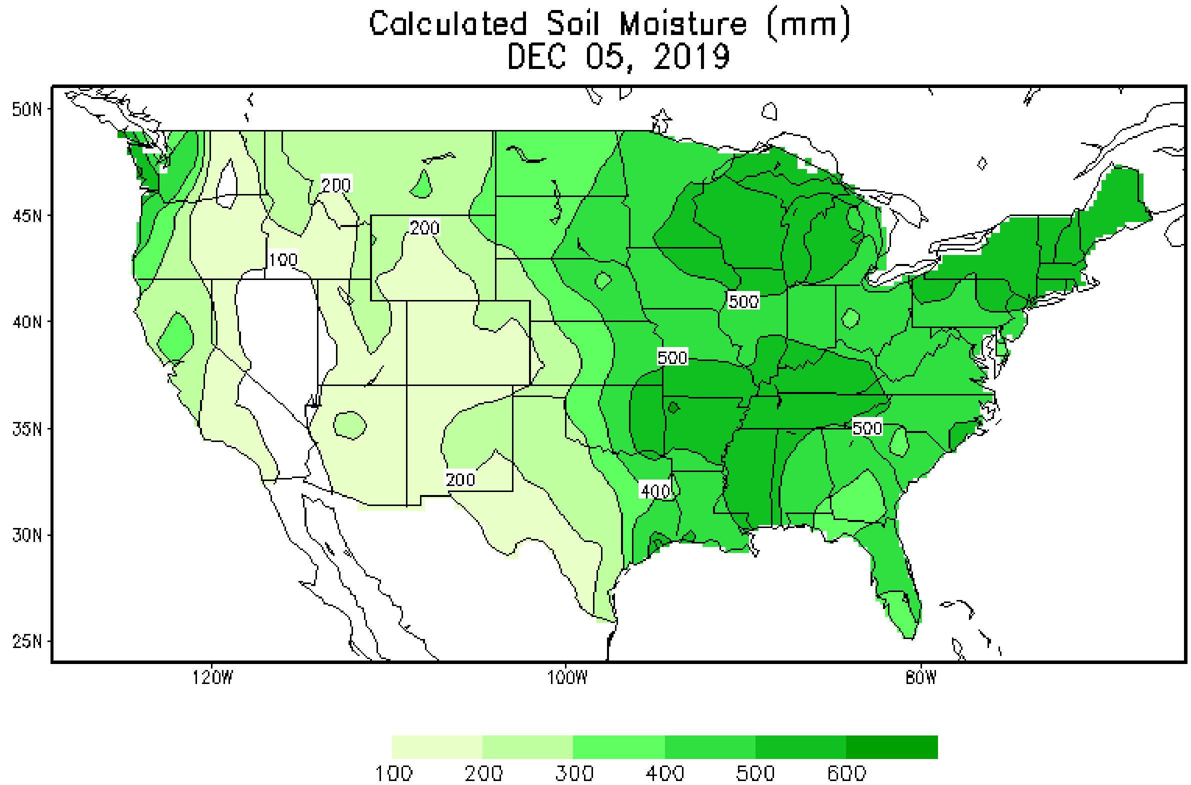

Figure 7-6 Palmer Crop Moisture Index

7.2.4 Frequency

Empirical studies conducted over the past century have shown that meteorological drought is never the result of a single cause. It is the result of many causes, often synergistic in nature; these include global weather patterns that produce persistent, upper-level high-pressure systems along the West Coast with warm, dry air resulting in less precipitation.

In temperate regions, including Washington, long-range forecasts of drought have limited reliability. In the tropics, empirical relationships have been demonstrated between precipitation and El Niño events, but few such relationships have been demonstrated above 30º north latitude. Meteorologists do not believe that reliable forecasts are attainable at this time a season or more in advance for temperate regions.

A great deal of research has been conducted in recent years on the role of interacting systems in explaining regional and even global patterns of climatic variability. These patterns tend to recur periodically with enough frequency and with similar characteristics over a sufficient length of time that they offer opportunities to improve the ability for long-range climate prediction. However, too many variables exist in determining the frequency with which a drought will occur.

According to the Washington State Hazard Mitigation Plan data (2012) "At this time, reliable forecasts of drought are not attainable for temperate regions of the world more than a season in advance. However, based on a 100-year history with drought, the state as a whole can expect severe or extreme drought at least

5 percent of the time in the future, with most of eastern Washington experiencing severe or extreme drought about 10 to 15 percent of the time." (WA EMD, 2012)

7.3 VULNERABILITY ASSESSMENT

7.3.1 Overview

Drought produces a complex web of impacts that spans many sectors of the economy and reaches well beyond the area experiencing physical drought. This complexity exists because water is integral to the ability to produce goods and provide services. Drought can affect a wide range of economic, environmental, and social activities. The vulnerability of an activity associated with the effects of drought usually depends on its water demand, how the demand is met, and what water supplies are available to meet the demand.

All people, property and environments in the planning area could be exposed to some degree to the impacts of moderate to extreme drought. Areas densely wooded, especially areas in parks which host campers, increase the exposure to forest fires. Additional exposure comes in the form of economic impact should a prolonged drought occur that would impact fishing, fish rearing, recreation, agriculture, and timber harvesting—primary sources of income in the planning area. Prolonged drought would also decrease capacity within the watersheds, thereby reducing fish runs and, potentially, spawning areas.

The Washington State Enhanced Hazard Mitigation plan has established criteria on which it defines jurisdictions as being vulnerable to drought, changing the 2018 methodology from that in previous plan editions. To that degree, the State's plan identifies the tribal planning area among those areas referenced as being in a "medium-low" status with respect to vulnerability to drought in the Washington State Enhanced Hazard Mitigation Plan (see Figure 7-7).

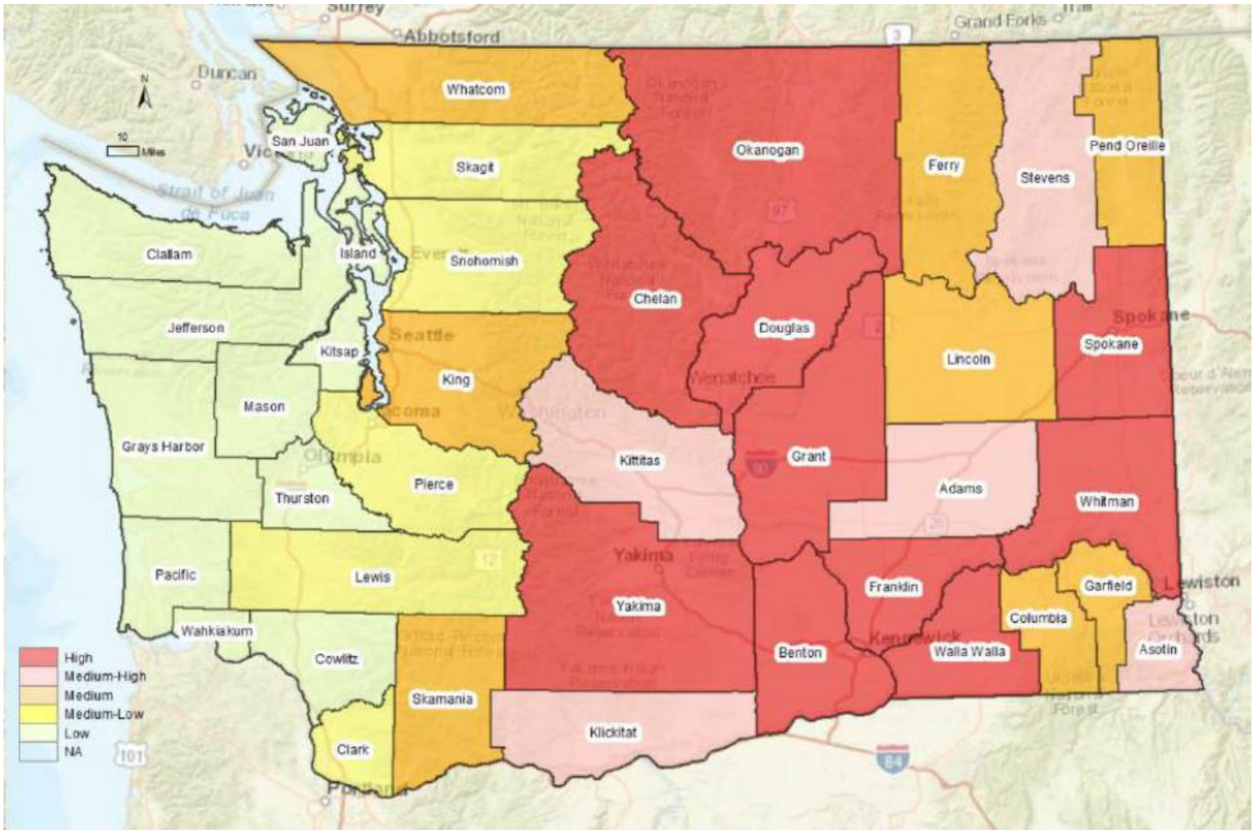

Figure 7-7 WA EMD Drought Risk Index (2018)

Warning Time

A drought is not a sudden-onset hazard. Droughts are climatic patterns that occur over long periods, providing for some advance notice. In many instances, annual situations of low water levels are identified months in advance (e.g., snowpack at lower levels are identified during winter months), allowing for advanced planning for water conservation.

Meteorological drought is the result of many causes, including global weather patterns that produce persistent, upper-level high-pressure systems along the West Coast resulting in less precipitation. Only general warning can take place, due to the numerous variables that scientists have not pieced together well enough to make accurate and precise predictions. It is often difficult to recognize a drought before being in the middle of it. Droughts do not occur spontaneously; they evolve over time as certain conditions are met.

Scientists do not know how to predict drought more than a month in advance for most locations. Predicting drought depends on the ability to forecast precipitation and temperature. Weather anomalies may last from several months to several decades. How long they last depend on interactions between the atmosphere and the oceans, soil moisture and land surface processes, topography, internal dynamics, and the accumulated influence of weather systems on the global scale. In temperate regions such as Washington, long-range forecasts of drought have limited reliability. Meteorologists do not believe that reliable forecasts are attainable at this time a season or more in advance for temperate regions.

7.3.2 Impact on Life, Health, and Safety

A drought directly or indirectly impacts all people in affected areas. Most notably, the planning area does have a fairly large number of privately owned wells, which may be impacted by reduced water flows and aquifer to supply drinking water.

A drought can also result in farmers not being able to plant crops or the failure of planted crops, a significant level of the established economy in the region. This results in loss of work for farm workers and those in related food processing jobs. Other water- or electricity-dependent industries are commonly forced to shut down all or a portion of their facilities, resulting in further layoffs, impacting income. A drought can also harm recreational companies that use water (e.g., swimming pools, water parks, and river rafting companies) as well as landscape and nursery businesses because people will not invest in new plants if water is not available to sustain them. With much of Washington’s energy coming from hydroelectric plants, a drought means less inexpensive electricity coming from dams and probably higher electric bills. All people will pay more for water if utilities increase their rates. This has become an issue within Washington State as a whole previously, when a lack of snowpack has decreased hydroelectric generating capacity, and raised the electric prices, impacting residents.

Wildfires are often associated with drought. A prolonged lack of precipitation dries out vegetation, which becomes increasingly susceptible to ignition as the duration of the drought extends. This increases the risk to the health and safety of the residents within the planning area, especially those in wildland-urban interface areas. Smoke and particles embedded within the smoke are of significant concern for the elderly and very young, especially those with breathing problems.

7.3.3 Impact on Property

No structures will be directly affected by drought conditions, though some may become vulnerable to wildfires, which are more likely following years of drought. Droughts can also have significant impacts on landscapes, which could cause a financial burden to property owners. However, these impacts are not considered critical in planning for impacts from the drought hazard.

7.3.4 Impact on Critical Facilities and Infrastructure

Critical facilities will continue to be operational during a drought unless impacted by fire. Critical facility elements such as landscaping may not be maintained due to limited resources, but the risk to the planning area’s critical facilities inventory will be largely aesthetic. For example, when water conservation measures are in place, landscaped areas will not be watered and may die. These aesthetic impacts are not considered significant.

7.3.5 Impact on Economy

As indicated above, economic impact from a drought is associated with different aspects, including, among others, the potential loss of agri- and aqua-cultural production and, of importance within the tribal planning area, tourism and entertainment.

The area’s agricultural producers are among the less than two percent of the population in the United States today that produce the food and fiber consumed by the remaining population and they do it more efficiently and at less cost to the consumer than any other industrialized country in the world. Loss of revenue to these producers would impact not only the owners, but the employees, and ultimately surrounding businesses and entertainment centers.

Additional economic impact stems from the potential loss of critical infrastructure due to fire damage and impacts on industries that depend on water for their business, such as aquaculture and fishing industries, and water-based recreational activities and areas.

Problems of domestic and municipal water supplies have historically been corrected by building another reservoir, a larger pipeline, new well, or some other facility. The Tribe is self-reliant with respect to its own water supplies on the Reservation. A drought impacting well-water supply would be significant, as the Tribe has limited capacity in this respect, and would be required to drill additional well sites. With drought conditions increasing pressure on aquifers and increased pumping, which can result in saltwater intrusion into freshwater aquifers, resultant reductions or restrictions on economic growth and development could occur. Given this potential, a drought situation, if prolonged, could restrict building within specific areas due to lack of supporting infrastructure, thereby impacting the economy of the tribe and the region as a whole by limiting growth. In addition, impact to or the lack of hydroelectric generating capacity associated with drought conditions as a result of reduced precipitation levels could raise electric prices throughout the region.

A substantial reduction in stream flows could severely impact the generation of electricity from the hydro-electric dams located in the area. A reduction in hydro-electric generation will result in increased electricity rates for all residents and businesses in the area.

7.3.6 Impact on Environment

Environmental losses from drought are associated with aquatic life, plants, animals, wildlife habitat, air and water quality, forest fires, landscape quality, biodiversity, and soil erosion, among others.

The Tribe currently has several restoration projects in place to preserve the natural resources of the Stillaguamish Watershed. In addition, the Skagit River and its watershed is the only river in Washington State that is home to five (5) species of salmon. The Skagit River supports some of the largest and healthiest Chinook runs and Pink salmon stock in Washington. (Ecology, 2014) A severe drought could cause reduced stream flows thereby creating a major environmental and economic impact on local salmon runs due to potentially warmer waters and low water levels.

Some effects are short-term, and conditions quickly return to normal after the drought. Other effects linger or even become permanent. Wildlife habitat, for example, may be degraded through the loss of wetlands, lakes, and vegetation, but many species will eventually recover from this effect. Degraded landscape quality, including soil erosion, may lead to a more permanent loss of biological productivity. Lifecycles for fish spawning in the area would have environmental impacts years into the future. The Tribe does maintain two fish hatcheries, from which it annually releases stock.

Public awareness and concern for environmental quality has led to greater attention to these effects. Drought conditions within the planning area could increase the demand for water supplies. Water shortages would have an adverse impact on the environment. If such conditions persisted for several years, the economy of the area could experience significant environmental setbacks.

7.3.7 Impact from Climate Change

The impact from climate change on drought will be significant. With historic records demonstrating increased temperature rise, the results will only further exacerbate drought stations. Drought plays a significant role in the wildfire system, fire behavior, ignitions, fire management, and vegetation fuels. Hot dry spells create the highest fire risk. Increased temperatures may intensify wildfire danger by warming and drying out vegetation. Climate change will further change the use of water available for fish spawning due to increased temperatures. It will also impact availability for agricultural growers for their crops; with decreased precipitation in the form of snow, water levels will fall, creating water shortages for use by consumers as drinking water, irrigation and watering of livestock, and firefighters to control and fight fires.

7.4 FUTURE DEVELOPMENT TRENDS

With an increase in population, there is also a propensity to increase water demands, as well as increase demands on other infrastructure, and increase the potential for wildfires. Practicing a low water-use lifestyle will increasingly become the norm for many as summer flows substantially reduce many of our rivers. Reducing water use will help meet future needs and result in cost savings and decrease energy use, helping preserve the environment.

The Tribe continues to provide information, tools, and incentives to assist tribal members, local residents, businesses, other local governments, and water providers to design and implement comprehensive and proven conservation strategies. The Tribe continues to acquire lands within the watershed to re-establish its natural environment. Such actions help to protect the area, and significantly reduce the impacts from drought. The Tribe has been forward-thinking in developing policies directing land use and dealing with development on tribal lands. Many of the restoration projects currently underway will continue to provide the capability to protect future development from the impacts of drought.

7.5 ISSUES

Combinations of low precipitation and unusually high temperatures could occur over several consecutive years, especially in response to climate change. Intensified by such conditions, extreme wildfires could break out throughout the area, increasing the need for water. Surrounding communities, also in drought conditions, could increase their demand for water, causing social and political conflicts. Low water tables could increase issues of life, safety, and health, while also impacting the economy both for loss of potential agricultural income, but also with respect to decreased ability to construct new housing due to lack of ability to provide water. If such conditions persisted for several years, the economy of the region could experience setbacks, especially in water dependent industries.

7.6 IMPACT AND RESULTS

Based on review and analysis of the data, the Planning Team has determined that the probability for impact from Drought throughout the area is likely. The area has experienced drought conditions, with drought incidents occurring in 2015 and 2019. As of this 2020 update, the State experienced one of its driest summers on record for the last 30 years occurring in 2017, with several counties in the state issuing declarations in April and June 2019. With anticipated increase in temperatures as a result of climate change, drought situations will only intensify. In addition, higher temperatures anticipated with climate change would increase vulnerability of the population due to excessive heat, while also potentially impacting power supplies at the hydro-dam in the area.

Current water supplies are relatively resistant to short-term drought episodes. Should a severe, long-term drought occur, it will be vital that local elected officials and governmental agencies work cooperatively to help ensure efforts are made to protect public water supplies, aid agriculture and local industry, and safeguard fish and stream flows.

Based on the potential impact, the Planning Team determined the CPRI score to be 2.15, with overall vulnerability determined to be a medium level.

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CHAPTER 8.
EARTHQUAKE

An earthquake is the vibration of the earth's surface following a release of energy in the earth's crust. This energy can be generated by a sudden dislocation of the crust or by a volcanic eruption. Its epicenter is 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. Earthquakes many times occur along a fault, which is a fracture in the earth's crust.

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.

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.

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

Hypocenter—The region underground where an earthquake's energy originates

Liquefaction— Loosely packed, water-logged sediments losing their strength in response to strong shaking, causing major damage during earthquakes.

8.1 GENERAL BACKGROUND

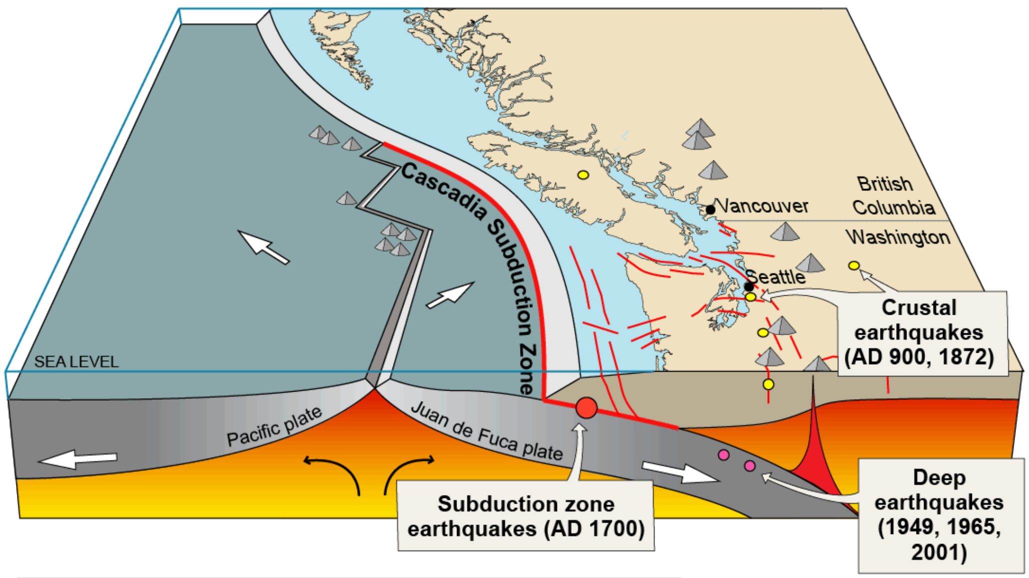
Most destructive quakes are caused by dislocations of the crust. The crust may first bend and then, when the stress exceeds the strength of the rocks, break and snap to a new position. In the process of breaking, vibrations called "seismic waves" are generated. These waves travel outward from the source of the earthquake at varying speeds.

Earthquakes tend to reoccur along faults, which are zones of weakness in the crust. Even if a fault zone has recently experienced an earthquake, there is no guarantee that all the stress has been relieved. Another earthquake could still occur.

Geologists classify faults by their relative hazards. Active faults, which represent the highest hazard, are those that have ruptured to the ground surface during the Holocene period (about the last 11,000 years). Potentially active faults are those that displaced layers of rock from the Quaternary period (the last 1,800,000 years). Determining if a fault is "active" or "potentially active" depends on geologic evidence, which may not be available for every fault.

Faults are more likely to have earthquakes on them if they have more rapid rates of movement, have had recent earthquakes along them, experience greater total displacements, and are aligned so that movement can relieve accumulating tectonic stresses. A direct relationship exists between a fault's length and location 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.

It is generally agreed that three source zones exist for Pacific Northwest quakes: a shallow (crustal) zone; the Cascadia Subduction Zone; and a deep, intraplate "Benioff" zone. These are shown in Figure 8-1. More than 90 percent of Pacific Northwest earthquakes occur along the boundary between the Juan de Fuca plate and the North American plate.



Source	Max. Size	Recurrence
Subduction zone	M 9+	200–600 years
Deep Juan de Fuca plate	M 7+	30–50 years
Crustal faults	M 7+	Hundreds of years?

Volcano

Active crustal fault

Active plate boundary fault

*figure modified from USGS Cascadia earthquake graphics at http://geomaps.wr.usgs.gov/pacnw/pacnweq/index.html

Figure 8-1 Earthquake Types in the Pacific Northwest and Recurrence Intervals

An earthquake will generally produce the strongest ground motions near the epicenter (the point on the ground above where the earthquake initiated) with the intensity of ground motions diminishing with increasing distance from the epicenter. The intensity of ground shaking at a given site depends on four main factors:

- Earthquake magnitude
- Earthquake epicenter
- Earthquake depth
- Soil or rock conditions at the site, which may amplify or de-amplify earthquake ground motions.

For any given earthquake, there will be contours of varying intensity of ground shaking with distance from the epicenter. The intensity will generally decrease with distance from the epicenter, and often in an irregular pattern, not simply in concentric circles. The irregularity is caused by soil conditions, the complexity of earthquake fault rupture patterns, and directionality in the dispersion of earthquake energy.

8.1.1 Earthquake Classifications

Earthquakes are typically classified in one of two ways: By the amount of energy released, measured as *magnitude* (size or power based on the Richter Scale); or by the impact on people and structures, measured as *intensity* (based on the Mercalli Scale). Magnitude is related to the amount of seismic energy released at the hypocenter of an earthquake. It is determined by the amplitude of the earthquake waves recorded on instruments. Magnitude is represented by a single, instrumentally determined value for each earthquake event. Intensity indicates how the earthquake is felt at various distances from the earthquake epicenter.

Table 8-1 presents a classification of earthquakes according to their magnitude.

TABLE 8-1
EARTHQUAKE MAGNITUDE CLASSES

Magnitude Class	Magnitude Range (M = magnitude)
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

Estimates of moment magnitude roughly match the local magnitude scale (ML) commonly called the Richter scale. One advantage of the moment magnitude scale is that, unlike other magnitude scales, it does not saturate at the upper end. That is, there is no value beyond which all large earthquakes have about the same magnitude. For this reason, moment magnitude is now the most often used estimate of large earthquake magnitudes.

Intensity

There are many measures of the severity or intensity of earthquake ground motions. The Modified Mercalli Intensity scale (MMI) was widely used beginning in the early 1900s. MMI is a descriptive, qualitative scale that relates severity of ground motions to the types of damage experienced. MMI values range from I to XII (USGS, 1989). Table 8-2 compares the moment magnitude scale to the modified Mercalli intensity scale.

TABLE 8-2
EARTHQUAKE MAGNITUDE AND INTENSITY

Magnitude (Mw)	Intensity (Modified Mercalli)	Description
1.0—3.0	I	I. Not felt except by a very few under especially favorable conditions

**TABLE 8-2
EARTHQUAKE MAGNITUDE AND INTENSITY**

Magnitude (Mw)	Intensity (Modified Mercalli)	Description
3.0—3.9	II—III	II. Felt only by a few persons at rest, especially on upper floors of buildings. III. Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it is an earthquake. Standing cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
4.0—4.9	IV—V	IV. Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like a heavy truck striking building. Standing cars rocked noticeably.
5.0—5.9	VI—VII	VI. Felt by all; many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight. VII. Damage negligible in buildings of good design and construction; slight in well-built ordinary structures; considerable in poorly built or badly designed structures. Some chimneys broken.
6.0—6.9	VII—IX	VIII. Damage slight in specially designed structures; considerable damage in ordinary buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
7.0 and higher	VIII and higher	X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent. XI. Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly. XII. Damage total. Lines of sight and level are distorted. Objects thrown into the air.

More accurate, quantitative measures of the intensity of ground shaking have largely replaced the MMI and are used in this mitigation plan. These scales use terms that can be physically measured with seismometers, such as the acceleration, velocity, or displacement (movement) of the ground. The intensity may also be measured as a function of the frequency of earthquake waves propagating through the earth. In the same way that sound waves contain a mix of low-, moderate- and high-frequency sound waves, earthquake waves contain ground motions of various frequencies. The behavior of buildings and other structures depends substantially on the vibration frequencies of the building or structure versus the frequency of earthquake waves. Earthquake ground motions also include both horizontal and vertical components.

Ground Motion

Earthquake hazard assessment is also based on expected ground motion. This involves determining the probability that certain ground motion accelerations will be exceeded over a time period of interest. A common physical measure of the intensity of earthquake ground shaking, and the one used in this mitigation plan, is peak ground acceleration (PGA). PGA is a measure of the intensity of shaking relative to the acceleration of gravity (g). For example, an acceleration of 1.0 g PGA is an extremely strong ground motion, which does occur near the epicenter of large earthquakes. With a vertical acceleration of 1.0 g, objects are thrown into the air. With a horizontal acceleration of 1.0 g, objects accelerate sideways at the same rate as if they had been dropped from the ceiling. A PGA equal to 10% g means that the ground acceleration is 10 percent that of gravity, and so on (see Figure 8-2).[5]

Damage levels experienced in an earthquake vary with the intensity of ground shaking and with the seismic capacity of structures. The following generalized observations provide qualitative statements about the likely extent of damage for earthquakes with various levels of ground shaking (PGA) at a given site:

- Ground motions of only 1% g or 2% g are widely felt by people; hanging plants and lamps swing strongly, but damage levels, if any, are usually very low.
- Ground motions below about 10% g usually cause only slight damage.
- Ground motions between about 10% g and 30% g may cause minor to moderate damage in well-designed buildings, with higher levels of damage in more vulnerable buildings. At this level of ground shaking, some poorly built buildings may be subject to collapse.
- Ground motions above about 30% g may cause significant damage in well-designed buildings and very high levels of damage (including collapse) in poorly designed buildings.
- Ground motions above about 50% g may cause significant damage in most buildings, even those designed to resist seismic forces.

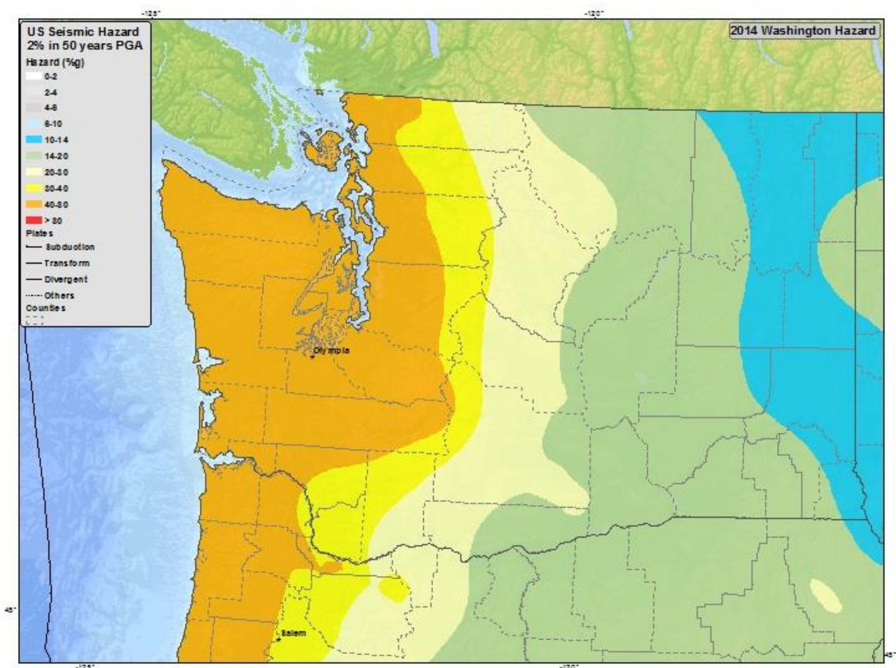


Figure 8-2 USGS PGA for Washington State (2014)

[5] USGS. Accessed 6/5/19. Available at: https://earthquake.usgs.gov/earthquakes/byregion/washington.php

PGA is the basis of seismic zone maps that are included in building codes such as the International Building Code. Washington State DNR's Seismic Zone Map is illustrated in Figure 8-3.[6] Building codes that include seismic provisions specify the horizontal force due to lateral acceleration that a building should be able to withstand during an earthquake.

PGA values are directly related to these lateral forces that could damage "short period structures" (e.g. single-family dwellings). Longer period response components determine the lateral forces that damage larger structures with longer natural periods (apartment buildings, factories, high-rises, bridges). The amount of earthquake damage and the size of the geographic area affected generally increase with earthquake magnitude:

- Earthquakes below M5 are not likely to cause significant damage, even near the epicenter.
- Earthquakes between about M5 and M6 are likely to cause moderate damage near the epicenter.
- Earthquakes of about M6.5 or greater (e.g., the 2001 Nisqually earthquake in Washington) can cause major damage, with damage usually concentrated fairly near the epicenter.
- Larger earthquakes of M7+ cause damage over increasingly wider geographic areas with the potential for very high levels of damage near the epicenter.
- Great earthquakes with M8+ can cause major damage over wide geographic areas.
- A M9 mega-quake on the Cascadia Subduction Zone could affect the entire Pacific Northwest from British Columbia, through Washington and Oregon, and as far south as Northern California, with the highest levels of damage nearest the coast.

Table 8-3 identifies damage potential and perceived shaking by PGA factors, compared to the Mercalli scale.

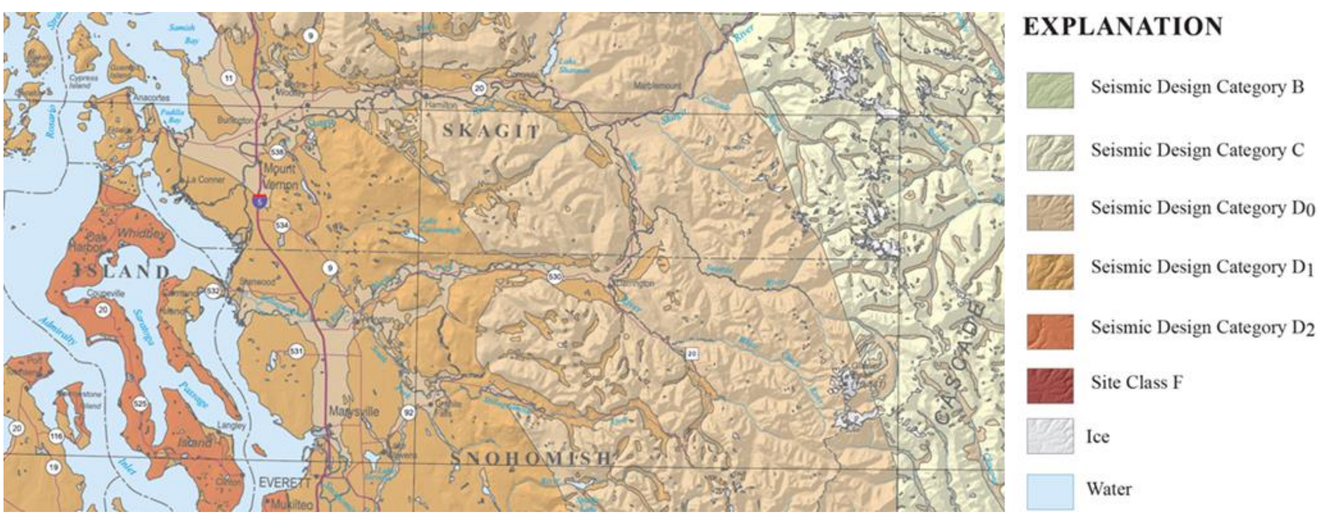


Figure 8-3 Seismic Design Codes

[6] Washington State Department of Natural Resources (2007). Accessed Nov. 2019. Available at: https://www.dnr.wa.gov/programs-and-services/geology/geologic-hazards/geologic-hazard-maps#seismic-design-categories

TABLE 8-3
COMPARISON OF MERCALLI SCALE AND PEAK GROUND ACCELERATION

Modified Mercalli Scale	Perceived Shaking	Potential Structure Damage: Resistant Buildings	Potential Structure Damage: Vulnerable Buildings	Estimated PGA[a] (%g)
I	Not Felt	None	None	<0.17%
II-III	Weak	None	None	0.17%—1.4%
IV	Light	None	None	1.4%—3.9%
V	Moderate	Very Light	Light	3.9%—9.2%
VI	Strong	Light	Moderate	9.2%—18%
VII	Very Strong	Moderate	Moderate/Heavy	18%—34%
VIII	Severe	Moderate/Heavy	Heavy	34%—65%
IX	Violent	Heavy	Very Heavy	65%—124%
X—XII	Extreme	Very Heavy	Very Heavy	>124%

a. PGA measured in percent of g, where g is the acceleration of gravity
Sources: USGS, 2008; USGS, 2010

8.1.2 Effect of Soil Types

Liquefaction is 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. Liquefaction generally occurs in soft, unconsolidated sedimentary soils. The National Earthquake Hazard Reduction Program (NEHRP) creates maps based on soil characteristics to help identify locations subject to liquefaction. Figure 8-4 identifies the soils classifications for the Stillaguamish Reservation.

Table 8-4 summarizes NEHRP soil classifications. NEHRP Soils B and C typically can sustain ground shaking without much effect, dependent on the earthquake magnitude. Areas that are commonly most affected by ground shaking and susceptible to liquefaction have NEHRP Soils D, E and F.

Review of the existing data identifies the Reservation as having Soils Class C, meaning that the liquefaction factor for the Reservation boundary is very low based on NEHRP soils classifications. This should not be construed to mean that no impact will be sustained, as this data is for planning purposes only, and should not be utilized for determining life-safety measures. Such assessments would require engineered analysis and is far beyond the scope of this project.

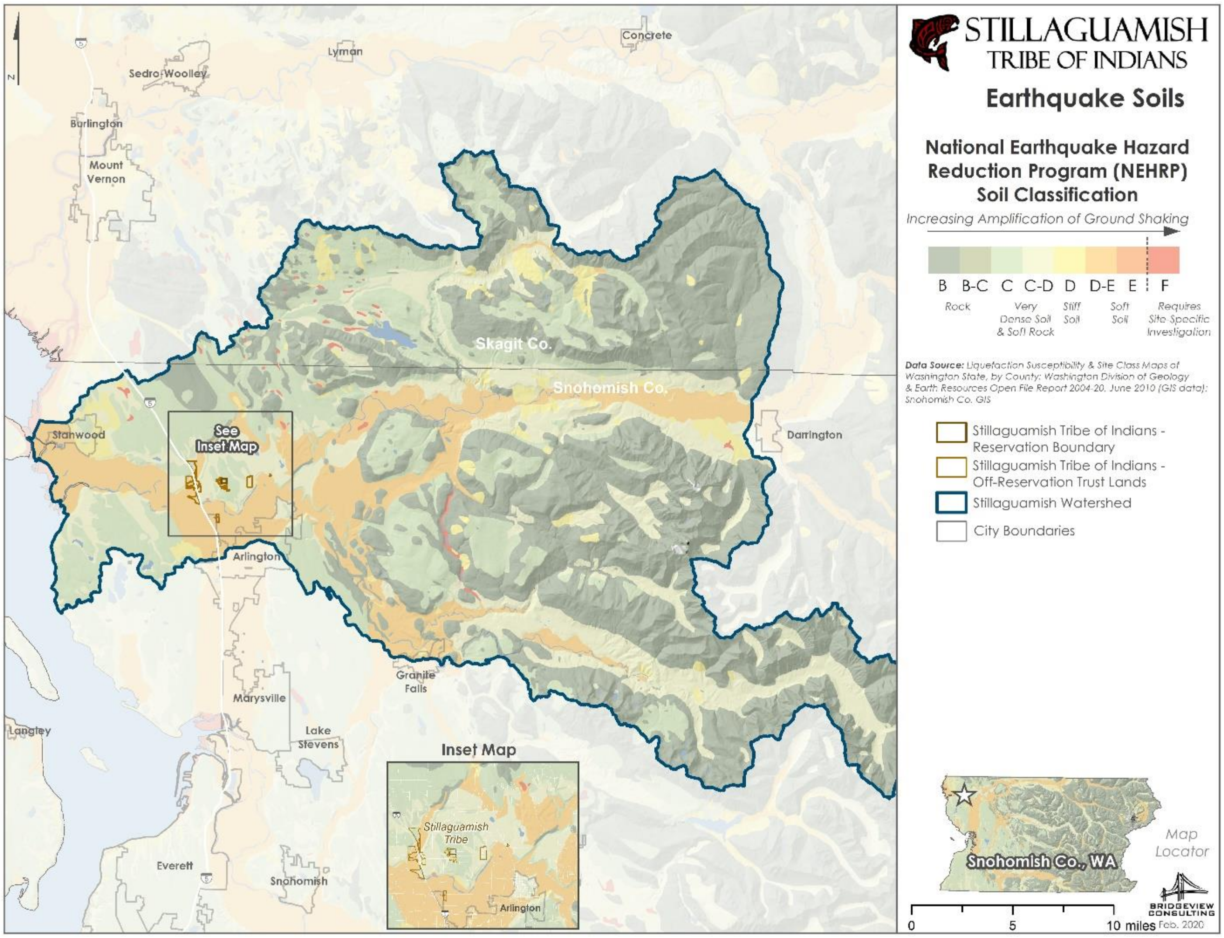


Figure 8-4 NEHRP Soils Classifications

TABLE 8-4 NEHRP SOIL CLASSIFICATION SYSTEM		
NEHRP Soil Type	**Description**	**Mean Shear Velocity to 30 Meters (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)	

8.1.3 Fault Classification

The U.S. Geologic Survey defines four fault classes based on evidence of tectonic movement associated with large-magnitude earthquakes during the Quaternary period, which is the period from about 1.6 million years ago to the present:

- Class A—Geologic evidence demonstrates the existence of a Quaternary fault of tectonic origin, whether the fault is exposed by mapping or inferred from liquefaction or other deformational features.
- Class B—Geologic evidence demonstrates the existence of Quaternary deformation, but either (1) the fault might not extend deep enough to be a potential source of significant earthquakes, or (2) the currently available geologic evidence is too strong to confidently assign the feature to Class C but not strong enough to assign it to Class A.
- Class C—Geologic evidence is insufficient to demonstrate (1) the existence of tectonic faulting, or (2) Quaternary slip or deformation associated with the feature.
- Class D—Geologic evidence demonstrates that the feature is not a tectonic fault or feature; this category includes features such as joints, landslides, erosional or fluvial scarps, or other landforms resembling fault scarps but of demonstrable non-tectonic origin.

8.2 HAZARD PROFILE

Seismic-related hazards include ground motion from shallow (less than 20 miles deep) or deep faults; liquefaction and differential settling of soil in areas with saturated sand, silt, or gravel; and tsunamis that result from seismic activities. Earthquakes also can cause damage by triggering landslides or bluff failure. The Puget Sound region is entirely within Seismic Risk Zone 3, requiring that buildings be designed to withstand major earthquakes measuring 7.5 in magnitude. It is anticipated, however, that earthquakes caused from subduction plate stress can reach a magnitude greater than 8.0.

High-magnitude earthquakes are possible in planning area when the Juan de Fuca slips beneath the North American plates. Deep zone or Benioff zone quakes have occurred within the Juan de Fuca plate (1949, 1965, and 2001) and can be expected in the future.

8.2.1 Extent and Location

Washington State as a whole is one of the most seismically active states in United States. Figure 8-5 depicts the faults known or suspected to be active within the state. Several major faults are located in the vicinity. 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.

One of the most notable faults, according to the Washington State Department of Natural Resources Geology Division, is the Devils Mountain Fault lying near Mt. Vernon which is roughly 125 km (78 miles) long, runs generally east to west through Darrington in Snohomish County to Vancouver Island, Canada, and has been determined to be active with at least one earthquake generated about 2,000 years ago (Personius and others, 2014). If a magnitude seven (M7) or greater the event was to occur, it would affect 15 counties, including Snohomish County.

Additional information is available from Washington State Department of Natural Resources Scenario catalogue, available at: https://fortress.wa.gov/dnr/seismicscenarios/index.html?config=canyonRiver.xml.

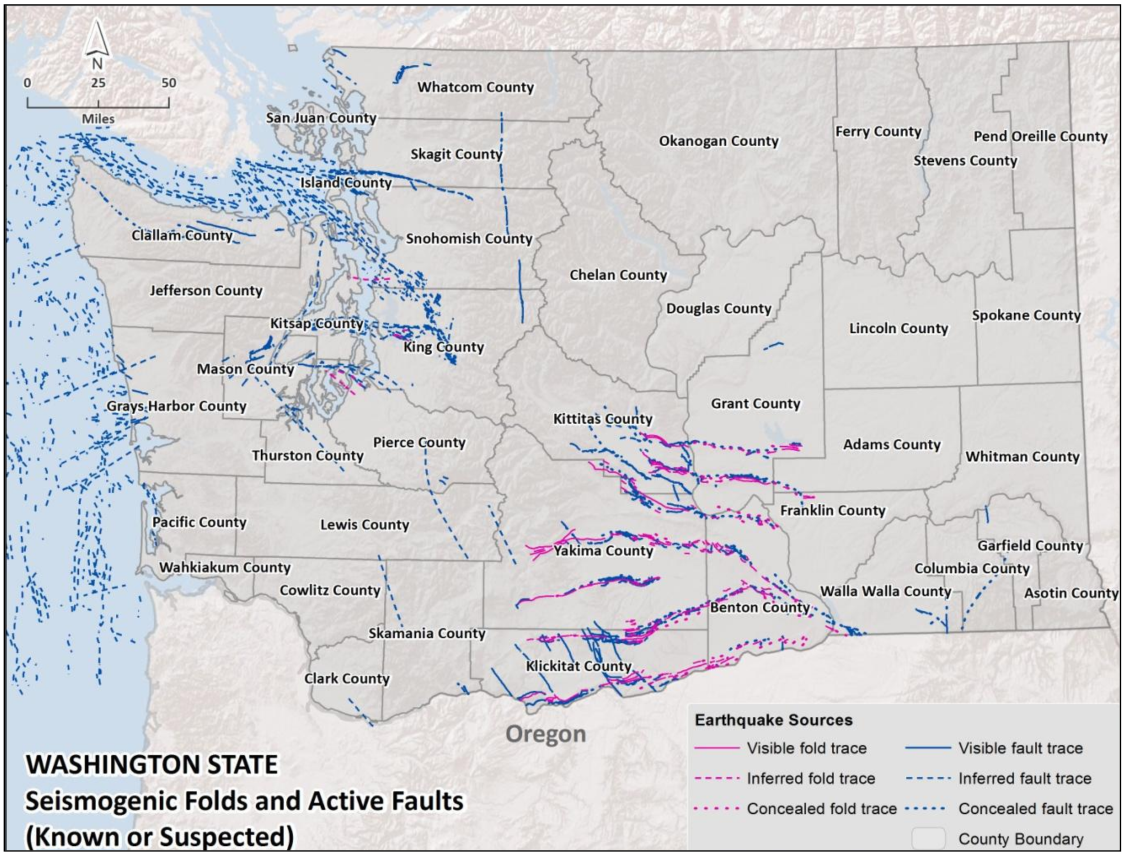


Figure 8-5 Washington State Seismogenic Folds and Active Faults (2013 HMP)

Hazard Mapping

Identifying the extent and location of an earthquake is not as simple as it is for other hazards such as flood, landslide, or wildfire. The impact of an earthquake is largely a function of the following factors:

- Ground shaking (ground motion accelerations)
- Liquefaction (soil instability)
- Distance from the source (both horizontally and vertically).

Mapping that shows the impacts of these components was used to assess the risk of 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. The mapping used in this assessment is described below.

ShakeMaps

A shake map is a representation of ground shaking produced by an earthquake (Peak Ground Acceleration). 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 resulting from 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 shows the extent and variation of ground shaking in a region immediately following significant earthquakes.

Ground motion and intensity maps are derived from peak ground motion recorded on seismic sensors, with interpolation where data are lacking and site-specific corrections. Color-coded intensity maps are derived from empirical relations between peak ground motions and Modified Mercalli intensity. Two types of shake map are typically generated from the data:

- 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 scenario maps describe the expected ground motions and effects of hypothetical large earthquakes for a region. Maps of these scenarios can be used to support all phases of emergency management.

For this plan update, Devils Mountain M7.5 Earthquake (Figure 8-6) and Cascadia M9.0 (Figure 8-7) scenario earthquakes were chosen.

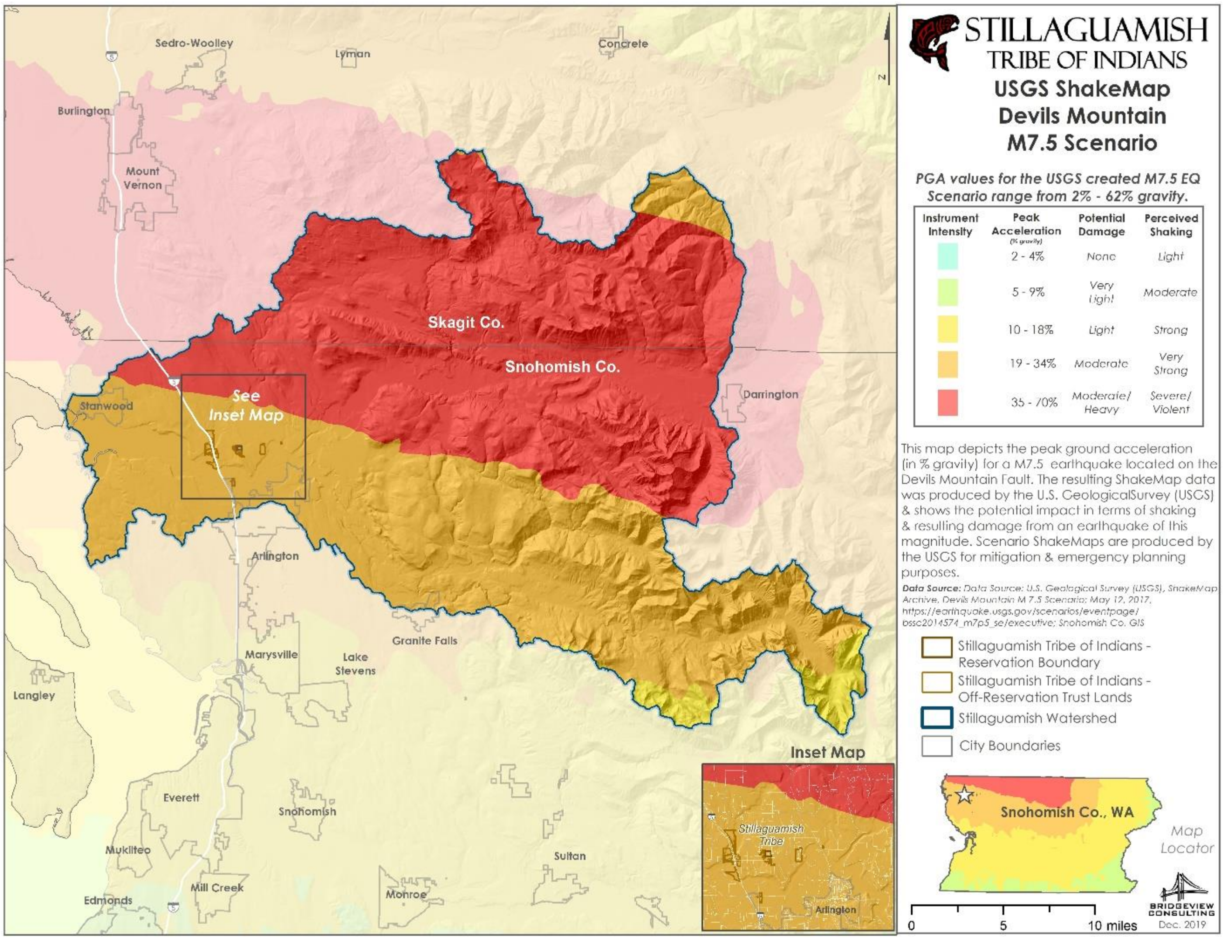


Figure 8-6 Devils Mountain M7.5 Fault Scenario - Modified Mercalli Shaking Intensity

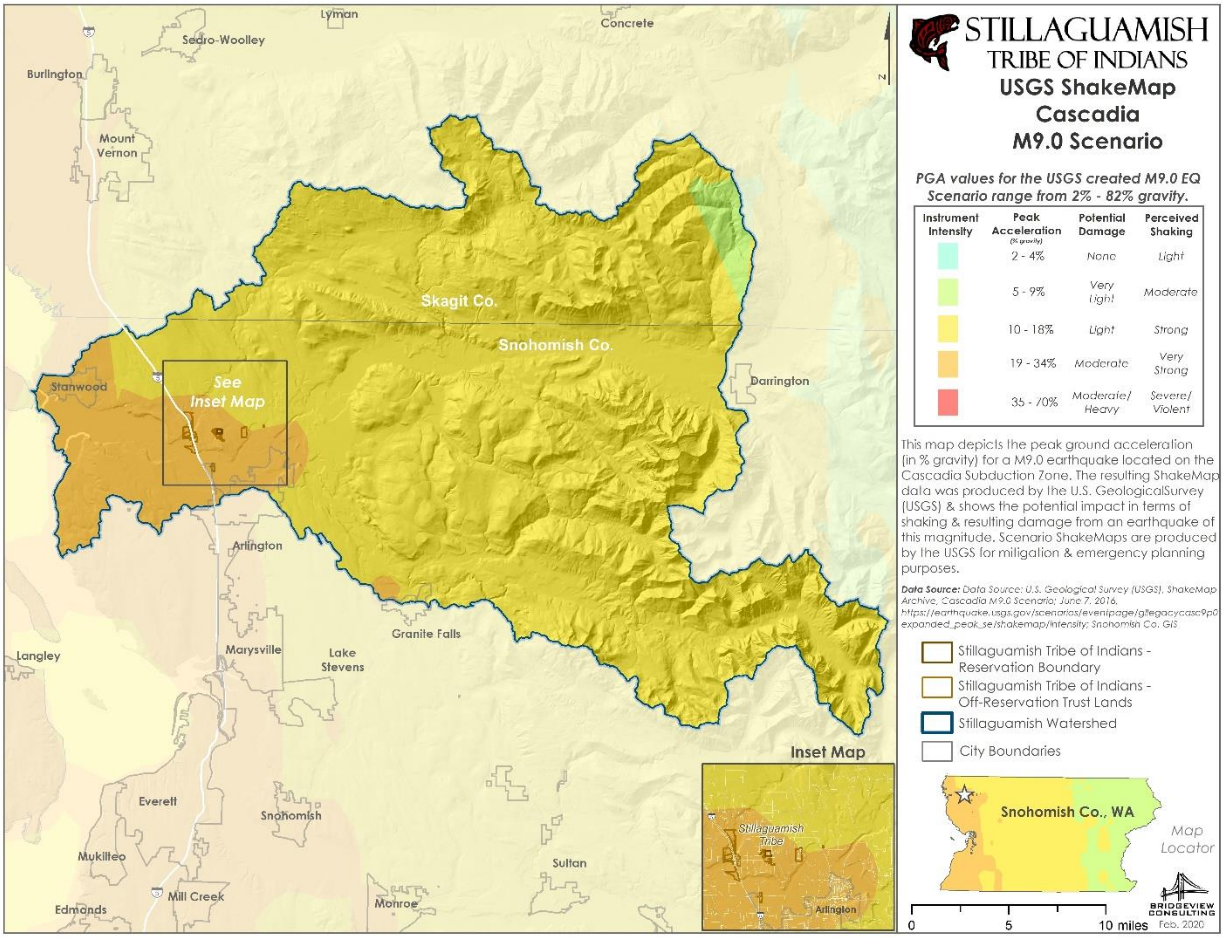


Figure 8-7 Cascadia M9.0 Fault Scenario - Modified Mercalli Shaking Intensity

Liquefaction Maps

Soil liquefaction maps are useful tools to assess potential damage from earthquakes. When the ground liquefies, sandy or silty materials saturated with water behave like a liquid, causing pipes to leak, roads and airport runways to buckle, and building foundations to be damaged. In general, areas with NEHRP Soils D, E and F are susceptible to liquefaction. 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 and creating sand boils. Figure 8-8 shows liquefaction susceptibility in the surrounding areas of the Stillaguamish Reservation (filter applied to surrounding area). Figure 8-9 shows liquefaction susceptibility on the Reservation boundary (filter applied).

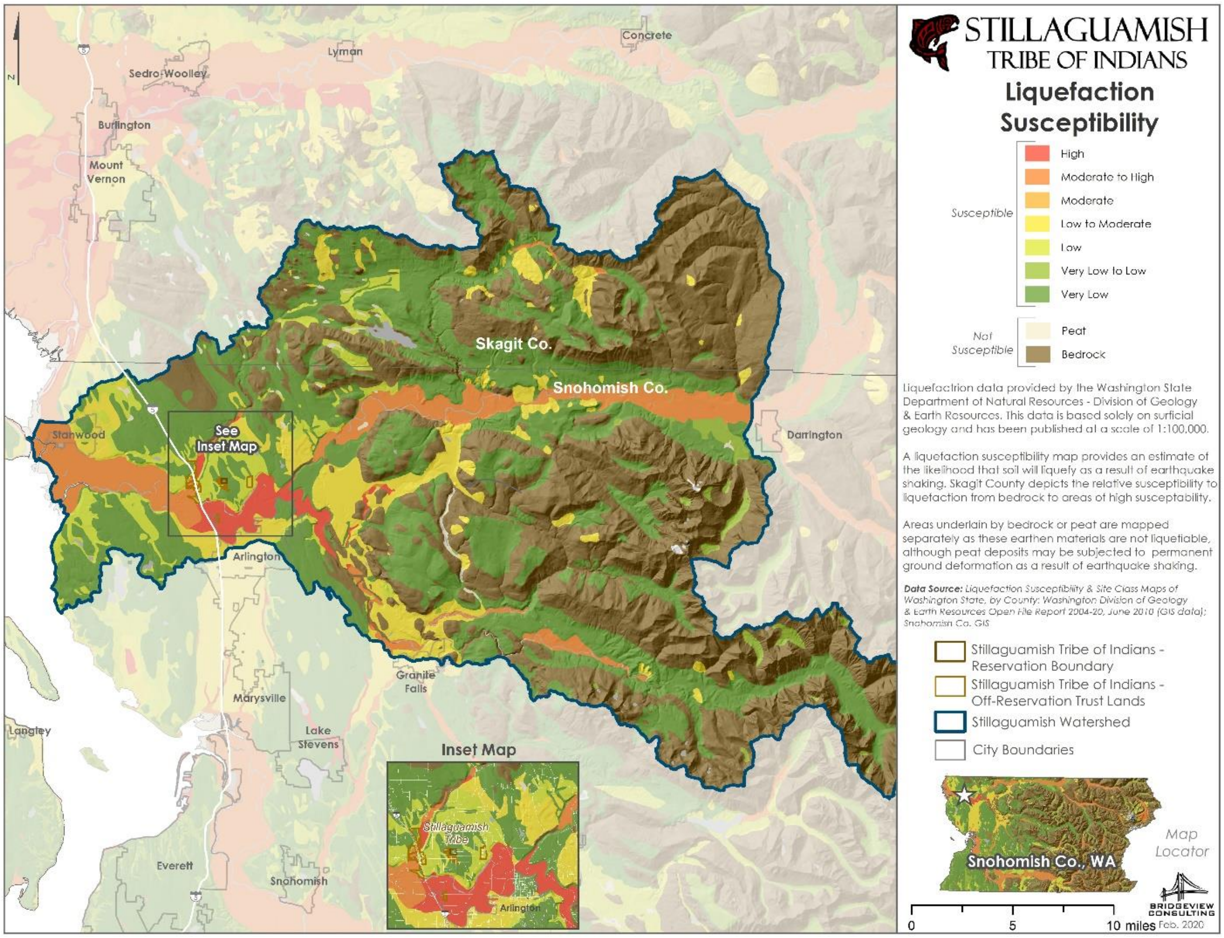


Figure 8-8 Liquefaction Susceptibility Zones Throughout Watershed

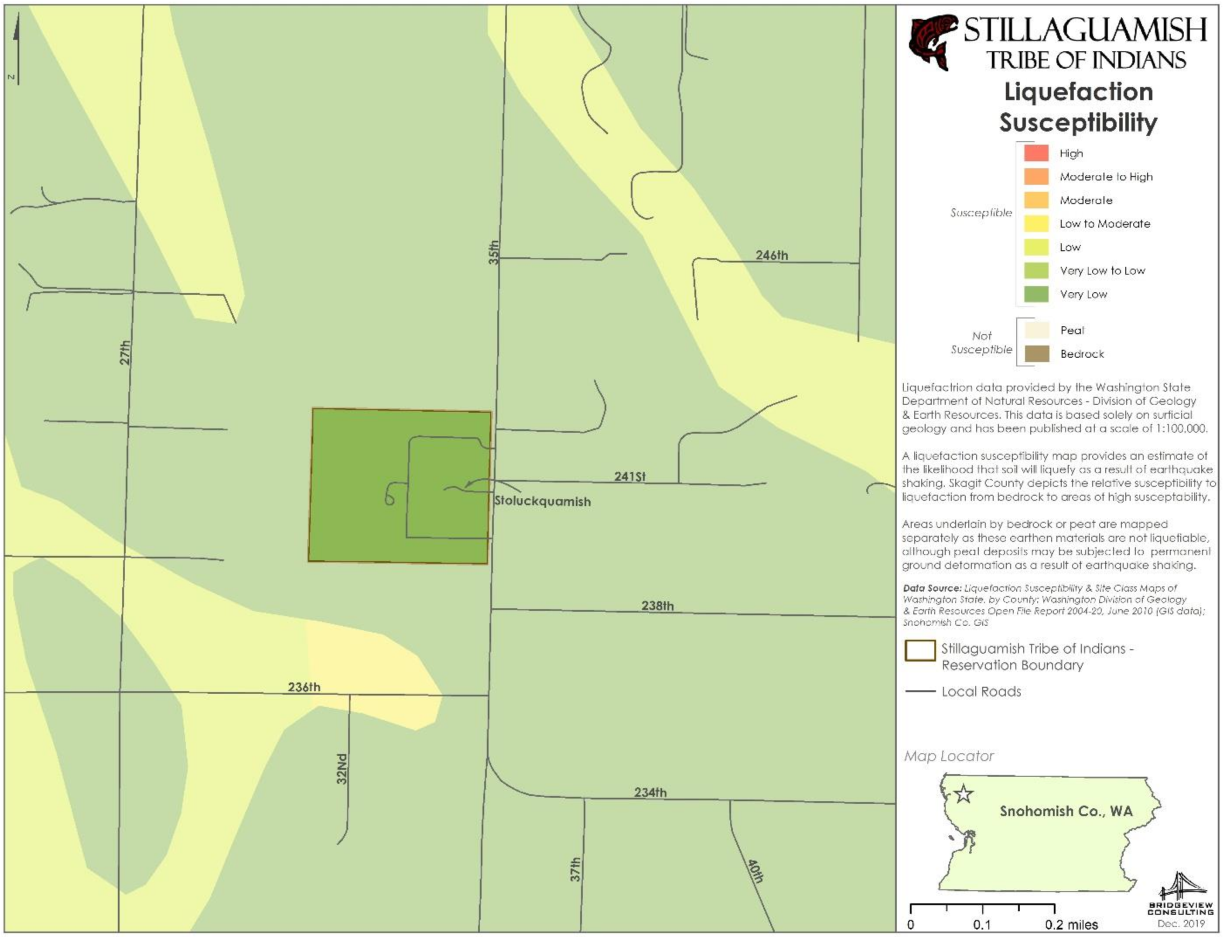


Figure 8-9 Liquefaction Susceptibility Zone On Reservation

8.2.2 Previous Occurrences

Earthquakes have been reported in the area from as early as the 1872 North Cascades quake. Table 8-5 lists past seismic events that have affected the Puget Sound area.[7] One disaster declaration has occurred in recent past as a result of earthquake damage – the Nisqually Earthquake, which occurred on February 28, 2001 (discussed below). The following facts represent some of the more significant earthquakes occurring in the area:

- **1949, Nisqually Delta Area North of Olympia**—This earthquake had a magnitude of 7.1 on the Richter scale. The Snohomish County zone that experienced most intense effects is along the South Stillaguamish River valley from Granite Falls to Arlington, and along the Snohomish and Skykomish River valleys from Everett to Snohomish and Monroe. Within this area, the effects included fallen chimneys and building cornices; cracked plaster; broken water and gas mains; damaged docks, bridges, and water storage tanks; cracked ground and pavement; and landslides, mudflows, and debris slides.

[7] PNSN, 2019

- **1969, Marblemount -** The largest earthquake recorded in Skagit County by PNSN was a magnitude 4.6 event on November 9, 1969, near Marblemount. It was located at a depth of about 8 miles, which makes it a shallow crustal event, rather than an earthquake that takes place in the subducting crust. This earthquake had M4.3 and M4.0 foreshocks and a rich aftershock sequence, all at depths of less than about 1 mile.
- **1996, Duvall**—This earthquake had a magnitude of 5.6 on the Richter scale. Near the epicenter, merchandise fell off shelves and at least one resident reported a cracked chimney. In Snohomish County, 16,000 residents were reportedly without power for several hours as a result of breakers tripping in four substations. There was, however, no report of physical damage to electrical power facilities.
- **2001, Nisqually -** The Nisqually earthquake occurred February 2, 2001 with the epicenter about 11 miles northeast of the City of Olympia. It was a deep magnitude 6.8 event and due to extensive damage in several counties, was declared Federal Disaster #1361. One person died of a heart attack; 700 people were injured; damages were greater than $1,000,000,000 as a result of the Nisqually Earthquake. Snohomish County had combined public and private sector damage between $2 million and $3 million. There were 13 minor injuries. A few older unreinforced masonry structures suffered significant damage, but there were no building collapses in the county. The greatest shaking and highest percentage of damaged structures were in the main river valleys and communities along the rivers: Darrington, Sultan, Monroe, and Snohomish.
- **1700 Cascadia Subduction Zone** – Based on geologic evidence along the Washington coast, the Cascadia Subduction Zone has ruptured and created tsunamis at least seven times in the past 3,500 years and has a considerable range in recurrence intervals, from as little as 140 years between events to more than 1,000 years. The last Cascadia Subduction Zone-related earthquake is believed to have occurred on January 26, 1700, and researchers predict a 10 to 14 percent chance that another could occur in the next 50 years.

A Cascadia Subduction Zone earthquake is felt to be the largest earthquake threat to the state as a whole. The fault runs from California to British Columbia. Abundant physical evidence for the 1700 earthquake includes evidence for abrupt tectonic subsidence. This event was probably about M9 and is one of the largest earthquakes in historic or paleoseismic record. The evidence for this earthquake is documented in Atwater and others (2005) and Goldfinger and others (2012). This fault has an average recurrence interval of approximately 500 years for earthquakes of about M9.

TABLE 8-5
HISTORICAL EARTHQUAKES IMPACTING THE PLANNING AREA

Year	Magnitude	Epicenter
1/2009	4.5	Near Kingston
7/2002	3.1	North Bend
5/2002	4.2	Friday Harbor, San Juan Islands
2/28/2001 (DR 1361)	6.8	Olympia (Nisqually)
6/10/2001	5.0	Matlock
7/3/1999	5.8	5 miles north of Satsop
2/1998	2.8	Northeast of Seattle
8/1997	3.4	Unknown*
7/1997	3.1	Duvall

TABLE 8-5
HISTORICAL EARTHQUAKES IMPACTING THE PLANNING AREA

Year	Magnitude	Epicenter
6/23/1997	4.7	Bremerton
7/1996	5.4	5 miles east-northeast of Duvall
5/3/1996	5.5	Duvall
1/29/1995	5.1	Seattle-Tacoma
10/25/1991	3.4	Unknown*
4/14/1990	5.0	Deming Area
2/14/1981	5.5	Mt. St. Helens
9/9/76	4.5	Union
5/11/1965 (DR 196)	6.6	18.3 KM N of Tacoma
4/29/1965	6.5	11 miles North of Tacoma
4/13/1949	7.1	Olympia
1/13/1949	7.0	8 miles east-northeast of Olympia
6/23/1946	7.3	Strait of Georgia
2/14/1946	6.3	Puget Sound
4/29/1945	5.7	North Bend (8 miles south/southeast)
11/13/1939	5.8	Puget Sound – Near Vashon Island
5/15/1936	5.7	Southwest Washington
7/17/1932	5.3	Central Cascades
1/23/1920	5.5	Puget Sound
12/6/1918	7.0	Vancouver Island
8/18/1915	5.6	North Cascades
1/11/1909	6.0	Puget Sound
3/6/1904		Washington coastline and Olympic Mountains
3/27/1884		Hoquiam
4/30/1882	5.8	Olympia area
12/15/1872	6.8	Pacific Coast

Source: Pacific Northwest Seismic Network

8.2.3 Severity

Earthquakes can last from a few seconds to over five minutes; they may also occur as a series of tremors over several days. The actual movement of the ground in an earthquake is seldom the direct cause of injury or death. Casualties generally result from falling objects and debris, because the shocks 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.

Small, local faults produce lower magnitude quakes, but ground shaking can be strong, and damage can be significant in areas close to the fault. In contrast, large regional faults can generate earthquakes of great magnitudes but, because of their distance and depth, they may result in only moderate shaking in an area.

USGS ground motion maps based on current information about fault zones show the PGA that has a certain probability (2 or 10 percent) of being exceeded in a 50-year period. The PGA is measured in %g. Figure 8-10 shows the PGA with a 2 percent exceedance chance in 50 years in Washington.

The Devils Mountain Fault, which is roughly 78 miles long and runs east to west through Snohomish and Skagit Counties to Vancouver Island, Canada, has been determined to be an event of great concern for the planning area. If a Magnitude 7.5 event or greater were to occur, it would affect 15 counties. Effects of a major earthquake in the Puget Sound basin area could be catastrophic, providing the worst-case disaster short of drought-induced wildfire sweeping through a suburban area. Hundreds of residents could be killed and a multitude of others left homeless.

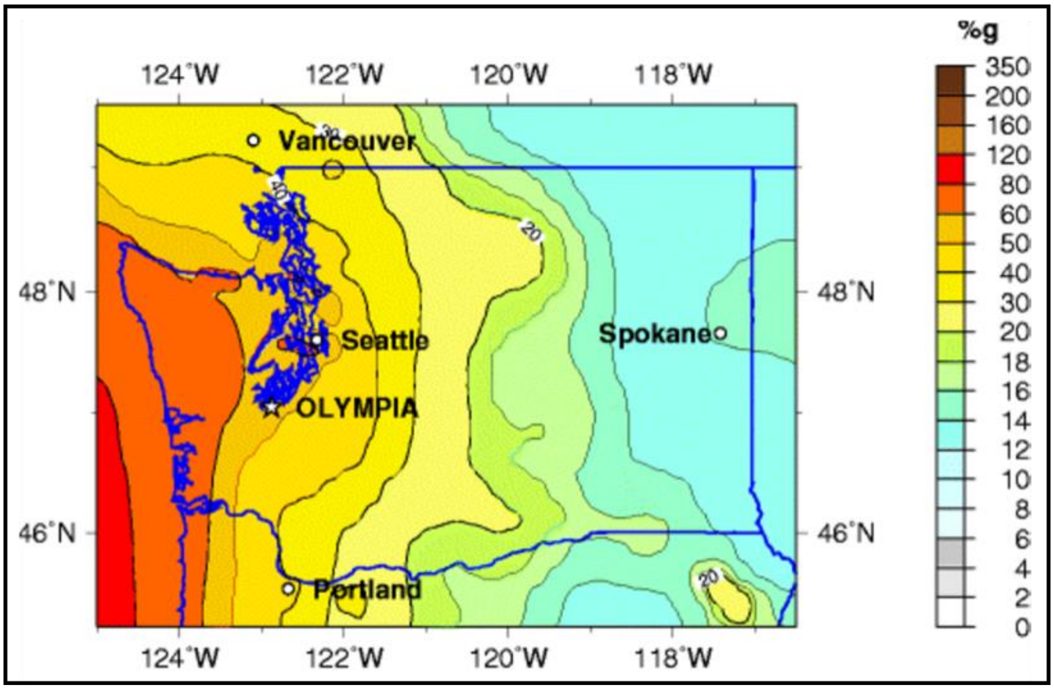


Figure 8-10 PGA with 2-Percent Probability of Exceedance in 50 Years, Northwest Region

8.2.4 Frequency

Scientists are currently developing methods to more accurately determine when an earthquake will occur. Recent advancements in determining the probability of an earthquake in a given period use a log-normal, Brownian Passage Time, or other probability distribution in which the probability of an event depends on the time since the last event. Such time-dependent models produce results broadly consistent with the elastic rebound theory of earthquakes. The USGS and others are beginning to develop such products as new geologic and seismic information regarding the dates of previous events along faults becomes more and more available (USGS, 2015a).

- Current estimates of the likelihood of another potentially damaging intraplate earthquake during a 50-year time window with the Puget Sound region put the probability at 84 percent, with somewhat lower probabilities as one goes southward (Earthquake Hazard Program, 2012).

- Scientists currently estimate that a Magnitude-9 earthquake in the Cascadia Subduction Zone occurs about once every 500 years. The last one was in 1700. Paleoseismic investigations have identified 41 Cascadia Subduction Zone interface earthquakes over the past 10,000 years, which corresponds to one earthquake about every 250 years. About half were M9.0 or greater earthquakes that represented full rupture of the fault zone from Northern California to British Columbia. The other half were M8+ earthquakes that ruptured only the southern portion of the subduction zone.

- The 300+ years since the last major Cascadia Subduction Zone earthquake is longer than the average of about 250 years for M8 or greater and shorter than some of the intervals between M9.0 earthquakes.

- Scientists currently estimate the frequency of deep earthquakes similar to the 1965 Magnitude-6.5 Seattle-Tacoma event and the 2001 Magnitude-6.8 Nisqually event as about once every 35 years. The USGS estimates an 84-percent chance of a Magnitude-6.5 or greater deep earthquake over the next 50 years.

- Scientists estimate the approximate recurrence rate of a Magnitude-6.5 or greater earthquake anywhere on a shallow fault in the Puget Sound basin to be once in about 350 years. There have been four earthquakes of less than Magnitude 5 in the past 20 years.

- Earthquakes on the Seattle Faults have a 2-percent probability of occurrence in 50 years. A Benioff zone earthquake has an 85 percent probability of occurrence in 50 years, making it the most likely of the three types.

8.3 VULNERABILITY ASSESSMENT

8.3.1 Overview

Several faults within the planning region have the potential to cause direct impact. The area also is vulnerable to impact from an event outside the area, although the intensity of ground motions diminishes with increasing distance from the epicenter. As a result, the entire population of the planning area is exposed to both direct and indirect impacts from earthquakes. The degree of direct impact (and exposure) is dependent on factors including the soil type on which homes are constructed, the proximity to fault location, the type of materials used to construct residences and facilities, etc. Indirect impacts are associated with elements such as the inability to evacuate the area as a result of earthquakes occurring in other regions of the state as well as impact on commodity flow for goods and services into the area, many of which are serviced only by one roadway in or out. Impact from other parts of the state could require shipment of supplies via a barge due to impact to roadways.

The following are also general areas of vulnerability to be considered:

- Large hazardous materials incidents may occur as the result of damage to local oil refineries, chemical plants, rail lines and major petroleum pipelines. Transportation along the rail lines of chemicals is concerning, although no rail lines traverse the Reservation directly.
- Levees and salt-water dikes may be damaged.
- Large hydroelectric dams may be damaged or possibly fail.
- Localized seiche action in local waters may result in increased levels of damage along shoreline areas.
- The arrival of outside resources to assist with debris removal, repair of critical facilities, and sheltering of victims may be delayed due to severe damage in adjacent areas with larger populations and needs.
- The overall economy of the area and possibly the region could be affected.
- Large areas lying within the floodplains are susceptible to liquefaction.

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 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 they are working with, or shut down a computer system.

8.3.2 Impact on Life, Health, and Safety

The entire population of the planning area is exposed to direct and indirect impacts from earthquakes. This would include residents, visitors, and employees of the Tribe. This would also include individuals seeking services for health, etc., which the tribe provides.

Two of the most vulnerable populations to a disaster incident such as this are the young and the elderly. Linguistically isolated populations and those living below poverty level are also more susceptible. The planning area as a whole (when looking at county-based data) has a fairly high population of retirees and individuals with disabilities, both higher than the state averages. The need for increased rescue efforts and/or to provide assistance to such a large population base could tax the first-responder resources in the area during an event. Although many injuries may not be life-threatening, people will require medical attention and, in many cases, hospitalization. Potential life-threatening injuries and fatalities are expected; these are likely to be at an increased level if an earthquake happens during the afternoon or early evening. This would be a significant factor when considering the daily population at the casino and hotel, as well as the Tribal offices and services provided on the Reservation.

The degree of exposure is dependent on many factors, including the soil type their homes are constructed on, quality of construction, their proximity to fault location, etc. Whether impacted directly or indirectly, the entire population will have to deal with the consequences of earthquakes to some degree. Business interruption could keep people from working, road closures could isolate populations, and loss of functions of utilities could impact populations that suffered no direct damage from an event itself.

It should be noted that there are significant variables that exist in the data which is used to populate the inputs necessary to reach conclusions identified within this document, including the type of structure, year built, remodeling, engineered assessments, etc. All of these factors play a significant role in determining potential impact, and therefore any outputs from the Hazus model are considered to have a high rate of error unless better, more accurate (engineered) building specific data is utilized. Such efforts far exceed the scope of this project, and as such, outputs gained during this process should be considered for planning purposes only, and in no manner should be considered for life-safety measures.

8.3.3 Impact on Property

All structures owned by the Tribe are at risk to impact from earthquake. This current update included 36 structures owned and operated by the Tribe, with a total structure and content value of $326 million dollars. However, the Tribe does own additional structures as well off the reservation in various parts of Snohomish and Skagit County, those structures being primarily housing units. Due to the area of impact and the proximity to the fault or epicenter location, those structures could also be impacted. The majority of off-reservation structures are older in nature, which may increase impact potential. The Tribe also has a significant of land mass off the Reservation, which has been restored to its natural environment, with structures removed. Those project areas could be impacted by secondary hazards of landslides or hazardous materials exposure many times associated with earthquakes.

Building Age

Structures that are in compliance with the Uniform Building Code (UBC) of 1970 or later are generally less vulnerable to seismic damage because 1970 was when the UBC started including seismic construction standards based on regional location. This stipulated that all structures be constructed to at least seismic risk Zone 2 standards.

The State of Washington adopted the UBC as its state building code in 1972, so it is assumed that buildings in the planning area built after 1972 were built in conformance with UBC seismic standards and have less vulnerability. Issues such as code enforcement and code compliance could impact this assumption. Construction material is also important when determining the potential risk to a structure. However, for planning purposes, establishing this line of demarcation can be an effective tool for estimating vulnerability. In 1994, seismic risk Zone 3 standards of the UBC went into effect in Washington, requiring all new construction to be capable of withstanding the effects of 0.3 g. More recent housing stock is in compliance with Zone 3 standards. In July 2004, the state again upgraded the building code to follow International Building Code Standards. While the "zones" are still referenced, they are, in large part, no longer used in the capacity they once were as there can be different zones within political subdivisions, making it difficult to apply. For instance, within Washington, there are both Seismic Zones 2B and 3. The Hazus analysis also considers the age in which buildings were built to a specific building code. Hazus identifies key changes in earthquake building codes based on year. Homes built prior to 1941 are considered pre-code; they were constructed before earthquake building codes were put in place. Homes constructed after 1941 are considered moderate code and may include some earthquake building components.

8.3.4 Impact on Critical Facilities and Infrastructure

Similar to the impact to property, all critical facilities are exposed to the earthquake hazard. The degree of impact from an earthquake is largely determined based on proximity, magnitude, and ground motion causing liquefaction. Given the size of the Reservation, it can be determined that impact will be similar reservation wide.

Review of the Hazus program outputs provide some information which, at this level of planning, can be used by emergency managers for planning purposes, but *not* for the purposes of determining life safety measures. Based on the M9.0 Cascadia-type scenario event and utilizing the (36) Tribal structures identified for this assessment, Hazus outputs indicate that when averaged, ~65 percent of the structures are anticipated to have no significant damage, while ~23 percent are identified as having only slight damage; ~10.6 percent are identified as having moderate damage; ~1.2 percent are expected to have extensive damage, and ~0.014 percent are expected to have complete damage. It should be noted that Hazus output analysis is supplemented with default data and does not include building-specific information necessary to conduct life-safety determination, as such analysis is well beyond the scope of this project.

Based on further review of the identified critical facilities and infrastructure information captured during this process, the following would apply with respect to application of building codes and age of the critical facilities and infrastructure with respect to considerations used in determining the ability of structures to withstand ground shaking:

- Three structures, all wood construction, were built prior to (significant) codes being in place. Two of those are medical in nature, and one a three-story multi-family residential structure.
- Three structures (all maintenance facilities) were built between 1982 and 1985.
- 24 structures were built between 1990 and 2020, with three masonry structures all built after 2009.
- 10 of the 24 structures are steel, seven are wood, and one is concrete (a parking garage), built in 2019.

- The elders' Longhouse and cottages, and the youth townhomes (residential structures) were constructed with the most current building codes in place.
- The community center, which also serves as the educational building and daycare, is a masonry structure built in 2014.

Earthquakes can also cause disruption to communications, electrical power, wastewater and potable water services and supplies. Such disruptions should be expected. Earthquakes may also trigger fires, dam failures, landslides, or releases of hazardous material. Hazardous materials releases can occur during an earthquake from both fixed facilities or transportation-related incidents, leaking into the surrounding area or an adjacent waterway, having a disastrous effect on the environment.

There is limited access onto the reservation. An earthquake could cause isolation if the roadways leading to the reservation were impacted. In addition, closure of major arterials around the reservation could also require increased evacuation periods in some instances by several hours. Commodities could also be impacted in area, requiring supplies by air or water

In the event of a major earthquake, areas lying within the floodplain are susceptible to liquefaction. Magnitude 7+ earthquakes can potentially trigger slope failures as well. The potential for landslide-induced roadway closure is of significant concern in addition to the steep and/or unstable slopes in various locations susceptible to landslides.

The Stillaguamish Tribe currently has no pipelines carrying natural gas or water to the Reservation. Gas needs are met by propane tanks. Water systems are on the reservation and include a purification system to meet the needs of the Tribe. Wastewater is tanked out multiple times per week. While the structures on the reservation are built to current building code standards, they could nonetheless be impacted. In addition, the Tribe is reliant on physical disposal of its wastewater. Impact to the roadways in the area could cause issues with respect to disposal. Wastewater holding facilities on the reservation could also be impacted by an earthquake.

Within the watershed area, there are several major transmission pipelines carrying oil, gasoline, and natural gas. While not on the reservation, some of these lines cross major rivers, such as the Skagit River (among others), and include both underground and above-ground lines supported by cable suspension structures. Damage to those pipelines would significantly impact the various waterways of the area, including potentially within the Stillaguamish Watershed.

Bridges are one of the most vulnerable components of highway transportation systems and the loss of bridges will have a direct effect the delivery of emergency services to a large number of citizens. Very few bridges in the area have been retrofitted to withstand the effects of a major earthquake. In addition, bridge foundations are typically located in soils susceptible to liquefaction thereby allowing bridge piers to move and bridge girders to collapse.

8.3.5 Impact on Economy

Economic losses due to earthquake damage include damage to buildings, including the cost of structural and non-structural damage, damage to contents, and loss of inventory, loss of wages and loss of income. Economic impact would also include loss to the various business ventures owned and operated by the Tribe, including the casino and hotel, among others. In addition, loss of goods and services may hamper recovery efforts, and even preclude residents from rebuilding within the area, further impacting potential income streams. No specific loss data is available with respect to loss of inventory, wages, or loss of income.

8.3.6 Impact on Environment

Earthquake-induced landslides can significantly impact habitat. It is also possible for streams to be rerouted after an earthquake. This can change water quality, possibly damaging habitat and feeding areas. There is a possibility of streams fed by groundwater drying up because of changes in underlying geology. There also exists the impact from hazardous materials impacting the environment, including the coastlines, estuaries, and watersheds, among others.

8.3.7 Impact from Climate Change

The impacts of global climate change on earthquake probability are unknown. Some scientists say that melting glaciers could induce tectonic activity. As ice melts and water runs off, tremendous amounts of weight are shifted on the earth’s crust. As newly freed crust returns to its original, pre-glacier shape, it could cause seismic plates to slip and stimulate volcanic activity, according to research into prehistoric earthquakes and volcanic activity. NASA and USGS scientists found that retreating glaciers in southern Alaska may be opening the way for future earthquakes (NASA, 2004).

Secondary impacts of earthquakes could be magnified by climate change. Soils saturated by repetitive storms could experience liquefaction or an increased propensity for slides during seismic activity due to the increased saturation. Dams storing increased volumes of water due to changes in the hydrograph could fail during seismic events. There are currently no models available to estimate these impacts.

8.4 FUTURE DEVELOPMENT TRENDS

The Tribe does utilize the International Building Code, which requires structures to be built at a level which supports soil types and earthquake hazards (ground shaking). As existing buildings are renovated, provisions are in place which require reconstruction at higher standards.

8.5 ISSUES

While the planning area has a high probability of an earthquake event occurring within its boundaries, an earthquake does not necessarily have to occur in the planning area to have a significant impact as such an event would disrupt transportation to and from the region as a whole, and impact commodity flow. As such, any seismic activity of 6.0 or greater on faults in or near the planning area would have significant impact. Potential warning systems could give approximately 40 seconds notice that a major earthquake is about to occur. This would not provide adequate time for preparation. Earthquakes of this magnitude or higher would lead to massive structural failure of property on NEHRP C, D, E, and F soils. Levees and revetments built on these poor soils would likely fail, representing a loss of critical infrastructure. These events could cause secondary hazards, including landslides and mudslides that would further damage structures. River valley hydraulic-fill sediment areas are also vulnerable to slope failure, often as a result of loss of cohesion in clay-rich soils. Soil liquefaction would occur in water-saturated sands, silts, or gravelly soils.

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 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 risks for earthquakes. Earthquakes at sea can generate destructive tsunamis.

8.6 IMPACT AND RESULTS

Based on review and analysis of the data, the Planning Team has determined that the probability for impact from an Earthquake throughout the area is highly likely. Either a Cascadia Subduction Zone or a Devils Mountain-type event, such as those utilized as the scenarios modeled for this update, have a high probability of occurring within the region.

A Devils Mountain earthquake could generate a large amount of damage within the general planning area, including outside of the reservation. Also a factor is the large number of buildings being designated as pre-code buildings which, while not owned by the Tribe, in some cases are residences owned by Tribal members, or provide services on which the Tribal members or Tribal businesses rely (e.g., supply-chain). Due to the age of these buildings and the absence of building codes at time of construction, they may not perform as well during an earthquake compared to structures built after code implementation. That would impact both tribal members' safety, as well as the economy of the region.

Based on the potential impact, the Planning Team determined the CPRI score to be 3.65, with overall vulnerability determined to be a high level.

CHAPTER 9.
FLOOD

Floods are one of the most common natural hazards in the U.S. They can develop slowly over a period of days or develop quickly, with disastrous effects that can be local (impacting a neighborhood or community) or regional (affecting entire river basins, coastlines and multiple counties or states) (FEMA, 2010). Most communities in the U.S. have experienced some kind of flooding, after spring rains, heavy thunderstorms, coastal storms, or winter snow thaws. Floods are one of the most frequent and costly natural hazards in terms of human hardship and economic loss, particularly to communities that lie within flood-prone areas or floodplains of a major water source.

DEFINITIONS

Flood—The inundation of normally dry land resulting from the rising and overflowing of a body of water.

Floodplain—The land area along the sides of a river that becomes inundated with water during a flood.

100-Year Floodplain—The area flooded by a flood that has a 1-percent chance of being equaled or exceeded each year. This is a statistical average only; 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.

Floodway—The channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height.

9.1 GENERAL BACKGROUND

Flooding is a general and temporary condition of partial or complete inundation on normally dry land from the following:

- Riverine flooding, including overflow from a river channel, flash floods, alluvial fan floods, dam-break floods and ice jam floods;
- Local drainage or high groundwater levels;
- Fluctuating lake levels;
- Coastal flooding;
- Coastal erosion;
- Unusual and rapid accumulation or runoff of surface waters from any source;
- Mudflows (or mudslides);
- Collapse or subsidence of land along the shore of a lake or similar body of water that result in a flood, caused by erosion, waves or currents of water exceeding anticipated levels (Floodsmart.gov, 2012);
- Sea level rise;
- Climate Change (USEPA, 2012).

9.1.1 Flooding Types

Many floods fall into one of three categories: riverine, coastal, or shallow (FEMA, 2005). Other types of floods include alluvial fan floods, dam failure floods, and floods associated with local drainage or high groundwater. For this hazard mitigation plan, riverine/stormwater flooding are the main flood types of concern for the planning area.

Riverine

Riverine floods are the most common flood type. They occur along a channel and include overbank and flash flooding. Channels are defined ground features that carry water through and out of a watershed. They may be called rivers, creeks, streams, or ditches. When a channel receives too much water, the excess water flows over its banks and inundates low-lying areas (FEMA, 2005).

Flash Floods

A flash flood is a rapid, extreme flow of high water into a normally dry area, or a rapid water level rise in a stream or creek above a predetermined flood level, beginning within six hours of the causative event (e.g., intense rainfall, dam failure, ice jam). The time may vary in different areas. Ongoing flooding can intensify to flash flooding in cases where intense rainfall results in a rapid surge of rising floodwaters (NWS, 2009).

Coastal Flooding

Coastal flooding is the flooding of normally dry, low-lying coastal land, primarily caused by severe weather events along the coast, estuaries, and adjoining rivers. These flood events are some of the more frequent, costly, and deadly hazards that can impact coastal communities. Factors causing coastal flooding include:

- Storm surges, which are rises in water level above the regular astronomical tide caused by a severe storm’s wind, waves, and low atmospheric pressure. Storm surges are extremely dangerous, because they are capable of flooding large coastal areas.
- Large waves, whether driven by local winds or swell from distant storms, raise average coastal water levels and individual waves roll up over land.
- High tide levels are caused by normal variations in the astronomical tide cycle (discussed below).
- Other larger scale regional and ocean scale variations are caused by seasonal heating and cooling and ocean dynamics.

Coastal floods are extremely dangerous, and the combination of tides, storm surge, and waves can cause severe damage. Coastal flooding is different from river flooding, which is generally caused by severe precipitation. Depending on the storm event, in the upper reaches of some tidal rivers, flooding from storm surge may be followed by river flooding from rain in the upland watershed. This increases the flood severity. Within the National Flood Insurance Flood Maps (discussed below), coastal flood zones identify special flood hazard areas (SFHA) which are subject to waves with heights of between 1.5 and 3 feet during a 1-percent annual chance storm (100-year event).

Tidal Flooding

Spring tides, the highest tides during any month, occur with each full and new moon. When these coincide with a northerly wind piling water, tidal flooding can occur. The tides can also enhance flooding in delta areas when rivers or creeks are at or near flood stage. Such flooding is also a threat to low-lying farmlands in the area. Tidal impact is of most concern in delta areas when rivers are at flood stage and high tide exacerbates the situation. Concerns about tidal flooding are anticipated to increase due to the impacts of global climate change and sea level rise, particularly in areas where restoration projects have been completed or are underway.

9.1.2 Dam Failure

Dam failures in the United States typically occur in one of four ways (Association of State Dam Safety Officials, 2012):

- Overtopping of the primary dam structure, which accounts for 34 percent of all dam failures, can occur due to inadequate spillway design, settlement of the dam crest, blockage of spillways, and other factors.

- Foundation defects due to differential settlement, slides, slope instability, uplift pressures, and foundation seepage can also cause dam failure. These account for 30 percent of all dam failures.
- Failure due to piping and seepage accounts for 20 percent of all failures. These are caused by internal erosion due to piping and seepage, erosion along hydraulic structures such as spillways, erosion due to animal burrows, and cracks in the dam structure.
- Failure due to problems with conduits and valves, typically caused by the piping of embankment material into conduits through joints or cracks, constitutes 10 percent of all failures.

The remaining 6 percent of U.S. dam failures are due to miscellaneous causes. Many dam failures in the United States have been secondary results of other disasters. The prominent causes are earthquakes, landslides, extreme storms, massive snowmelt, equipment malfunction, structural damage, foundation failures, and sabotage. The most likely disaster-related cause of dam failure in the planning area is related to earthquakes. 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.

The potential for catastrophic flooding due to dam failures led to passage of the National Dam Safety Act (Public Law 92-367). The National Dam Safety Program requires a periodic engineering analysis of every major dam in the country. The goal of this FEMA-monitored effort is to identify and mitigate the risk of dam failure so as to protect the lives and property of the public.

There have been no reported incidents of dam failure impacting the Tribe.

Washington Department of Ecology Dam Safety Program

The Dam Safety Office (DSO) of the Washington Department of Ecology regulates over 1,000 dams in the state that impound at least 10 acre-feet of water. The DSO has developed dam safety guidelines to provide dam owners, operators, and design engineers with information on activities, procedures, and requirements involved in the planning, design, construction, operation, and maintenance of dams in Washington. The authority to regulate dams in Washington and to provide for public safety is contained in the following laws:

- State Water Code (1917)—RCW 90.03
- Flood Control Act (1935)—RCW 86.16
- Department of Ecology (1970)—RCW 43.21A .

Where water projects involve dams and reservoirs with a storage volume of 10 acre-feet or more, the laws provide for the Department of Ecology to conduct engineering review of the construction plans and specifications, to inspect the dams, and to require remedial action, as necessary, to ensure proper operation, maintenance, and safe performance. The DSO was established within Ecology's Water Resources Program to carry out these responsibilities.

The DSO provides reasonable assurance that impoundment facilities will not pose a threat to lives and property, but dam owners bear primary responsibility for the safety of their structures, through proper design, construction, operation, and maintenance. The DSO regulates dams with the sole purpose of reasonably securing public safety; environmental and natural resource issues are addressed by other state agencies. The DSO neither advocates nor opposes the construction and operation of dams.

U.S. Army Corps of Engineers Dam Safety Program

The U.S. Army Corps of Engineers is responsible for safety inspections of some federal and non-federal dams in the United States that meet the size and storage limitations specified in the National Dam Safety Act. The Corps has inventoried dams; surveyed each state and federal agency's capabilities, practices and regulations regarding design, construction, operation, and maintenance of the dams; and developed guidelines for inspection and evaluation of dam safety (U.S. Army Corps of Engineers, 1997).

Federal Energy Regulatory Commission Dam Safety Program

The Federal Energy Regulatory Commission (FERC) cooperates with a large number of federal and state agencies to ensure and promote dam safety. There are 3,036 dams that are part of regulated hydroelectric projects in the FERC program. Two-thirds of these are more than 50 years old. As dams age, concern about their safety and integrity grows, so oversight and regular inspection are important. FERC staff inspects hydroelectric projects on an unscheduled basis to investigate the following:

- Potential dam safety problems;
- Complaints about constructing and operating a project;
- Safety concerns related to natural disasters;
- Issues concerning compliance with the terms and conditions of a license.

Every five years, an independent engineer approved by the FERC must inspect and evaluate projects with dams higher than 32.8 feet (10 meters), or with a total storage capacity of more than 2,000 acre-feet.

FERC staff monitors and evaluates seismic research and applies it in investigating and performing structural analyses of hydroelectric projects. FERC staff also evaluates the effects of potential and actual large floods on the safety of dams. During and following floods, FERC staff visits dams and licensed projects, determines the extent of damage, if any, and directs any necessary studies or remedial measures the licensee must undertake. The FERC publication *Engineering Guidelines for the Evaluation of Hydropower Projects* guides the FERC engineering staff and licensees in evaluating dam safety. The publication is frequently revised to reflect current information and methodologies.

The FERC requires licensees to prepare emergency action plans and conducts training sessions on how to develop and test these plans. The plans outline an early warning system if there is an actual or potential sudden release of water from a dam due to failure. The plans include operational procedures that may be used, such as reducing reservoir levels and reducing downstream flows, as well as procedures for notifying affected residents and agencies responsible for emergency management. These plans are frequently updated and tested to ensure that everyone knows what to do in emergency situations.

Hazard Ratings

The DSO classifies dams and reservoirs in a hazard rating system based solely on the potential consequences to downstream life and property that would result from a failure of the dam and sudden release of water. The following codes are used as an index of the potential consequences in the downstream valley if the dam were to fail and release the reservoir water:

- 1A = Greater than 300 lives at risk (High hazard);

- 1B = From 31 to 300 lives at risk (High hazard);
- 1C = From 7 to 30 lives at risk (High hazard);
- 2 = From 1 to 6 lives at risk (Significant hazard);
- 3 = No lives at risk (Low hazard).

The Corps of Engineers developed the hazard classification system for dam failures shown in Table 9-1. The Washington and Corps of Engineers hazard rating systems are both based only on the potential consequences of a dam failure; neither system takes into account the probability of such failures.

TABLE 9-1
CORPS OF ENGINEERS HAZARD POTENTIAL 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

The owner of a dam is responsible for developing an inundation map, which is used in determining exposure to a potential dam failure or breech during development of dam response plans. Presently, no such maps are available for public release for any of the dams as inundation maps are considered privileged information. Therefore, it is difficult to estimate the population living within the inundation zone beyond the information designated in the dam classification analysis. Without the ability to perform an inundation study, it is also not possible to estimate property losses from a dam failure which could ultimately affect the planning area.

While no additional dam failure inundation studies are available, in some instances those inundation areas coincide with flood hazard areas. Review of the flood profile may provide a general concept of structures at risk, although, based on the size of the dams, damage would vary. As development occurs downstream of dams, it is necessary to review the dams' emergency action plans and inundation maps to determine whether the dams require reclassification based on the established standards.

There are no dams on the reservation boundary; however, Snohomish County has 58 dams within its boundaries identified by the Washington State Department of Ecology Dam Safety Program.[8] Of those, Koch Slough Dam, which is situated below I-5, is a diversion damn intended to keep the flow in the Old Stillaguamish Channel. If it were to fail, besides the increased flow down Koch and Hatt Slough, the riverbed could potentially head-cut towards the I-5 bridge.

9.1.3 Measuring Floods and Floodplains

A floodplain is the area adjacent to a river, creek or lake that becomes inundated during a flood. Floodplains may be broad, as when a river crosses an extensive flat landscape, or narrow, as when a river is confined in a canyon. Connections between a river 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 with levees and other flood control facilities, natural, built-in benefits can be lost, altered, or significantly reduced.

In the case of riverine or flash flooding, once a river reaches flood stage, the flood extent or severity categories used by the NWS include minor flooding, moderate flooding, and major flooding. Each category has a definition based on property damage and public threat (NWS, 2011):

- Minor Flooding—Minimal or no property damage, but possibly some public threat or inconvenience.
- Moderate Flooding—Some inundation of structures and roads near streams. Some evacuations of people and/or transfer of property to higher elevations are necessary.
- Major Flooding—Extensive inundation of structures and roads. Significant evacuations of people and/or transfer of property to higher elevations.

9.1.4 Flood Insurance Rate Maps

According to FEMA, flood hazard areas are defined as areas that are shown to be inundated by a flood of a given magnitude on a map (see Figure 9-1). These areas are determined using statistical analyses of records of river flow, storm tides, and rainfall; information obtained through consultation with the community; floodplain topographic surveys; and hydrologic and hydraulic analyses. Three primary areas make up the flood hazard area: the floodplains, floodways, and floodway fringes. Figure 9-2 depicts the relationship among the various designations, collectively referred to as the special flood hazard area.

[8] https://fortress.wa.gov/ecy/publications/documents/94016.pdf

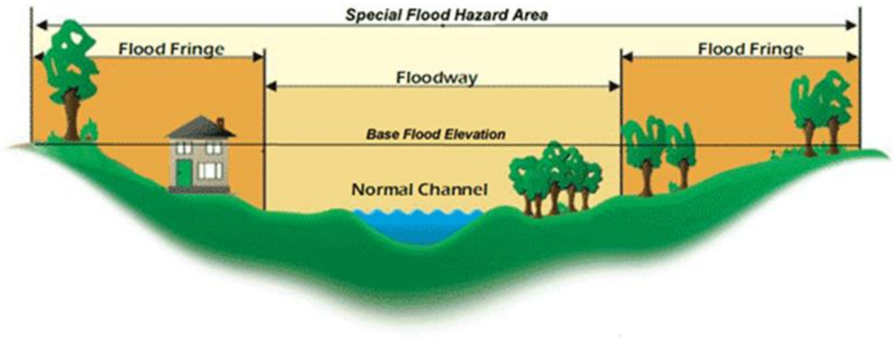


Figure 9-1 Flood Hazard Area Referred to as a Floodplain

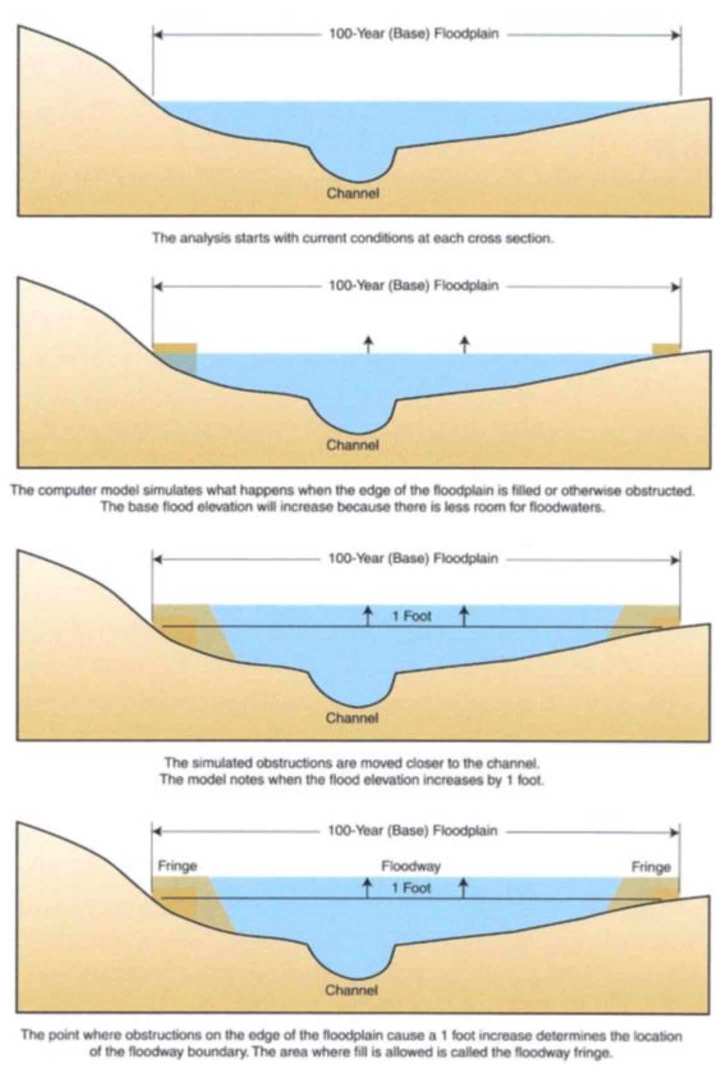


Figure 9-2 Special Flood Hazard Area

Flood hazard areas are delineated on FEMA's Flood Insurance Rate Maps (FIRM), which are official maps of a community on which the Federal Insurance and Mitigation Administration has indicated both the special flood hazard areas (SFHA) and the risk premium zones applicable to the community. These maps identify the geographic areas or zones that FEMA has defined according to varying levels of flood risk, and include: special flood hazard areas; the location of a specific property in relation to the special flood hazard area; the base (100-year) flood elevation at a specific site; the magnitude of a flood hazard in a specific area; and undeveloped coastal barriers where flood insurance is not available. The maps also locate regulatory floodways and floodplain boundaries—the 100-year and 500-year floodplain boundaries (FEMA, 2003; FEMA, 2005; FEMA, 2008). Table 9-2 identifies the various rate map zones.[9]

TABLE 9-2
FLOOD INSURANCE RATE MAP ZONES

Moderate to Low Risk Areas: Areas of moderate or minimal hazard are studied based upon the principal source of flood in the area. However, buildings in these zones could be flooded by severe, concentrated rainfall coupled with inadequate local drainage systems. Local stormwater drainage systems are not normally considered in a community's flood insurance study. The failure of a local drainage system can create areas of high flood risk within these zones. Flood insurance is available in participating communities but is not required by regulation in these zones. Nearly 25-percent of all flood claims filed are for structures located within these zones.	
Zone	**Description**
B and X (shaded)	Area of moderate flood hazard, usually the area between the limits of the 100-year and 500-year floodplain area with a 0.2% (or 1 in 500 chance) annual chance of flooding. B Zones are also used to designate base floodplains of lesser hazards, such as areas protected by levees from 100-year flood, or shallow flooding areas with average depths of less than one foot or drainage areas less than one (1) square mile.
C and X (unshaded)	Area of minimal flood hazard, usually depicted on FIRMs as above the 500-year flood level. Zone C may have ponding and local drainage problems that do not warrant a detailed study or designation as base floodplain. Zone X is the area determined to be outside the 500-year flood and protected by levee from 100-year flood.
High Risk Areas: Special Flood Hazard Areas represent the area subject to inundation by 1-percent-annual chance flood. Structures located within the SFHA have a 26-percent chance of flooding during the life of a standard 30-year mortgage. Federal floodplain management regulations and mandatory flood insurance purchase requirements apply to participating communities in these zones.	
Zone	**Description**
A	Areas with a 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage. Because detailed analyses are not performed for such areas, no depths or base flood elevations are shown within these zones.
AE	The base floodplain where base flood elevations are provided. AE Zones are now used on new format FIRMs instead of A1-A30 Zones.
A1-30 (old map format)	These are known as numbered A Zones (e.g., A7 or A14). This is the base floodplain where the FIRM shows a BFE (old format). Older maps still utilize this numbered system, but newer FEMA products no longer use the "numbered" A Zones. (Zone AE is used on new and revised maps in place of Zones A1–A30.)
AH	Areas with a 1% annual chance of shallow flooding, usually in the form of a pond, with an average depth ranging from 1 to 3 feet. These areas have a 26% chance of flooding over the life of a 30-year mortgage. Base flood elevations derived from detailed analyses are shown at selected intervals within these zones.
AO	River or stream flood hazard areas, and areas with a 1% or greater chance of shallow flooding each year, usually in the form of sheet flow, with an average depth ranging from 1

[9]http://msc.fema.gov/webapp/wcs/stores/servlet/info?storeId=10001&catalogId=10001&langId=-1&content=floodZones&title=FEMA%20Flood%20Zone%20Designations

TABLE 9-2 FLOOD INSURANCE RATE MAP ZONES	
	to 3 feet. These areas have a 26% chance of flooding over the life of a 30-year mortgage. Average flood depths derived from detailed analyses are shown within these zones.
AR	Areas with a temporarily increased flood risk due to the building or restoration of a flood control system (such as a levee or a dam). Mandatory flood insurance purchase requirements will apply, but rates will not exceed the rates for unnumbered A zones if the structure is built or restored in compliance with Zone AR floodplain management regulations.
A99	Areas with a 1% annual chance of flooding that will be protected by a Federal flood control system where construction has reached specified legal requirements. No depths or base flood elevations are shown within these zones.
High Risk - Coastal High Hazard Areas (CHHA): These represent the area subject to inundation by 1-percent-annual chance flood, extending from offshore to the inland limit of a primary front al dune along an open coast and any other area subject to high velocity wave action from storms or seismic sources. Structures located within the CHHA have a 26-percent chance of flooding during the life of a standard 30-year mortgage. Federal floodplain management regulations and mandatory purchase requirements apply in the following zones.	
Zone	**Description**
V	Coastal areas with a 1% or greater chance of flooding and an additional hazard associated with storm waves. These areas have a 26% chance of flooding over the life of a 30-year mortgage. No base flood elevations are shown within these zones.
VE, V1-30	Coastal areas with a 1% or greater chance of flooding and an additional hazard associated with storm waves. These areas have a 26% chance of flooding over the life of a 30-year mortgage. Base flood elevations derived from detailed analyses are shown at selected intervals within these zones.
Undetermined Risk Areas	
Zone	**Description**
D	Areas with possible but undetermined flood hazard. No flood hazard analysis has been conducted. Flood insurance rates are commensurate with the uncertainty of the flood risk.

The frequency and severity of flooding are measured using a discharge probability, which is a statistical tool used to define the probability that a certain river discharge (flow) level will be equaled or exceeded within a given year. Flood studies use historical records to determine the probability of occurrence for the different discharge levels.

The extent of flooding associated with a 1-percent annual probability of occurrence (the base flood or 100-year flood) is used as the regulatory boundary by many agencies. Also referred to as the special flood hazard area, this boundary is a convenient tool for assessing vulnerability and risk in flood-prone communities. Many communities have maps that show the extent and likely depth of flooding for the base flood. Corresponding water-surface elevations describe the elevation of water that will result from a given discharge level, which is one of the most important factors used in estimating flood damage.

A structure located within a 1 percent (100-year) floodplain has a 26 percent chance of suffering flood damage during the term of a 30-year mortgage. The 100-year flood is a regulatory standard used by federal agencies and most states to administer floodplain management programs. The 1 percent (100-year) annual chance flood is used by the NFIP as the basis for insurance requirements nationwide. FIRMs also depict 500-year flood designations, which is a boundary of the flood that has a 0.2-percent chance of being equaled or exceeded in any given year (FEMA, 2003; FEMA, 2005). It is important to recognize, however, that flood events and flood risk are not limited to the NFIP delineated flood hazard areas. The table below illustrates the estimated probability of flood events as utilized by the NFIP.

TABLE 9-3
ESTIMATED PROBABILITY OF FLOOD EVENT

EVENT	ANNUAL CHANCE OF OCCURRENCE
10-year flood	10%
25-year flood	4%
50-year flood	2%
100-year flood	1%
500-year flood	0.2%

9.1.5 National Flood Insurance Program (NFIP)

The NFIP is a federal program enabling property owners in participating communities to purchase insurance as a protection against flood losses in exchange for state and community floodplain management regulations that reduce future flood damage. The U.S. Congress established the NFIP with the passage of the National Flood Insurance Act of 1968 (FEMA's 2002 *National Flood Insurance Program (NFIP): Program Description*). There are three components to the NFIP: flood insurance, floodplain management, and flood hazard mapping. Nearly 20,000 communities across the U.S. and its territories participate in the NFIP by adopting and enforcing floodplain management ordinances to reduce future flood damage. In exchange, the NFIP makes federally backed flood insurance available to homeowners, renters, and business owners in these communities. Community participation in the NFIP is voluntary.

For most participating communities, FEMA has prepared a detailed Flood Insurance Study. The study presents water surface elevations for floods of various magnitudes, including the 1-percent annual chance flood and the 0.2-percent annual chance flood (the 500-year flood). Base flood elevations and the boundaries of the 100- and 500-year floodplains are shown on Flood Insurance Rate Maps (FIRMs), which are the principle tool for identifying the extent and location of the flood hazard. FIRMs are the most detailed and consistent data source available, and for many communities they represent the minimum area of oversight under their floodplain management program.

NFIP Participants must regulate development in floodplain areas in accordance with NFIP criteria. Before issuing a permit to build in a floodplain, participating jurisdictions must ensure that three criteria are met:

- New buildings and those undergoing substantial improvements must, at a minimum, be elevated to protect against damage by the 100-year flood.
- New floodplain development must not aggravate existing flood problems or increase damage to other properties.
- New floodplain development must exercise a reasonable and prudent effort to reduce its adverse impacts on threatened salmonid species.

NFIP Status and Severe Loss/Repetitive Loss Properties

The Stillaguamish Tribe of Indians currently is not a member of the NFIP but will continue to evaluate this opportunity as it feels appropriate. The Tribe has identified this as a potential mitigation strategy.

- There were previously two identified repetitive loss properties owned by the Tribe identified in the 2015 plan. One of those properties was mitigated by moving the structure out of the floodplain. Current information received from the State of Washington and FEMA indicate no additional repetitive loss properties.
- In addition, the Oso landslide, which was caused, in part, by excessive precipitation, affected members of the Stillaguamish Tribe, and specifically damaged a significant restoration project that was built within the slide zone.

Repetitive Flood Claims

Residential or non-residential (commercial) properties that have received one or more NFIP insurance payments are identified as repetitive flood properties under the NFIP. Such properties are eligible for funding to help mitigate the impacts of flooding through various FEMA programs, subject to meeting certain criteria and maintaining a Repetitive Loss Strategy. Repetitive flood claims provide funding to reduce or eliminate the long-term risk of flood damage to structures insured under the NFIP that have had one or more claim payments for flood damages.

A Repetitive Loss Strategy must identify the specific actions taken to reduce the number of repetitive loss properties, which must include severe repetitive loss properties, and specify how the Tribe intends to reduce the number of such repetitive loss properties. In addition, the hazard mitigation plan must describe the strategy it will take to reduce the number of these properties, including the development of Tribal hazard mitigation plan.

In preparation of this plan, the Planning Team did review Washington State's 2018 Hazard Mitigation Plan, which does contain a Repetitive Loss Strategy. While a sovereign nation and not required to adhere to state policies and procedures, the Tribe, as appropriate, will continue to work with the state in its endeavor to reduce impact from flooding both on the Reservation and within the tribal planning area, such as the Tribe regularly does within its various natural resource protection programs. At the Tribe's election, this may include seeking opportunities for mitigation funds under the various Stafford Act Grant Programs.

Tribal Repetitive Loss Strategy:

The Tribe will continue to address repetitive loss properties by ensuring that new construction is built to the highest building code standards required, and also continue to view the mitigation plan for identified areas of risk. As was previously done, the Tribe will continue to mitigate structures within the floodplain, including, if feasible, to move structures out of the floodplain or to take other such corrective actions as appropriate and feasible.

The Planning Team will use five-year updates of this Hazard Mitigation Plan as an opportunity to evaluate hazard management laws, regulations, and policies, and work with the Tribal legal department to create the most effective and efficient regulatory authority to continue to mitigate flood issues within the Reservation.

Severe Repetitive Loss Program

The severe repetitive loss program is authorized by Section 1361A of the National Flood Insurance Act (42 U.S.C. 4102a), with the goal of reducing flood damages to residential properties that have experienced *severe* repetitive losses under flood insurance coverage and that will result in the greatest savings to the NFIP in the shortest period of time. A severe repetitive loss property is a residential property that is covered under an NFIP flood insurance policy and:

- a) That has at least four NFIP claim payments (including building and contents) over $5,000 each, and the cumulative amount of such claims payments exceeds $20,000; or

- b) For which at least two separate claims payments (building payments only) have been made with the cumulative amount of the building portion of such claims exceeding the market value of the building.

For both (a) and (b) above, at least two of the referenced claims must have occurred within any 10-year period, and must be greater than 10 days apart.

- ➢ The Tribe has no severe repetitive loss properties on the Reservation.

The Community Rating System

The Community Rating System (CRS) is a voluntary program within the NFIP that encourages floodplain management activities that exceed the minimum NFIP requirements. Flood insurance premiums are discounted to reflect the reduced flood risk resulting from community actions.

- ➢ The Tribe is not currently a CRS Community.

9.2 HAZARD PROFILE

9.2.1 Extent and Location

Flooding is the most common hazard occurring in the tribal planning area. The severity of flood damage is also dependent upon ground elevation, the surrounding topography, peak flow volumes, surface flow velocities, and proximity to the river or a levee break.

The most common form of flooding to occur in the area is riverine flooding, which occurs to some extent annually. Tidal flooding has not previously impacted the Tribe to the level of a disaster declaration; however, tidal flooding can overtop levees in the lower estuary areas along the Stillaguamish River valleys. In addition, the impact from sea level rise on estuarine/delta areas would be exacerbated. Urban floods can be a great disturbance to daily life in the area. Roads can be blocked, and people may be unable to engage in normal activities of traversing roadways, but the water levels are considered more of a nuisance than life-threatening.

The Stillaguamish Community is located near the Stillaguamish River, which is subject to annual flooding. New infrastructure is being located out of the flood hazard zones; however, the Tribe specifically purchases land located within the river's channel migration zone for habitat protection and restoration. Flooding can cause damage to these restoration projects, newly planted trees, and access roads or bridges.

Previous flooding has been documented by gauge records, high water marks, damage surveys, and personal accounts. The Tribe has also worked with FEMA on previous flood events with respect to damage assessment and recovery.

Major floods on rivers and streams within the planning area are typically caused by rainstorms. Floods can be classified as either spring snowmelt or winter rain on snow events. The threat of flooding in is greatest in the months of November, December, and January, with events occurring as early as October or as late as March. Winter flood events have the potential to produce the highest peak flows when significant low elevation snowfall is present, followed by rising freezing levels, heavy rain, and wind. Winter floods occur in most of the county's floodplains every 2 to 5 years.

FEMA Flood Maps

FEMA performed a recent Flood Insurance Study (FIS) for Snohomish County. As a result of that process, FEMA issued new flood maps to the County, which as of December 2019 remaining pending adoption by the County. Skagit County data remains the 1989 maps as the County has not adopted any new maps since that time, and those remain the official record, encompassing the Skagit County portion of the Stillaguamish Watershed. As that information constitutes best available data, both studies were used in this analysis. Figure 9-3 illustrates the flood hazard areas throughout the Stillaguamish Watershed based on the identified maps and studies.

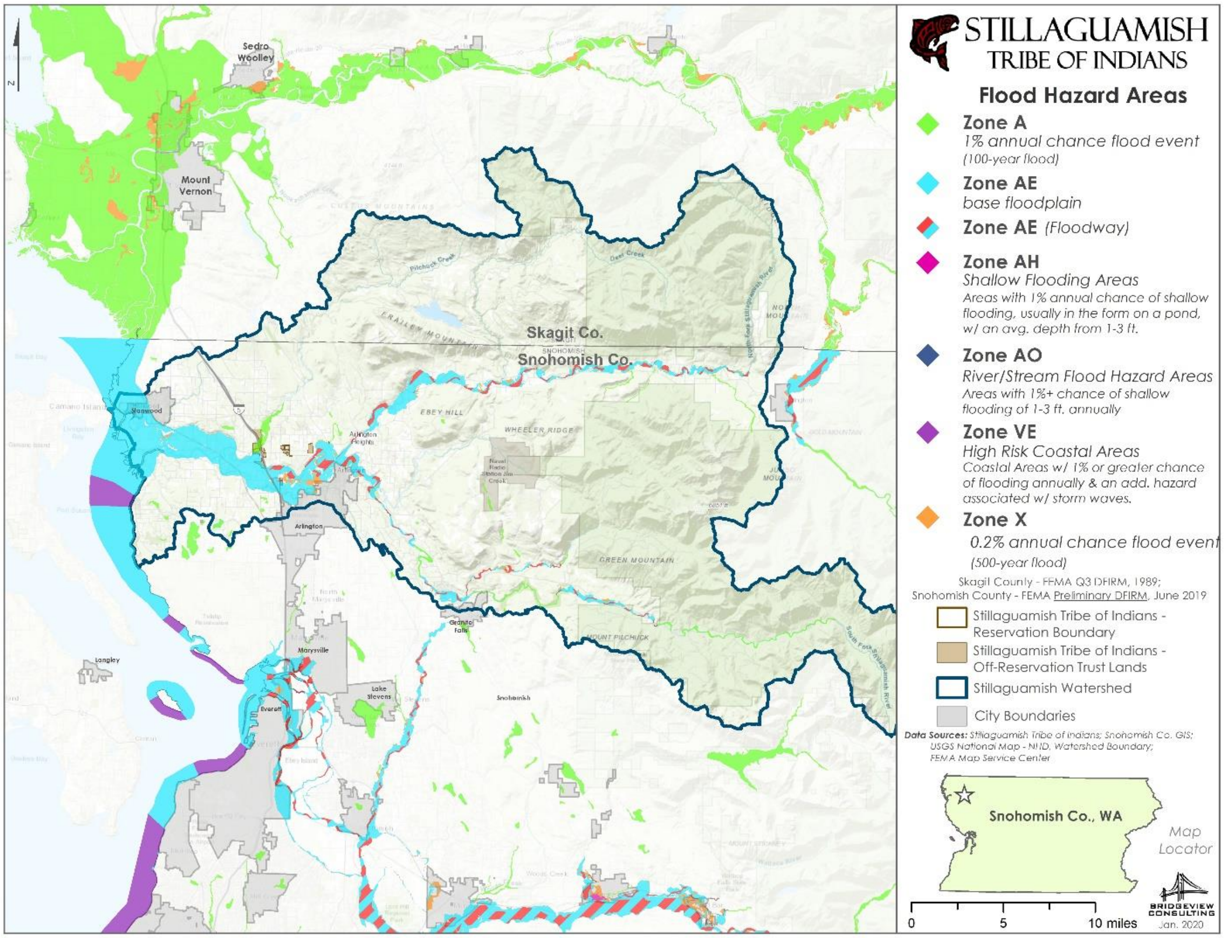


Figure 9-3 Stillaguamish Watershed Flood Hazard Zones

9.2.2 Previous Occurrences

Major floods in the planning area have resulted from intense rainstorms customarily between October and March. The highest months for declared flood or flood-included events occur in March.

The Stillaguamish Tribe has been impacted by four significant events which have included flooding. One of those events, DR-4168, which occurred in March 2014, was typed by FEMA as a Mud/Landslide and Flood. DR-4168, also referred to as the Oso Landslide, resulted in the loss of 43 lives. In excess of $53 million dollars in damages were incurred throughout Snohomish County, including Tribal impact. Impact to the Tribe included significant damage to a restoration project that was built within the slide area.

The remaining three events which included flooding were typed as a severe weather event, and include DR-4056, DR-1963, and DR-1825 (see Disaster History data in Chapter 3 for additional information). The Tribe has no dollar figures which indicate loss impact. The Tribe has identified the capturing of such data as a mitigation strategy for future updates.

9.2.3 Severity

The severity of a flood depends not only on the amount of water that accumulates in a period of time, but also on the land's ability to manage this water. One element is the size of rivers and streams in an area; but an equally important factor is the land's absorbency. When it rains, soil acts as a sponge. When the land is saturated or frozen, infiltration into the ground slows and any more water that accumulates must flow as runoff (Harris, 2001).

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. This is especially true when a channel migrates over a broad floodplain, redirecting high velocity flows and transporting debris and sediment. Flood severity is often evaluated by examining peak discharges. The USGS maintains current stream gage data, and is available real-time for viewing. Figure 9-4 illustrates the type of data available from the USGS. Readers may elect to obtain data on stream gages directly from the USGS at: https://waterdata.usgs.gov/wa/nwis/rt.

Early flood management were local efforts such as the construction of dike and levee systems. As problems increased, the United State Army Corps of Engineers (USACE) began to play an important role in supporting flood management activities.

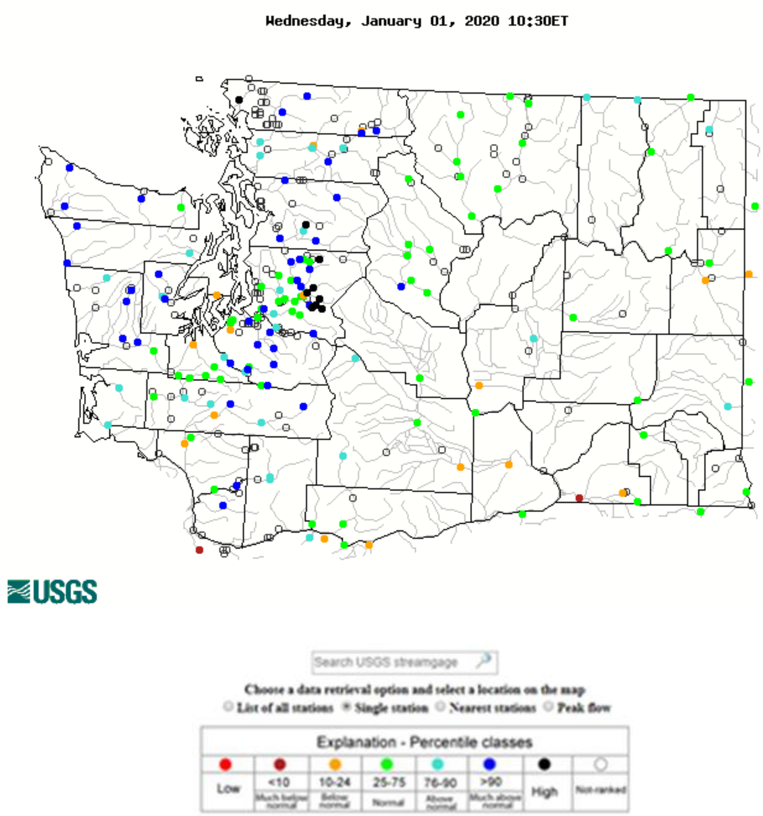


Figure 9-4 USGS Stream Flow Data for January 1, 2020

9.2.4 Frequency

Floods are commonly described as having a 10-, 50-, 100-, and 500-year recurrence interval, meaning that floods of these magnitudes have (respectively) a 10-, 2-, 1-, or 0.2-percent chance of occurring in any given year. These measurements reflect statistical averages only; it is possible for two or more rare floods (with a 100-year or higher recurrence interval) to occur within a short time period. Assigning recurrence intervals to historical floods on different rivers can help indicate the intensity of a storm over a large area.

Flooding has continued to increase over the decades, with all of the declared incidents impacting the Reservation being flood-related, although not typed by FEMA as a flood. According to records, 23 major flood events from 1960 to present in Snohomish County were included in Federal Disaster Declarations (some of these events were typed as severe storm rather than just flood). There are also incidents involving flooding issues which did not rise to the level of a disaster declaration. As damages have grown in frequency and in size, flood management efforts have accelerated throughout the County to help reduce the impact of flooding. In many cases, these actions were funded or developed by the Tribe through its natural resource practices.

The area historically experiences some level of flooding annually, although in some instances, the event exists more as a nuisance flooding related to drainage issues versus floods causing significant damage. It should be noted that the Reservation was not federally established until more recently, and therefore, while 23 major flood incidents have occurred throughout Snohomish County, only the four referenced above have impacted the Tribe, and that impact was not related to structure impact on the Reservation itself, but rather the various natural resource protection measures it has established throughout the watershed area.

9.3 VULNERABILITY ASSESSMENT

To understand risk, a community must evaluate what assets are exposed or vulnerable in the identified hazard area. For this planning purpose, the flood hazard areas identified include the 1-percent (100-year) and 0.2 % (500-year) floodplains. These events are generally those considered by planners and evaluated under federal programs such as the NFIP. The following text evaluates and estimates the potential impact of flooding in Skagit County.

9.3.1 Overview

All types of flooding can cause widespread damage throughout rural and urban areas, including but not limited to: water-related damage to the interior and exterior of buildings; destruction of electrical and other expensive and difficult-to-replace equipment; injury and loss of life; proliferation of disease vectors; disruption of utilities, including water, sewer, electricity, communications networks and facilities; loss of agricultural crops and livestock; placement of stress on emergency response and healthcare facilities and personnel; loss of productivity; and displacement of persons from homes and places of employment.

Warning Time

Due to the sequential pattern of meteorological conditions needed to cause serious flooding, it is unusual for a flood to occur without some warning. Warning times for floods can be between 24 and 48 hours. Flash flooding can be less predictable, but potential hazard areas can be warned in advanced of potential flash flooding danger. Dam inundation due to dam failure can occur within mere minutes of a dam breach or failure.

The potential warning time a community has to respond to a flooding threat is a function of the time between the first measurable rainfall and the first occurrence of flooding. The time it takes to recognize a flooding threat reduces the potential warning time to the time that a community has to take actions to protect lives and property. Another element that characterizes a community's flood threat is the length of time floodwaters remain above flood stage. Flood threat systems in the planning area consist of a network of precipitation gauges throughout the watershed and stream gauges at strategic locations that constantly monitor and report stream levels. This information is fed into a U.S. Geological Survey forecasting program, which assesses the flood threat based on the amount of flow in the stream (measured in cubic feet per second). In addition to this program, data and flood warning information is provided by the National Weather Service (NWS). All of this information is analyzed to evaluate the flood threat and possible evacuation needs.

The NWS issues watches and warnings when forecasts indicate rivers may approach bank-full levels. When a watch is issued, the public should prepare for the possibility of a flood. When a warning is issued, the public is advised to stay tuned to a local radio station for further information and be prepared to take quick action if needed. A warning means a flood is imminent, generally within 12 hours, or is occurring. Local media broadcast NWS warnings.

9.3.2 Impact on Life, Health, and Safety

The impact of flooding on life, health, and safety is dependent upon several factors, including the severity of the event and whether or not adequate warning time is provided to residents. Exposure represents the population living in or near floodplain areas that could be impacted should a flood event occur. Additionally, exposure should not be limited to only those who reside in a defined hazard zone, but everyone who may be affected by the effects of a hazard event (e.g., people are at risk while traveling in flooded areas, or their access to emergency services is compromised during an event). The degree of that impact will vary and is not measurable. However, of significant concern within the planning area is the number of tourists who can be impacted during periods of flooding. Tourism is a very large economic base within the planning area, with many tourists traveling through the area at all times of the year.

The Stillaguamish Tribe does not have residential structures on its reservation; however, there are several thousands of visitors to the casino and hotel on a daily basis, as well as individuals traveling to the reservation for services provided, such as health services, among others. In addition, there are also tribal employees, both full and part time, working for tribal government or the casino which would factor in for consideration.

Of the population exposed, the most vulnerable include the economically disadvantaged and the population over the age of 65. Economically disadvantaged populations are more vulnerable because they are likely to evaluate their risk and make decisions to evacuate based on the net economic impact on their family. The population over the age of 65 is also more vulnerable because they are more likely to seek or need medical attention which may not be available due to isolation during a flood event and they may have more difficulty evacuating.

The number of injuries and casualties resulting from flooding is generally limited based on advance weather forecasting, blockades, and warnings. Therefore, injuries and deaths generally are not anticipated if proper warning and precautions are in place. Ongoing mitigation efforts should help to avoid the most likely cause of injury, which results from persons trying to cross flooded roadways or channels during a flood.

9.3.3 Impact on Property

Review of the flood hazard areas indicates that two structures are within the 100- floodplain (one each in the A and AE Zones); no additional structures are within the 500-year floodplain. There are no tribally owned residential structures within either the 100- or 500-year floodplains which fall within the Reservation boundary as the Stillaguamish Tribe has no residential structures on the reservation. The majority of all structures on the reservation (with the exception of a few storage-shed type structures) were identified and assessed as critical facilities due to the limited number of structures on the Reservation, and the services provided.

While there is also no identified floodplain within the reservation boundary, there are ~186 acres identified within the 100-year floodplain on lands outside of the reservation boundary which the tribe owns, as well as 0.25 acres within the 500-year floodplain, also outside the reservation.

The Stillaguamish Tribe has initiated buy-outs of properties off the reservation which have previously flooded specifically for the purpose of restoring the property to its natural habitat. In most cases, as properties are purchased, structures are removed. These restoration projects are subject to impact from floods. Currently, the Tribe has a number of projects completed or underway to help mitigate the impact of flood within the Stillaguamish Watershed. Such activities have been extremely important to the Tribe in protecting the watershed, including U&A areas.

9.3.4 Impact on Critical Facilities and Infrastructure

Two structures identified as critical facilities are exposed in the FEMA 100- and 500-year flood hazard areas. Those include a facilities' building and a hatchery, with a building and content value at risk of $1.14 million combined.

In addition, while not owned by the Tribe, portions of Interstate 5, as well as other federal and state highways, and county roadways could be inundated and impassable as a result of a flood event. While many roadways in the area have been built above flood level or serve the function as a levee to prevent flooding, in certain instances, they may be impacted. In cases where short-term functionality is impacted by a hazard, other facilities of neighboring municipalities may need to increase support response functions during a disaster event. Mitigation planning should consider means to reduce impact on critical facilities and ensure sufficient emergency services remain when a significant event occurs.

9.3.5 Impact on Economy

Impact on the economy related to a flood event would include loss of property, inventory, equipment, and loss of business revenue. Flooding has the potential to impact all industrial sectors. Depending on the duration between the onset of the event and recovery, businesses within the area may not be able to sustain the economic loss of their business being disrupted for an extended period of time. The Tribe does have several business ventures in place, which could be significantly impacted. In addition, tribal members who work for either the tribe or surrounding businesses would be impacted due to loss of income. There is also a high volume of agricultural lands in the area which may be subject to flooding, with inundation affecting croplands. Forestland is also vulnerable to floods due to erosion when river and stream banks fail and overflow. As such, both of those industrial sectors could also be negatively impacted.

9.3.6 Impact on 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. Because they border water bodies, floodplains have historically been popular sites to establish settlements. Human activities tend to concentrate in floodplains for a number of reasons: water is readily available; land is fertile and suitable for farming; transportation by water is easily accessible; and land is flatter and easier to develop. But human activity in floodplains frequently interferes with the natural function of floodplains. It can affect the distribution and timing of drainage, thereby increasing flood problems. Human development can create local flooding problems by altering or confining drainage channels. This increases flood potential in two ways: it reduces the stream's capacity to contain flows, and it increases flow rates or velocities downstream during all stages of a flood event. 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, and logjams from timber harvesting can increase stream bank erosion, causing rivers and streams to migrate into non-natural courses. Flooding has significant impact on migrating fish, which can be washed onto roadways or over leaves, with no possibility of escape, or the chemicals or pollutants can wash into rivers and streams, killing the fish and their food supplies.

Floodplains can support ecosystems that are rich in quantity and diversity of plant and animal species. A floodplain can contain 100 or even 1000 times as many species as a river. Wetting of the floodplain soil releases an immediate surge of nutrients: those left over from the last flood, and those that result from the rapid decomposition of organic matter that has accumulated since then. Microscopic organisms thrive and larger species enter a rapid breeding cycle. Opportunistic feeders (particularly birds) move in to take advantage. The production of nutrients peaks and falls away quickly; however, the surge of new growth endures for some time. This makes floodplains particularly valuable for agriculture. Species growing in floodplains are markedly different from those that grow outside floodplains. For instance, riparian trees (trees that grow in floodplains) tend to be very tolerant of root disturbance and very quick growing compared to non-riparian trees.

9.3.7 Impact from Climate Change

According to University of Washington scientists, 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.

Changes in Hydrology

Use of historical hydrologic data has long been the standard of practice for designing and operating water supply and flood protection projects. For example, historical data are used for flood forecasting models and to forecast snowmelt runoff for water supply. This method of forecasting assumes that the climate of the future will be similar to that of the period of historical record. However, the hydrologic record cannot be used to predict changes in frequency and severity of extreme climate events such as floods. Going forward, model calibration or statistical relation development must happen more frequently, new forecast-based tools must be developed, and a standard of practice that explicitly considers climate change must be adopted. Climate change is already impacting water resources, and resource managers have observed the following:

- Historical hydrologic patterns can no longer be solely relied upon to forecast the water future.
- Precipitation and runoff patterns are changing, increasing the uncertainty for water supply and quality, flood management and ecosystem functions.
- Extreme climatic events will become more frequent, necessitating improvement in flood protection, drought preparedness and emergency response.

The amount of snow is critical for water supply and environmental needs, but so is the timing of snowmelt runoff into rivers and streams. Rising snowlines caused by climate change will allow more mountain area to contribute to peak storm runoff. High frequency flood events (e.g. 10-year floods) in particular will likely increase with a changing climate. Along with reductions in the amount of the snowpack and accelerated snowmelt, scientists project greater storm intensity, resulting in more direct runoff and flooding. Changes in watershed vegetation and soil moisture conditions will likewise change runoff and recharge patterns. As stream flows and velocities change, erosion patterns will also change, altering channel shapes and depths, possibly increasing sedimentation behind dams, and affecting habitat and water quality. With potential increases in the frequency and intensity of wildfires due to climate change, there is potential for more floods following fire, which increase sediment loads and water quality impacts.

As hydrology changes, what is currently considered a 100-year flood may strike more often, leaving many communities at greater risk. Planners will need to factor a new level of safety into the design, operation, and regulation of flood protection facilities such as dams, bypass channels and levees, as well as the design of local sewers and storm drains.

Sea Level Rise

Sea level and temperature are interrelated (U.S. EPA, 2016). Warmer temperatures result in the melting of glaciers and ice sheets. This melting means that less water is stored on land and, thus, there is a greater volume of water in the oceans. Water also expands as it warms, and the heat content of the world's oceans has been increasing over the last several decades. According to the EPA, there is likely to be 13 inches of sea level rise in the Puget Sound basin by 2100. According to the Washington State Department of Ecology the impacts of sea level rise could include the following: increased coastal community flooding, coastal erosion and landslides, seawater well intrusion, acidification of waters, and lost wetlands and estuaries.

9.4 FUTURE DEVELOPMENT TRENDS

Development has affected the natural features of the land over time as the area has been developed from a wilderness to the present day. Along with development came land alternations that have been a factor in increasing the magnitude and frequency of floods in the area. Encroachment on floodplains by structures and fill material reduces carrying capacity and increases flood heights and velocities.

The local municipalities in the area are subject to the provisions of the Washington State Growth Management Act (GMA) which regulate identified critical areas, but until those lands directly impacted can be returned to their normal condition, flooding will continue. The Tribe is not subject to the GMA; however, the Tribe is prepared to address flooding issues through various mitigation activities, including its restoration projects, and building outside of the floodplain when new construction occurs. In some cases, when development may occur in the floodplain, it will be regulated such that the degree of risk will be reduced through building standards and performance measures as the Tribe deems appropriate.

9.5 ISSUES

A large portion of the planning area in general has the potential to flood, generally in response to a succession of winter rainstorms, or tidal surge. Storm patterns of warm, moist air are normal events, usually occurring between October and April can cause severe flooding in the planning area, although flooding can occur at any time.

A worst-case scenario for a flood event would be a series of storms that result in high accumulations of runoff surface water within a relatively short time period, especially when occurring simultaneous with a high-tide event. These types of events have occurred in the planning area. High in-channel flows would cause watercourses to scour, possibly washing out roads or impacting bridges, causing levee structures to be impacted, and potentially creating more isolation problems, and further exacerbating erosion along the coast- and shore-lines. In the case of multi-basin flooding, repairs could not be made quickly enough to restore critical facilities and infrastructure. While human activities influence the impact of flooding events, human activities can also interface effectively with a floodplain as long as steps are taken to mitigate the activities' adverse impacts on floodplain functions.

9.6 IMPACT AND RESULTS

Based on review and analysis of the data, the Planning Team has determined that the probability for impact from Flood throughout the area is likely. The area experiences some level of flood annually, albeit not to the level of a disaster declaration.

While structural damage may vary due to flood depths and existing floodplain management regulations, the Tribe has been fortunate in that limited structures have been impacted; however, restoration projects have been impacted. Based on the potential impact, the Planning Team determined the CPRI score to be 2.25 with overall vulnerability determined to be a medium level.

CHAPTER 10.
LANDSLIDE

10.1 GENERAL BACKGROUND

DEFINITIONS

Landslide—The sliding movement of masses of loosened rock and soil down a hillside or slope. Such 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 or Debris Flow)—A river of rock, earth, organic matter and other materials saturated with water.

A landslide is defined as the sliding movement of masses of loosened rock and soil down a hillside or slope. Such failures occur when the strength of the soils forming the slope is exceeded by the pressure acting upon them, such as weight or saturation. Earthquakes provide many times more energy than needed to initiate soil liquefaction, enhancing not only the probability of a landslide, but also its magnitude. Washington State climate, topography, and geology create a perfect setting for landslides, which occur in the state every year. They can be initiated by storms, earthquakes, fires, volcanic eruptions, or human modification of the land.

In Western Washington, most landslides are triggered during fall and winter after storms dump large amounts of rain or snow (Washington Department of Natural Resources, 2015). Landslides can be shallow or deep. Shallow landslides typically occur in winter in Western Washington and summer in Eastern Washington, but are possible at any time. They often form as slumps along roadways or fast-moving debris flows down valleys or concave topography. They are commonly called “mudslides” by the news media. Deep-seated landslides are often slow moving, but can cover large areas and devastate infrastructure and housing developments.

Mudslides (or mudflows or debris flows) are rivers of rock, earth, organic matter, and other soil materials saturated with water. They develop in the soil overlying bedrock on sloping surfaces when water rapidly accumulates in the ground, such as during heavy rainfall or rapid snowmelt. Water pressure in the pore spaces of the material increases to the point that the internal strength of the soil is drastically weakened. The soil’s reduced resistance can then easily be overcome by gravity, changing the earth into a flowing river of mud or “slurry.” A mudslide or debris flow is a fast moving fluid mass of rock fragments, soil, water, and organic material with more than half of the particles being larger than sand size. Generally, these types of movement occur on steep slopes or in gullies and can travel long distances. A debris flow or mudflow can move rapidly down slopes or through channels, and can strike with little or no warning at avalanche speeds. The slurry can travel miles from its source, growing as it descends, picking up trees, boulders, cars, and anything else in its path. Although these slides behave as fluids, they pack many times the hydraulic force of water, due to the mass of material included in them. Locally, they can be some of the most destructive events in nature.

A rock fall is the fall of newly detached segments of bedrock of any size from a cliff or steep slope. The rock descends by free fall, bouncing, or rolling. Movements are very rapid to extremely rapid, and may not be preceded by minor movements.

All mass movements are caused by a combination of geological and climate conditions, as well as the encroaching influence of urbanization. Vulnerable natural conditions are affected by human residential, agricultural, commercial, and industrial development and the infrastructure that supports it.

The occurrence of a landslide is dependent on a combination of site-specific conditions and influencing factors. Most commonly, the factors that contribute to landslides fall into four broad categories:

- Climatic or hydrologic (rainfall or precipitation);
- Geomorphic (slope form and conditions, e.g., slope, shape, height, steepness, vegetation and underlying geology);
- Geologic/geotechnical/hydrogeological (groundwater);
- Human activity.

Change in slope of the terrain, increased load on the land, shocks, and vibrations, change in water content, groundwater movement, frost action, weathering of rocks, and removing or changing the type of vegetation covering slopes are all contributing factors. In general, landslide hazard areas are where the land has characteristics that contribute to the risk of the downhill movement of material, such as the following:

- Areas identified as having slopes greater than 40 percent;
- A history of landslide activity or movement during the last 10,000 years;
- Stream or wave activity, which has caused erosion, undercut a bank or cut into a bank to cause the surrounding land to be unstable;
- The presence of an alluvial fan, indicating vulnerability to the flow of debris or sediments;
- The presence of impermeable soils, such as silt or clay, which are mixed with granular soils such as sand and gravel.

Flows and slides are commonly categorized by the form of initial ground failure. Common types of slides are shown on Figure 10-1 through Figure 10-4 (Washington State Department of Ecology, 2014). The most common is the shallow colluvial slide, occurring particularly in response to intense, short-duration storms, where antecedent conditions are prevalent (Baum, et. al, 2000). The largest and most destructive are deep-seated slides, although they are less common.

Deep-seated landslides are much larger than shallow landslides and can occur at any time of the year. Soil degradation can happen over years, decades, and centuries with little to no warning to people above ground. The most notable and deadliest deep-seated landslide event in the United States was SR 530 (also known as the Oso Landslide) that took the lives of 43 people in Oso, Washington, in 2014.

Slides and earth flows can pose serious hazard to property in hillside terrain. They tend to move slowly and thus rarely threaten life directly. When they move—in response to such changes as increased water content, earthquake shaking, addition of load, or removal of downslope support—they deform and tilt the ground surface. The result can be destruction of foundations, offset of roads, breaking of underground pipes, or overriding of downslope property and structures.

The primary types of landslides that occur in the planning area are debris flows and earth flows. While small slides and debris flows occur on a somewhat regular basis, there have been slides and/or debris flows that have resulted in loss of life and/or property damage.

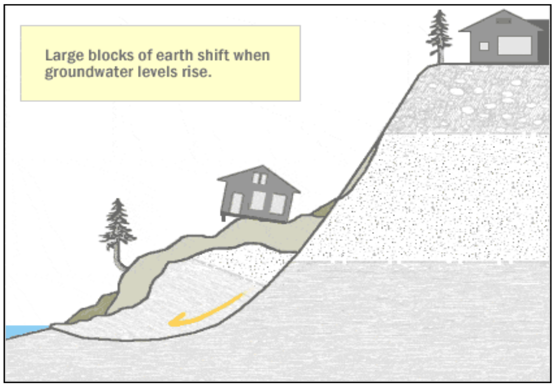


Figure 10-1 Deep Seated Slide

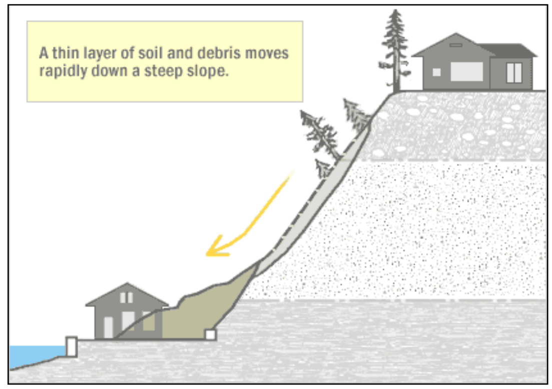


Figure 10-2 Shallow Colluvial Slide

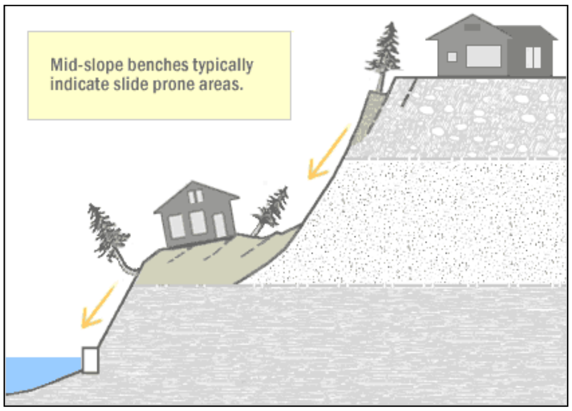


Figure 10-3 Bench Slide

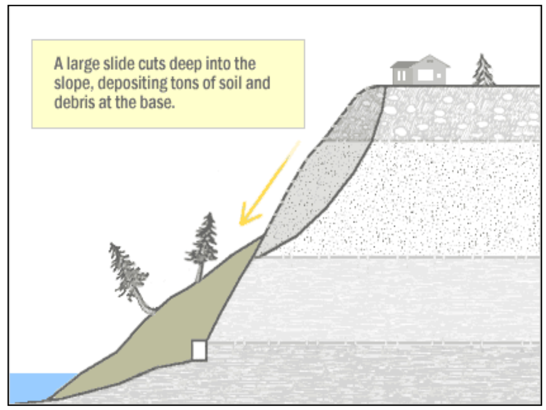


Figure 10-4 Large Slide

Coastal Erosion

Coastal erosion is a natural process that is common along the shoreline interface of a water body and the land. Along sedimentary coasts, a beach is commonly found at this interface, with sediments moving and changing the shape of the beach in response to hydrodynamic forcing. As such, the beach typically serves as a buffer zone between the water's edge and the more stable back beach dune or upland margin. While a net loss of sediment from a beach may be noticeable and affect human uses and the environment, often much greater concern and impact occurs when there is dune or upland erosion, particularly where this land has been considered to be stable and suitable for development.

Coastal erosion is defined as the wearing of coastal land by natural forces, such as by water waves, wind, and tidal currents. Beach sediments are routinely mobilized by these forces, which can change the shape and size of a beach over a range of time scales from hours to years. These changes are often only recognized as erosion when there is a significant net loss of material that causes an impact or instability to the adjacent upland. Coastal erosion can occur during an episodic event, such as a large storm, or as a chronic condition with the gradual loss of the beach or coastal land.

Washington's coastlines are subject to high energy waves that can cause rapid coastal erosion during typical winter storms that coincide with high tides and elevated water levels.

Localized coastal erosion such as adjacent to shoreline armoring or along a river mouth can result from the interactions of forces that locally change the transport and distribution of sediments. Large-scale coastal erosion can occur during the infrequent, yet periodic, Cascadia subduction zone earthquakes, associated with coastal subsidence and large tsunamis.

Much of shorelines in the area are composed of fine sand derived from the various rivers that are readily mobilized by wind and wave action. Seasonal fluctuations in waves and water levels typically cause beach erosion in the winter and beach accretion (or build up) in the summer. Where the beaches are backed by bluffs composed of older sedimentary deposits, bluff erosion constitutes a permanent loss of the upland.

In addition to rock composition, the geology may control the elevation and slope of the nearshore area, which in turn can determine how wave energy is dissipated before reaching the shoreline. A shallow and mild-sloped shoreface will cause waves to break offshore and greatly reduce their ability to erode coastal uplands. In contrast, a deep and steep shoreface will enable high waves to break directly onto the beach and dissipate as run-up onto the upper beach or bluff. In general, a deep and steep shoreface will manifest as a steep and rocky beach composed of larger particles, such as cobbles or boulders, because smaller particles, such as sand and gravel, are readily transported away and deposited in areas having a lower energy regime.

On a seasonal scale, coastal erosion typically occurs during the winter, when distant and local storms produce large waves, high winds, and elevated water levels. Winter storms typically approach the shoreline from the southwest, resulting in northerly and offshore sediment transport that erodes beaches, whereas as fair-weather summer conditions generally produce smaller waves approaching from the northwest that result in southerly and onshore sediment transport that builds up the beaches. During strong El Niño events, sustained elevated water levels can accentuate seasonal coastal erosion.

Coastal erosion is dependent on a combination of site-specific conditions and influencing factors. Most commonly, the factors that contribute to erosion fall into three broad categories:

- Hydraulic energy regime (waves, water levels, currents, winds, storm climatology).
- Geomorphic setting (sediment supply and grain size, geologically inherited substrate, landform and composition, e.g., coastal barrier, bluff, geology, vegetation, streams, rivers).
- Human activity (e.g. dams, jetties, coastal structures that affect sediment transport and sediment budget).

While a certain amount of erosion is natural and healthy for an ecosystem—such as gravel continuously moving downstream in watercourses—excessive erosion causes serious problems, such as receiving water sedimentation, ecosystem damage and loss of soil and slop stability. Erosion can cause a loss of forests and trees, which causes serious damage to aquatic life, irrigation, and power development by heavy silting of streams, reservoirs, and rivers. Concentrated surface water runoff in drainages and swales can lead to channel-confined slope failures, involving the rapid transport of fluidized debris, known as debris flows.

10.2 HAZARD PROFILE

10.2.1 Extent and Location

The best predictor of where slides and earth flows might occur is the location of past movements. Past landslides can be recognized by their distinctive topographic shapes, which can remain in place for thousands of years. Most landslides recognizable in this fashion range from a few acres to several square miles. Most show no evidence of recent movement and are not currently active. A small portion of them may become active in any given year. 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 or by exceptionally wet weather. Also, because they consist of broken materials and frequently involve disruption of groundwater flow, these dormant sites are vulnerable to construction-triggered sliding. A 2007 USGS Landslide Hazard area which occurred for the Seattle, Washington area further confirms that "when slopes are dry, steepness and strength control potential instability. However, where ground water perches on lower permeability clay layers, extended wet winter conditions can increase the water table near the bluff face. Elevated ground-water pressures can lower slope stability" (USGS, 2007).

As indicated, the primary types of landslides that occur in the area are debris flows and earth flows. Debris flows are also called mudslides, mudflows, or debris avalanches. They are rivers of a combination of loose soil, rock, organic matter, water, and air that flow downhill. As they continue downhill, they tend to grow in volume with the addition of water, soil, boulders and other materials. When the flow reaches flatter ground, it can spread over a large area. Earth flows usually occur in fine-grained materials or clay bearing rocks on moderate slopes. The slope's material liquefies and forms a bowl shape depression at the source area.

Figure 10-5 illustrates the locations of where previous landslides have occurred in proximity to the Reservation based on data available by WA DNR (2019).

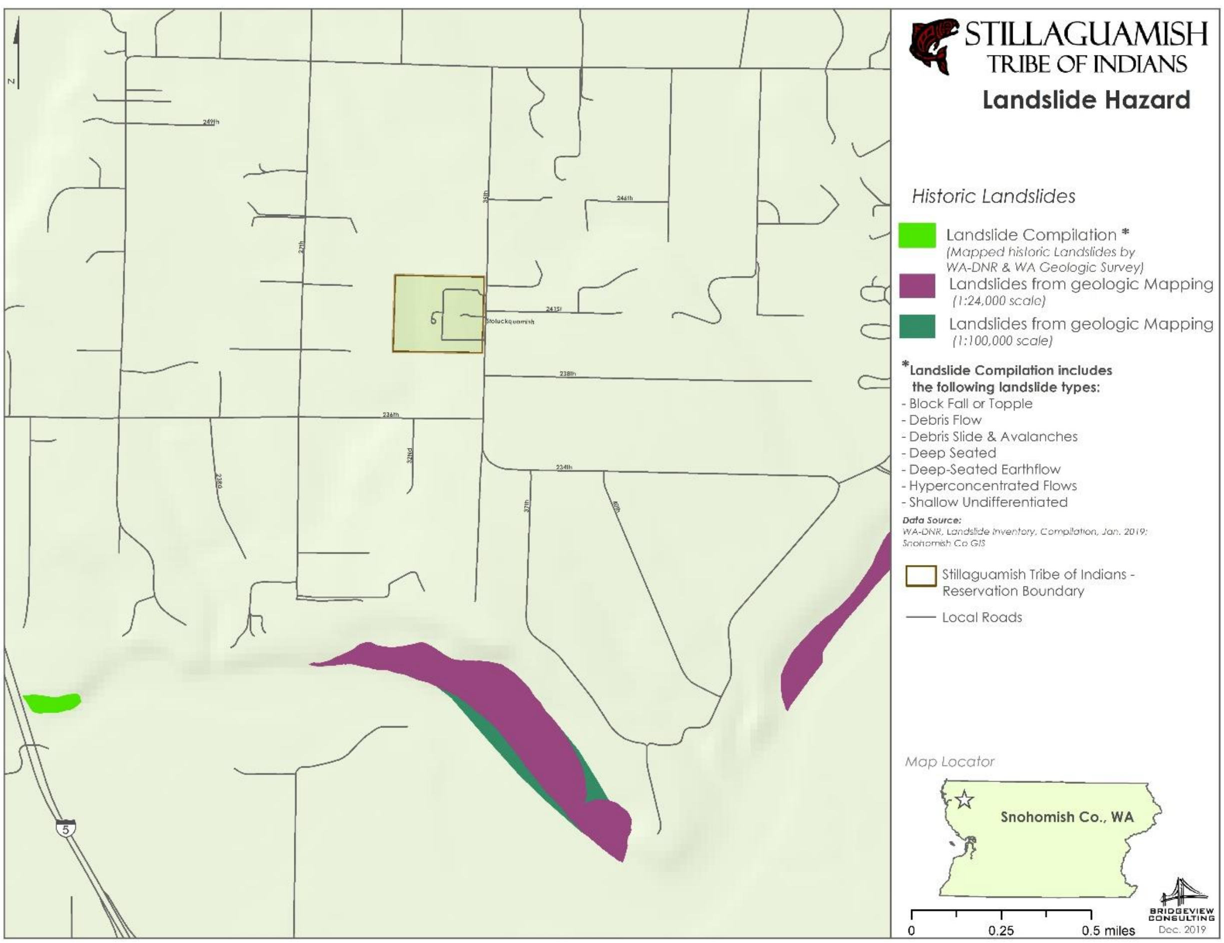


Figure 10-5 Historic Landslide Areas in Proximity to Reservation Boundary

10.2.2 Previous Occurrences

Landslides of some degree are common within the State of Washington as a whole. The state's largest and most tragic landslide, the SR-530 slide, occurred in March 2014, causing 43 fatalities. Frequently referred to as the Oso Landslide, it is the most significant landslide to have occurred in US history. The cost of damage and repair for the Oso Landslide is estimated to be in excess of $30 million. This is the only slide known to have caused fatalities in Snohomish County. However, across the Pacific Northwest, a number of deaths have occurred as a result of slides, slope collapses, and sinkholes.

The 2014 slide significantly impacted the Stillaguamish Tribe's restoration project which was underway in the area, resulting in the Tribe sustaining a disaster declaration for the event. While 43 lives were lost, no tribal members were injured in the event.

Landslides of some type do occur within the area in general regularly (see Snohomish County Hazard Mitigation Plan for further information), although none on the Reservation, nor any that have impacted reservation structures. They do, however, have the potential to impact ingress and egress to the Reservation, and have, such as with Oso, impacted tribal property and restoration projects.

10.2.1 Severity

Landslides destroy property and infrastructure, and can have a long-lasting effect on the environment and can take the lives of people. Nationally, landslides account for more than $2 billion in losses annually and result in an estimated 25 to 50 deaths a year (Spiker and Gori, 2003; Schuster and Highland, 2001; Schuster, 1996).

Washington is one of seven states listed by the Federal Emergency Management Agency as being especially vulnerable to severe land stability problems. Topographic and geologic factors cause certain areas to be highly susceptible to landslides. Ground saturation and variability in rainfall patterns are also important factors affecting slope stability in area susceptible to landslides. Strong earthquake shaking can cause landslides on slopes that are otherwise stable.

Figure 10-6 illustrates the Steep Slopes on or near the Reservation as identified by WA DNR which meet the thresholds of 40 percent or greater slopes, which WA DNR defines as those areas being more susceptible to landslide events. As no such other data currently exists, this is considered to be the best available data as of this update; however, WA DNR is currently in the process of updating landslide data in various parts of Washington, including Snohomish County. Such data may change the existing areas of concern, particularly as the Tribe continues to acquire land mass, including those within frequently flooded areas.

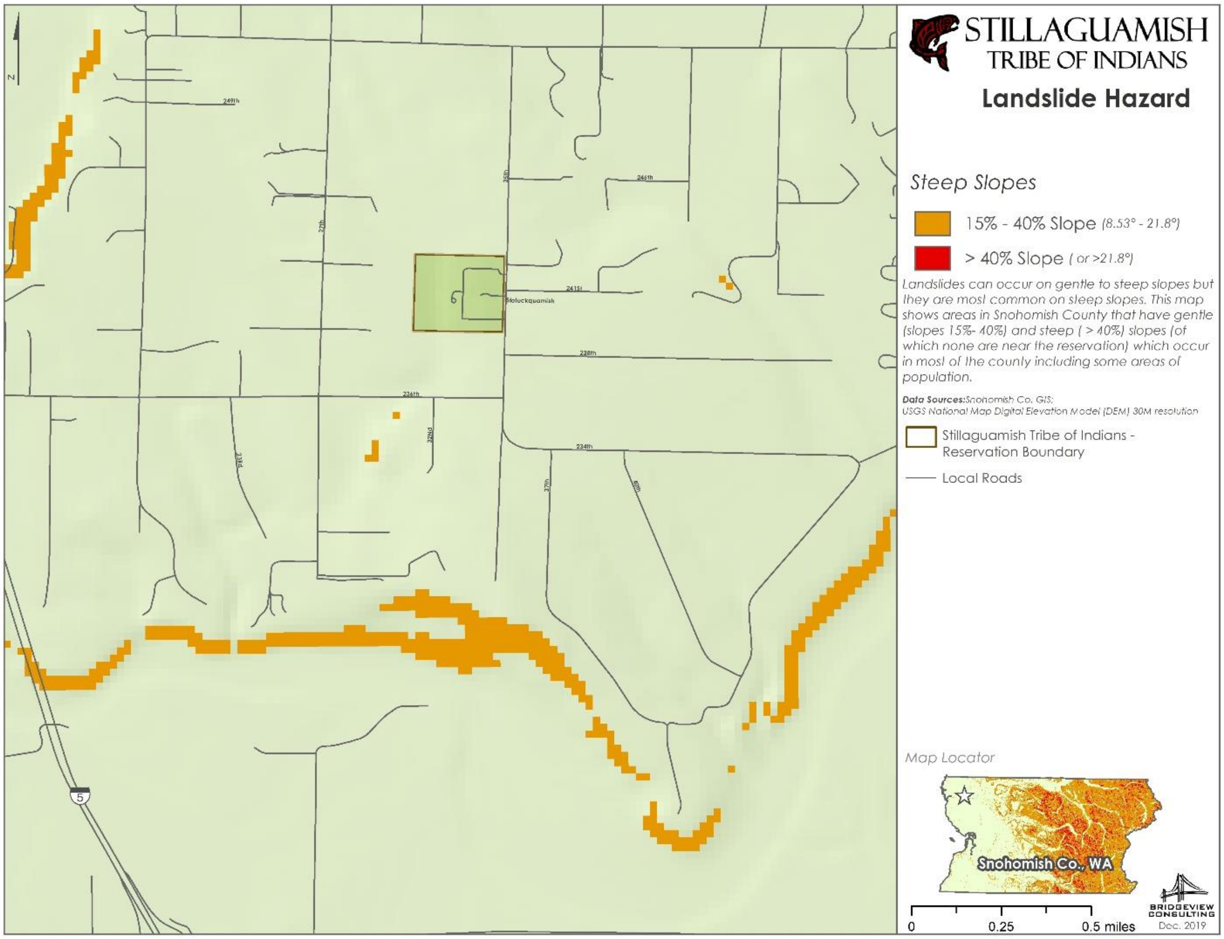


Figure 10-6 Landslide Hazard Areas

10.2.2 Frequency

A specific recurrence interval has not been established by geologists, but historical data indicates several successive years of slide activities may be followed by dormant periods. Landslides are also often triggered by other natural hazards such as earthquakes, heavy rain, floods, or wildfires, so landslide frequency is often related to the frequency of these other hazards.

Precipitation influences the timing of landslides on three scales: total annual rainfall, monthly rainfall, and single precipitation events. In general, landslides likely occur during periods of higher than average rainfall, so the potential for landslides largely coincides with the potential for sequential severe storms and flood events that saturate steep, vulnerable soils.

Studies conducted by the USGS have identified two precipitation thresholds to help identify when landslides are likely (USGS, 2007)[10]:

- Cumulative Precipitation Threshold (Figure 10-7)—A measure of precipitation over the last 18 days, indicating when the ground is wet enough to be susceptible to landslides. Rainfall of 3.5

[10] USGS Landslide Hazards in the Seattle, Washington, Area. Accessed 20 June 2019. Available at: https://pubs.usgs.gov/fs/2007/3005/pdf/FS07-3005_508.pdf

to 5.3 inches is required to exceed this threshold, depending on how much rain falls in the last 3 days.

- Intensity Duration Threshold (Figure 10-8)—A measure of rainfall during a storm, indicating when it is raining hard enough to cause multiple landslides if the ground is already wet.

These thresholds are most likely to be crossed during the rainy season. The 2007 USGS study indicates that by comparing recent and forecast rainfall amounts to the thresholds, meteorologists, geologists and city officials can help people know when to be prepared for landslides. The thresholds as developed and tested are accurate, but imperfect indicators of when landslides may occur. During the study, statistical analysis of landslides that occurred between 1978 and 2003 showed that 85% occurred when the Cumulative Precipitation Threshold was exceeded (USGS, 2007).

Review of existing disaster-related data illustrates that slide events in the planning area most commonly occur from November through January, after water tables have risen. Review of historic disasters illustrates that the month of December experienced the greatest number of slides, followed by January and November.

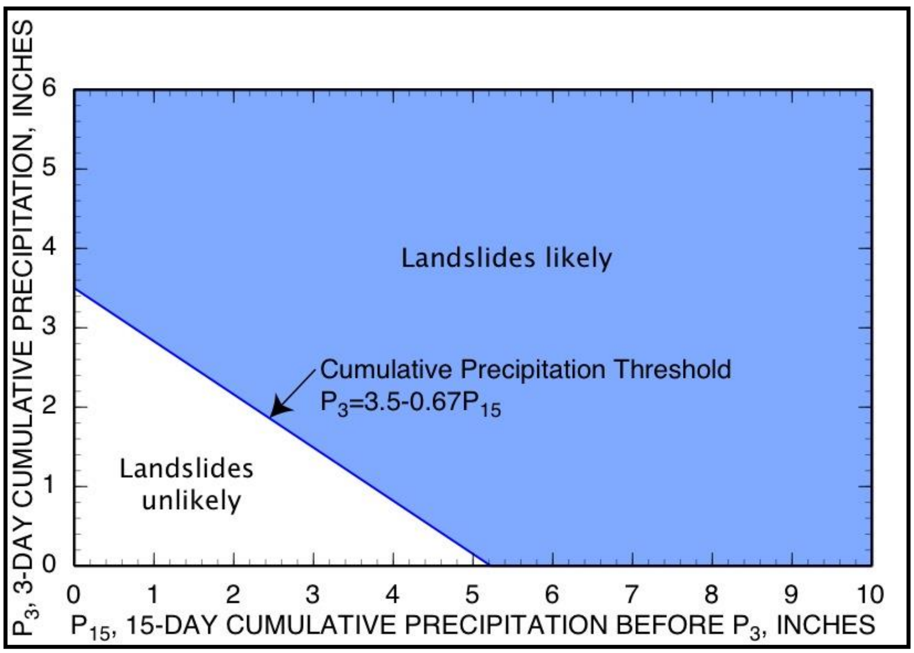


Figure 10-7 Cumulative Precipitation Threshold

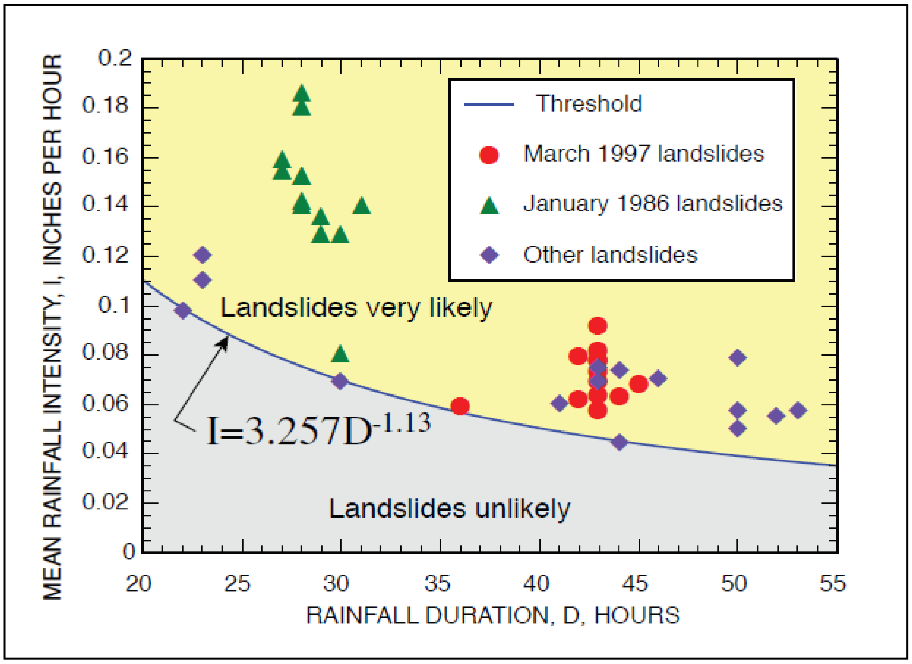


Figure 10-8 Landslide Intensity Duration Threshold

10.3 VULNERABILITY ASSESSMENT

10.3.1 Overview

Landslides have the potential to cause widespread damage throughout both rural and urban areas. While some landslides are more of a nuisance-type event, even the smallest of slides has the potential to injure or kill individuals and damage infrastructure. Studies have also indicated that of the slides recorded, the majority had some element of human-related causes which exacerbated the slide, such as development in hazard prone areas (City of Seattle 2015 Hazard Mitigation Plan).

Warning Time

Unlike flood hazards which often are predictable, mass movements or landslides are generally unpredictable, with little or no advanced warning. The speed of onset and velocity associated with a slide event can have devastating impacts. While some methods used to monitor mass movements can provide an idea of the type of movement and provide some indicators (potentially) with respect to the amount of time prior to failure, exact science is not available.

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

It is possible, based on historical occurrences, to determine what areas are at a higher risk. Assessing the geology, vegetation, and amount of predicted precipitation for an area can help in these predictions; such an analysis is beyond the scope of this planning effort. However, there is no practical warning system for individual landslides. Historical events remain the best indicators of potential landslide activity, but it is generally impossible to determine with precision the size of a slide event or when an event will occur. Increased precipitation in the form of snow or rain increases the potential for landslide activity. Steep slopes also increase the potential for slides, especially when combined with specific types of soil.

Within Washington State, in a partnership with the National Oceanic and Atmospheric Administration (NOAA) and the National Weather Service, Washington State Department of Natural Resources monitors conditions that could produce shallow landslides. Landslide warning information can be viewed at https://fortress.wa.gov/dnr/protection/landslidewarning/.

10.3.2 Impact on Life, Health, and Safety

There are currently no residential structures on the Reservation; however, there are approximately 1,345 employees working for the Tribe (Government/Enterprise, Tribal Member Services, and Casino personnel) which could also be negatively impacted by a landslide event. In addition, potential population impact also includes visitors to the various business enterprises owned by the Tribe, including the casino and hotel, and the various medical facilities, which service all tribal members, regardless of tribal affiliation.

While landslide hazard areas are identified in the various maps contained in this hazard profile, it should be noted that areas identified within this document were based on existing data; no geotechnical or scientific analyses were conducted for development of this hazard mitigation plan as such analyses far exceed the intent of this document; therefore, no data should not be relied upon for life safety measures, or anything other than informing emergency managers of potential risk for planning purposes.

Also to be taken into account when determining affected population are the area-wide impacts on transportation systems and the isolation of residents who may not be directly impacted but whose ability to ingress and egress is restricted, such as areas along major highways, which have a high transient population of tourists, especially during summertime months.

Landslides can be fast moving, or slow creeping, with the fast moving obviously increasing the potential for injury or death from such an event. Landslides can also damage water treatment facilities and wells, potentially harming water quality. The Tribe maintains its own water supply and treatment systems drawn from wells.

10.3.3 Impact on Property

Landslides and erosion affect both private property and public infrastructure and facilities. The predominant land use on the Reservation is for commercial/business and governmental operations, including health care services. The Tribe does anticipate development of residential structures during the life cycle of this plan. In addition, the Tribe has several restoration and preservation projects underway which are off the Reservation. Development in landslide hazard area is guided by building code and the critical area ordinance as discussed above, which help to prevent the acceleration of manmade and natural geological hazards, and to neutralize or reduce the risk to the property owner or adjacent properties from development activities.

The Tribe does not have an identified landslide hazard area designation within its land use planning; therefore, for mitigation planning purposes only, the Washington State Department of Natural Resources Landslide Dataset was utilized to identify areas of historic events. Increased hazard begins to occur on slopes 15-40 percent slope. In addition, slopes identified as being forty (40) percent or steeper were included in this analysis as those being of higher risk to landslides based on Washington DRN analysis and identification. For these planning purposes, risk area is defined as slopes 40% and above, and areas identified within WADNR mapped historic landslides. Data presented are not a substitute for site-specific investigations by qualified practitioners, such as geologists or engineers.

The area and percent of the total planning area exposed to the landslide hazard in the planning area are summarized as follows:

- There are no areas identified within the Reservation of +40 percent slope.
- Based on current reservation boundaries, there are no structures located in the +40 percent slope.

10.3.4 Impact on Critical Facilities and Infrastructure

Utilizing WA DNR's +40 percent slope identification for potential landslide hazard areas, there currently are no tribally owned critical facilities or infrastructure exposed to the landslide areas based on the 100-foot buffer intersecting the potential landslide hazard area. However, historical events have impacted restoration projects, as well as access to tribal fishing and hunting grounds and roadways.

The Tribe will continue to rely on the County's plan for identification of non-tribal owned critical infrastructure and facilities in the planning area at risk. Several types of infrastructure are exposed to mass movements, including transportation facilities, airports, bridges, and water, sewer, and power infrastructure. The Tribe relies wholly on water supplied by its own resources (e.g., wells, storage tanks and filtration/purifications systems). While not owned by the Tribe, but highly susceptible areas include mountain and coastal roads and transportation infrastructure, impact to which is of concern to the Tribal Planning Area as they serve as primary resources to the Tribe. All infrastructure and transportation corridors exposed to the landslide hazard are considered vulnerable. Significant infrastructure in the planning region (outside of the Reservation boundary) exposed to mass movements includes the following:

- **Roads**—Access to major roads is crucial to life-safety after a disaster event and to response and recovery operations. Landslides can block egress and ingress on roads, causing isolation for neighborhoods, traffic problems and delays for public and private transportation. This can result in economic losses for businesses.

- **Bridges, Marinas, and Boat/Ferry Docks**—Landslides can significantly impact road bridges, marinas, and boat/ ferry docks. Mass movements can knock out bridge and dock abutments, causing significant misalignment and restricting access and usages, as well as significantly weaken the soil supporting the structures, making them hazardous for use.

- **Power Lines**—Power lines are generally elevated above steep slopes, but the towers supporting them can be subject to landslides. A landslide could trigger failure of the soil beneath a tower, causing it to collapse and ripping down the lines. Power and communication failures due to landslides can create problems for vulnerable populations and businesses.

Based on review of both Snohomish and Skagit County's Hazard Mitigation Plans, there are a significant number of bridges, marinas, and boat/ferry docks that would be at risk from the landslide and erosion hazards; however, the Tribe does not own any such structures. Throughout the planning area, and in particular the areas leading onto the Reservation, there are also more above-ground power lines than below ground, increasing the risk of power outages due to landslides. However, Planning Team members do not recall many instances during which power outages have lasted for extended periods of time, the majority lasting less than one day.

10.3.5 Impact on Economy

A landslide or erosion event could have catastrophic impact on both the private sector and governmental agencies. Economic losses include damage costs as well as lost revenue, lost inventory, and lost wages. Damaged bridges, roadways, marinas, boat docks, municipal airports all can have a significant impact on the economy, including statewide depending on the impacted roadways and the ability to re-route traffic.

The impact on commodity flow from a significant landslide shutting down major access routes would not only limit available resources, but also would cause economic impact on businesses in the area. Debris accumulations from clearing sites could also impact cargo staging areas and lands needed for business operations. With primary transportation routes in the hazard areas impacted, the use of primary roadways increases travel time, and in some cases, restricts ingress and egress. Due to the limited roadways leading onto the Reservation, in some cases, travel time increases could significantly reduce the tourism/entertainment industry for the Tribe.

10.3.6 Impact on Environment

Environmental problems as a result of mass movements can be numerous. Landslides or erosion that fall into water bodies, wetlands or streams may significantly impact fish, salmon, and wildlife habitat, as well as affecting water quality. Hillsides that provide wildlife habitat can be lost for prolonged periods of time due to landslides or an erosion event. Impact to salmon spawning grounds have a long-term impact, and is not something which can be remedied once impact occurs. With impact already occurring due to increased sediment loads in the floodplain, landslides could cause additional impact within the area watersheds.

10.3.7 Impact from Climate Change

Climate change may impact storm patterns, increasing the probability of more frequent, intense storms with varying duration. Increase in global temperature could affect the snowpack and its ability to hold and store water. Warming temperatures also could increase the occurrence and duration of droughts, which would increase the probability of wildfire, reducing the vegetation that helps to support steep slopes. As the planning area maintains fairly dense forested areas, such incidents would be significant All of these factors would increase the probability for landslide occurrences.

10.4 FUTURE DEVELOPMENT TRENDS

Continued application of land use regulations, as well as implementation of the International Building Codes, will assist in reducing the risk of impact from landslide hazards. The Tribal Planning Area has experienced continued growth over the past 10 years, and anticipates such growth to continue. The Tribe continues to attempt to expand its business base, which will increase economic vitality by providing businesses that stimulate retail sales and services and increased tourism. The Tribe is committed to assessing the landslide risk and developing mitigation efforts to reduce impact or enhance resiliency. There are four basic strategies to mitigate landslide risk:

- Stabilization
- Protection
- Avoidance
- Maintenance and monitoring.

Stabilization seeks to counter one or more key failure mechanisms necessary to prevent slope failure or erosion. The other three strategies seek to avoid, protect against or limit associated impacts. Development of this mitigation plan creates an opportunity to enhance and develop wise land use decision-making policies. It allows for the Tribe's continued expansion of capital improvement plans to sustain future growth through the use of these four basic strategies.

10.5 ISSUES

Landslides and erosion occur as a result of soil conditions that have been affected by severe storms, groundwater, wave action, or human development. The worst-case scenario for landslide hazards in the planning area would generally correspond to a severe storm with a strong storm surge that had heavy rain and caused flooding and erosion. Landslides are most likely during late fall or early spring —months when the water tables are high. After heavy rains during October to April, soils become saturated with water. As water seeps downward through upper soils that may consist of permeable sands and gravels and accumulates on impermeable silt, it will cause weakness and destabilization in the slope. A short intense storm could cause saturated soil to move, resulting in landslides. As rains continue, the groundwater table rises, adding to the weakening of the slope. Gravity, a small tremor or earthquake, poor drainage, steep bank cutting, a rising groundwater table, and poor soil exacerbate hazardous conditions.

Mass movements are becoming more of a concern as development moves outside of urban centers and into areas less developed in terms of infrastructure. While most mass movements would be isolated events affecting specific areas, the areas impacted can be very large. It is probable that private and public property, including infrastructure, will be affected. Mass movements could affect bridges that pass over landslide prone ravines. Road obstructions caused by mass movements would create isolation problems for residents and businesses in sparsely developed areas, and impact commodity flows. Property/structures exposed to steep slopes or the undercutting of bluffs may suffer damage. Landslides carrying vegetation such as shrubs and trees may cause a break in utility lines, cutting off power and communication access to residents; landslides and erosion may block ingress and egress to areas of the reservation, especially for areas with limited roadways.

Coastal erosion is both a chronic and episodic problem that affects coastal communities. The severity of coastal erosion changes seasonally, interannually, and over decadal time scales in response to climate variability, sediment budgets, and human activities such as dredged material management and erosion mitigation methods that can either compound or reduce the impact. Previous studies and ongoing coastal change monitoring provide a solid scientific baseline for anticipating future erosion hazards. However, coastal conditions are changing over time, sea level and wave heights are increasing, strong El Niño events are predicted to increase, and the probability of a Cascadia subduction zone earthquake and tsunami increase with time since the previous event.

10.6 IMPACT AND RESULTS

Based on review and analysis of the data, the Planning Team has determined that the probability for impact from a landslide throughout the general area is possible when considering the potential to impact in the county to major roadways leading onto the Reservation. The surrounding area experiences some level of landslides almost annually when viewed with severe storm events, although only one declared event has occurred based on the landslide typing. That event occurred off of the Reservation, but had a significant impact on the Tribe due to impact to restoration projects.

The area of the Reservation itself has no previous indication of landslides based on review of WADNR data, nor does the slope identified by WADNR indicate itself to be susceptible to landslide hazards. Planning Team members cannot remember significant events occurring on the Reservation. However, landslides can nonetheless occur on fairly low slopes, and areas with no slopes can be impacted by slides at a distance. While the Tribe has no historic records of landslide events on the Reservation, there are events that have impacted Tribal lands, although no structure impact has occurred.

Based on the potential impact, the Planning Team determined the CPRI score to be 2.10, with overall vulnerability determined to be a medium level due to potential impacts in areas off the reservation, such as occurred with the Oso Landslide.

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CHAPTER 11.
SEVERE WEATHER

Severe weather refers to any dangerous meteorological phenomena with the potential to cause damage, serious social disruption, or loss of human life. It includes thunderstorms, downbursts, wind, tornadoes, waterspouts, and snowstorms. Severe weather differs from extreme weather, which refers to unusual weather events at the extremes of the historical distribution.

General severe weather covers wide geographic areas; localized severe weather affects more limited geographic areas. The severe weather event that most typically impacts the planning area is a damaging windstorm, which causes storm surges exacerbating coastal erosion. Flooding and erosion associated with severe weather are discussed in their respective hazard chapters. Snow historically does not accumulate in great amounts in the area, although even small amounts can impact the area through traffic-related issues and safety for citizens walking in areas of snow accumulation or ice. Excessive heat and cold, while they have occurred, are rare and the County has never received a disaster declaration for either type of event.

DEFINITIONS

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

Hail Storm—Any thunderstorm which produces hail that reaches the ground is known as a hailstorm. Hail has a diameter of 0.20 inches or more. Hail is composed of transparent ice or alternating layers of transparent and translucent ice at least 0.04 inches thick. Although the diameter of hail is varied, in the United States, the average observation of damaging hail is between 1 inch and golf ball-sized 1.75 inches. Stones larger than 0.75 inches are usually large enough to cause damage.

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

Thunderstorm—A storm featuring heavy rains, strong winds, thunder and lightning, typically about 15 miles in diameter and lasting about 30 minutes. Hail and tornadoes are also dangers associated with thunderstorms. Lightning is a serious threat to human life. Heavy rains over a small area in a short time can lead to flash flooding.

Tornado— Most tornadoes have wind speeds less than 110 miles per hour are about 250 feet across, and travel a few miles before dissipating. The most extreme tornadoes can attain wind speeds of more than 300 miles per hour, stretch more than two miles across, and stay on the ground for dozens of miles 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.

11.1 GENERAL BACKGROUND

The planning area has a predominantly maritime climate, influenced by the Pacific Ocean and the Olympic Mountain Range. The County can experience all types of severe weather (except hurricanes).

11.1.1 Semi-Permanent High- and Low-Pressure Areas Over the North Pacific Ocean

During summer and fall, the circulation of air around a high-pressure area over the north Pacific brings a prevailing westerly and northwesterly flow of comparatively dry, cool, and stable air into the Pacific Northwest. As the air moves inland, it becomes warmer and drier, resulting in a dry season. In the winter and spring, the high pressure is further south and low pressure prevails in the northeast Pacific. Circulation of air around both pressure centers brings a prevailing southwesterly and westerly flow of mild, moist air into the Pacific Northwest. Condensation occurs as the air moves inland over the cooler land and rises along the windward slopes of the mountains. This results in a wet season beginning in late October or November, reaching a peak in winter, and gradually decreasing by late spring.

West of the Cascade Mountains, summers are cool and relatively dry while winters are mild, wet, and generally cloudy. Measurable rainfall occurs on 150 days each year in interior valleys and on 190 days in the mountains and along the coast.

Thunderstorms occur up to 10 days each year over the lower elevations and up to 15 days over the mountains. Damaging hailstorms are rare in western Washington. During July and August, the driest months, two to four weeks can pass with only a few showers; however, in December and January, the wettest months, precipitation is 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 for brief periods; heavier intensities occur along the windward slopes of the mountains.

Severe storms hit the coastlines during the winter, bringing heavy rains, winds, and high waves. Windstorms with sustained winds of 50 miles per hour or greater occur with some regularity within the planning area, and are powerful enough to cause significant damage. On occasion, winter storms have exceeded hurricane force winds. Most of these storms cause transportation-related problems and damage to utilities. On occasion, homes and other structures are damaged either by high winds or falling trees. With its geographic position between the waters of Puget Sound and the Cascade Range, the local hills and valleys can generate variable wind patterns which are locally accelerated. Likewise, portions of the planning area can also experience locally accelerated winds due to the narrowing of the river valley and the close proximity to mountain passes. The Cascade Range located to the east, forms a natural barrier to moisture-laden marine air masses resulting in regular rainfall events as these air masses rise in elevation and pass over the mountains.

11.1.2 Thunderstorms

A thunderstorm is a rain event that includes thunder and lightning. A thunderstorm is classified as “severe” when it contains one or more of the following: hail with a diameter of three-quarter inch or greater, winds gusting in excess of 50 knots (57.5 mph), or tornado. Thunderstorms have three stages (see Figure 11-1):

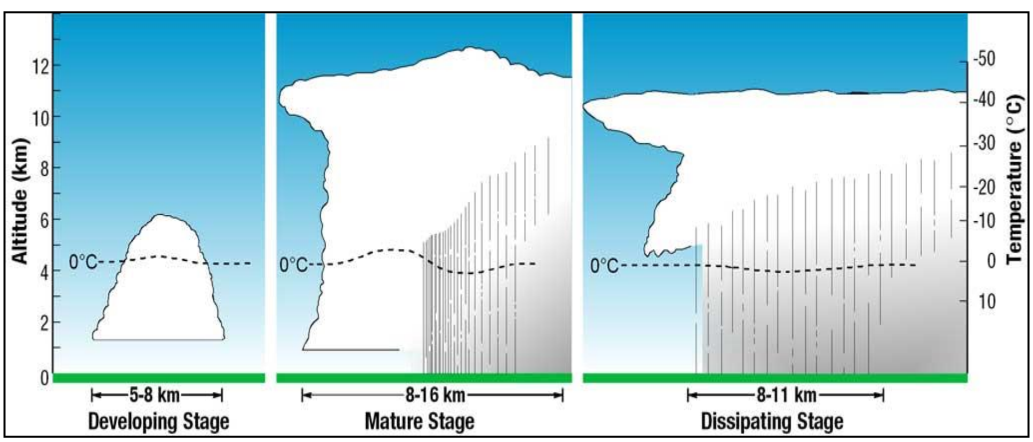


Figure 11-1 The Thunderstorm Life Cycle

Three factors cause thunderstorms: moisture, rising unstable air (air that keeps rising once disturbed), and a lifting mechanism to provide the disturbance. The sun heats the surface of the earth, which warms the air above it. If this warm surface air is forced to rise (hills or mountains can cause rising motion, as can the interaction of warm air and cold air or wet air and dry air) it will continue to rise as long as it weighs less and stays warmer than the air around it. As the air rises, it transfers heat from the earth surface to the upper atmosphere (the process of convection). The water vapor it contains begins to cool and it condenses into a cloud. The cloud eventually grows upward into areas where the temperature is below freezing. Some of the water vapor turns to ice and some of it turns into water droplets. Both have electrical charges. Ice particles usually have positive charges, and rain droplets usually have negative charges. When the charges build up enough, they are discharged in a bolt of lightning, which causes the sound heard as thunder. There are four types of thunderstorms:

- **Single-Cell Thunderstorms—**Single-cell thunderstorms usually last 20 to 30 minutes. A true single-cell storm is rare, because the gust front of one cell often triggers the growth of another. Most single-cell storms are not usually severe, but a single-cell storm can produce a brief severe weather event. When this happens, it is called a pulse severe storm.

- **Multi-Cell Cluster Storm—**A multi-cell cluster is the most common type of thunderstorm. The multi-cell cluster consists of a group of cells, moving as one unit, with each cell in a different phase of the thunderstorm life cycle. Mature cells are usually found at the center of the cluster and dissipating cells at the downwind edge. Multi-cell cluster storms can produce moderate-size hail, flash floods and weak tornadoes. Each cell in a multi-cell cluster lasts only about 20 minutes; the multi-cell cluster itself may persist for several hours. This type of storm is usually more intense than a single cell storm.

- **Multi-Cell Squall Line—**A multi-cell line storm, or squall line, is a long line of storms with a continuous well-developed gust front at the leading edge. The storms can be solid, or have gaps and breaks in the line. Squall lines can produce hail up to golf-ball size, heavy rainfall, and weak tornadoes, but they are best known as the producers of strong downdrafts. Occasionally, a strong downburst will accelerate a portion of the squall line ahead of the rest of the line. This produces what is called a bow echo. Bow echoes can develop with isolated cells as well as squall lines. Bow echoes are easily detected on radar but are difficult to observe visually.

- **Super-Cell Storm—**A super-cell is a highly organized thunderstorm that poses a high threat to life and property. It is similar to a single-cell storm in that it has one main updraft, but the updraft is extremely strong, reaching speeds of 150 to 175 miles per hour. Super-cells are rare. The main characteristic that sets them apart from other thunderstorms is the presence of rotation. The rotating updraft of a super-cell (called a mesocyclone when visible on radar) helps the super-cell to produce extreme weather events, such as giant hail (more than 2 inches in diameter), strong downbursts of 80 miles an hour or more, and strong to violent tornadoes.

As of 2018 (most recent analysis available) Washington ranks 49th nationwide in deaths associated with lightning strikes, having five deaths during the time period 1959-2018. No deaths were reported in 2017 or 2018 as a result of lightning strikes in the state. Washington ranks 49th with respect to cloud-to-ground flash densities during the time period 2007-2016.[11]

Annually, 30 percent of all power outages nationwide are lightning related, with total costs approaching $1 billion dollars (CoreLogic, 2015). Lightning starts approximately 4,400 house fires each year, with estimated losses exceeding $280 million.

[11] NOAA Lightning Safety. Accessed 3 December 2019. http://www.lightningsafety.noaa.gov/stats/59-16_State_Ltg_Fatality+Fatality_Rate_Maps.pdf

Based on an analysis completed in 2019 by John Jensenius, Jr., of the National Lightning Safety Council victims of lightning fatalities are most often engaged in leisure activities; of those, 80 percent of victims involved were male (see Figure 11-2).

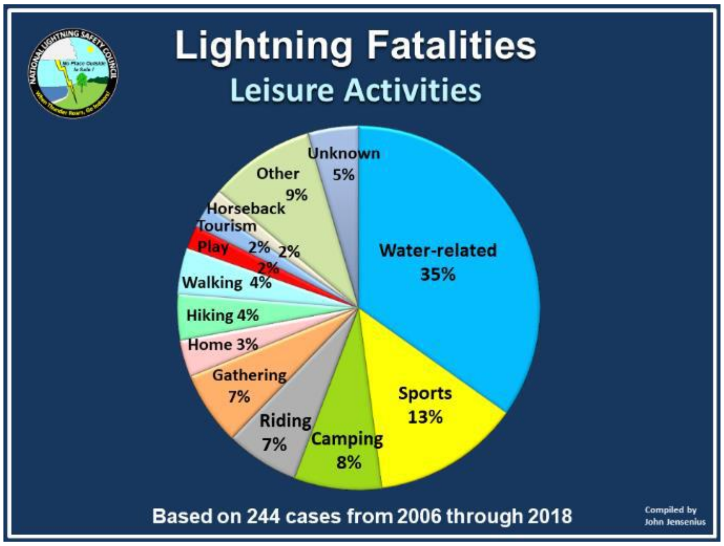


Figure 11-2 Lightning Fatalities by Leisure Activities

11.1.3 Damaging Winds

Damaging winds are classified as those exceeding 60 mph. Damage from such winds accounts for half of all severe weather reports in the lower 48 states and is more common than damage from tornadoes. Wind speeds can reach up to 100 mph and can produce a damage path extending for hundreds of miles. There are seven types of damaging winds:

- **Straight-line winds** —Any thunderstorm wind that is not associated with rotation; this term is used mainly to differentiate from tornado winds. Most thunderstorms produce some straight-line winds as a result of outflow generated by the thunderstorm downdraft.
- **Downdrafts** —A small-scale column of air that rapidly sinks toward the ground.
- **Downbursts**—A strong downdraft with horizontal dimensions larger than 2.5 miles resulting in an outward burst or damaging winds on or near the ground. Downburst winds may begin as a microburst and spread out over a wider area, sometimes producing damage similar to a strong tornado. Although usually associated with thunderstorms, downbursts can occur with showers too weak to produce thunder.
- **Microbursts**—A small concentrated downburst that produces an outward burst of damaging winds at the surface. Microbursts are generally less than 2.5 miles across and short-lived, lasting only 5 to 10 minutes, with maximum wind speeds up to 168 mph. There are two kinds of microbursts: wet and dry. A wet microburst is accompanied by heavy precipitation at the surface. Dry microbursts, common in places like the high plains and the intermountain west, occur with little or no precipitation reaching the ground.
- **Gust front**—A gust front is the leading edge of rain-cooled air that clashes with warmer thunderstorm inflow. Gust fronts are characterized by a wind shift, temperature drop, and gusty

winds out ahead of a thunderstorm. Sometimes the winds push up air above them, forming a shelf cloud or detached roll cloud.

- **Derecho—**A derecho is a widespread thunderstorm wind caused when new thunderstorms form along the leading edge of an outflow boundary (the boundary formed by horizontal spreading of thunderstorm-cooled air). The word "derecho" is of Spanish origin and means "straight ahead." Thunderstorms feed on the boundary and continue to reproduce. Derechos typically occur in summer when complexes of thunderstorms form over plains, producing heavy rain and severe wind. The damaging winds can last a long time and cover a large area.

- **Bow Echo—**A bow echo is a linear wind front bent outward in a bow shape. Damaging straight-line winds often occur near the center of a bow echo. Bow echoes can be 200 miles long, last for several hours, and produce extensive wind damage at the ground.

There are four main types of windstorm tracks that impact the Pacific Northwest as identified in Figure 11-3. These four tracks are distinguished by two basic windstorm patterns that have emerged in the Puget Sound Region: the South Wind Event and the East Wind Event. South wind events are generally large-scale events that affect large portions of Western Washington and possibly Western Oregon.

In contrast, easterly wind events are more limited. High pressure on the east side of the Cascade Mountain Range creates airflow over the peaks and passes, and through the funneling effect of the valleys, the wind increases dramatically in speed. As it descends into these valleys and then exits into the lowlands, the wind can pick up enough speed to damage buildings, rip down power lines, and destroy fences. Once it leaves the proximity of the Cascade foothills, the wind tends to die down rapidly.

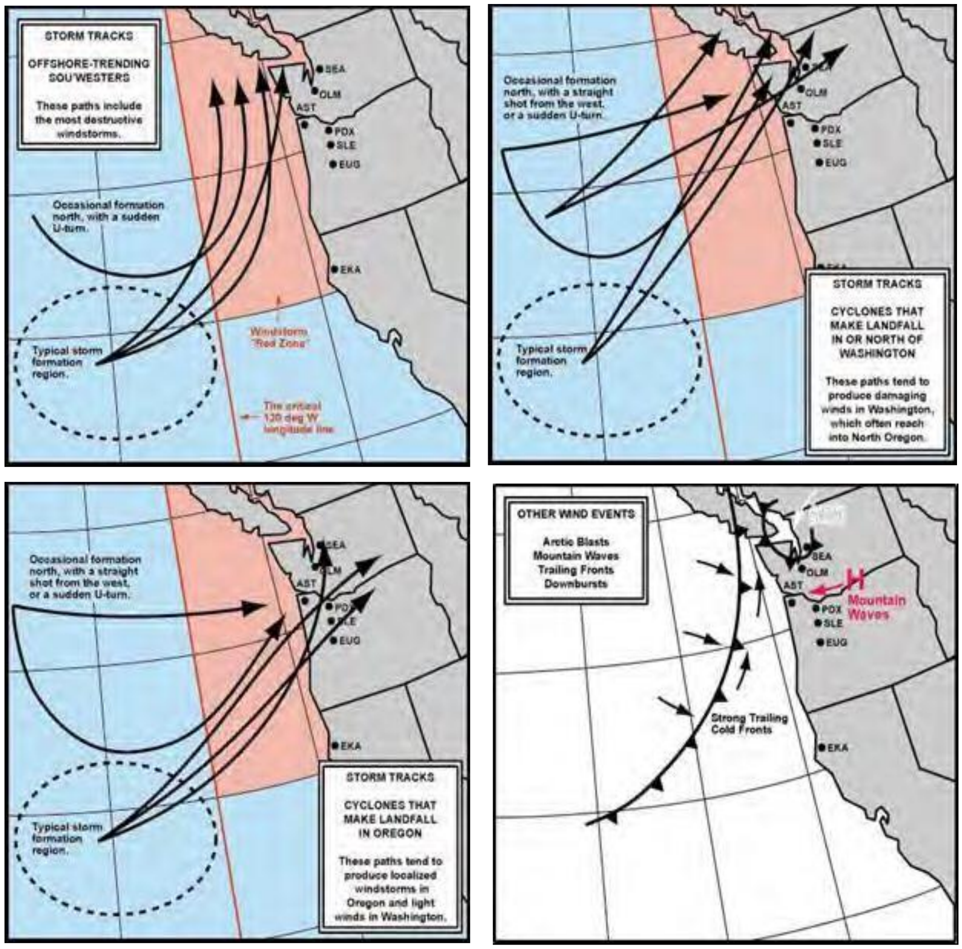
National Wind Zones are featured in Figure 11-4. These zones were utilized to guide structure development beginning with the 2006 International Building Code. These exposure zones further identify areas that are at higher risk from impacts of high winds. The closer development is to open waters and on top of steep cliffs, the higher the design criteria that is required through building code.

For each wind direction considered, an exposure category that adequately reflects the characteristics of ground surface irregularities are determined for the site at which the building or structure is to be constructed. Account shall be taken of variations in ground surface roughness that arise from natural topography and vegetation as well as from constructed features. Based on the International Building Code, the zones are further broken down into surface roughness categories and are defined as follows:

- Surface Roughness B. Urban and suburban areas, wooded areas or other terrain with numerous closely spaced obstructions having the size of single-family dwellings or larger.

- Surface Roughness C. Open terrain with scattered obstructions having heights generally less than 30 feet (9144 mm). This category includes flat open country, grasslands, and all water surfaces in hurricane-prone regions.

- Surface Roughness D. Flat, unobstructed areas, and water surfaces outside hurricane-prone regions. This category includes smooth mud flats, salt flats and unbroken ice.



Source: Oregon Climate Service, 2015

Figure 11-3 Windstorm Tracks Impacting the Pacific Northwest

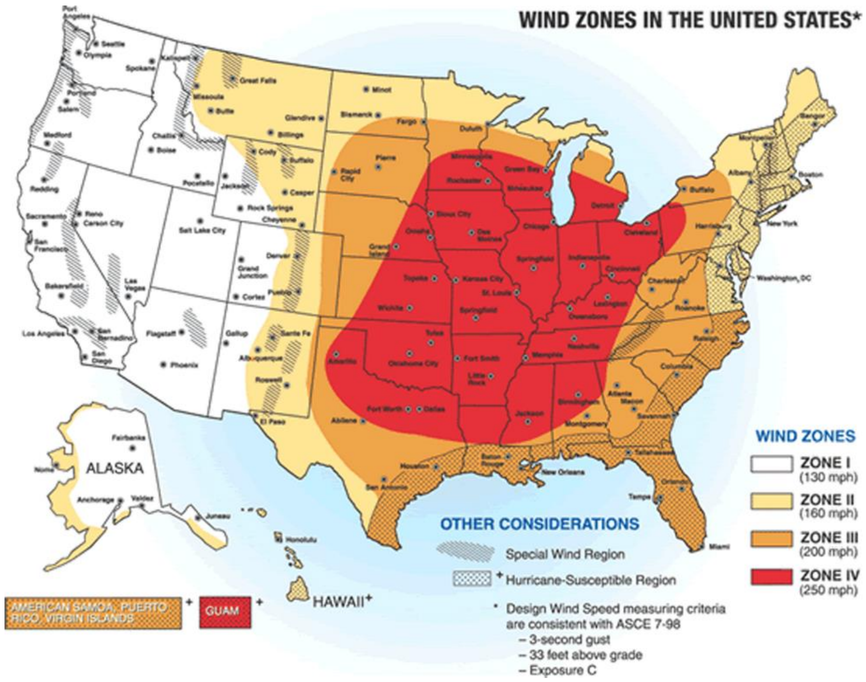


Figure 11-4 United States Wind Zones

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

11.1.4 Hail Storms

Hail occurs when updrafts in thunderstorms carry raindrops upward into extremely cold areas of the atmosphere where they freeze into ice. Recent studies suggest that super-cooled water may accumulate on frozen particles near the back side of a storm as they are pushed forward across and above the updraft by the prevailing winds near the top of the storm. Eventually, the hailstones encounter downdraft air and fall to the ground.

Hailstones grow two ways: by wet growth or dry growth. In wet growth, a tiny piece of ice is in an area where the air temperature is below freezing, but not super cold. When the tiny piece of ice collides with a super-cooled drop, the water does not freeze on the ice immediately. Instead, liquid water spreads across tumbling hailstones and slowly freezes. Since the process is slow, air bubbles can escape, resulting in a layer of clear ice. Dry growth hailstones grow when the air temperature is well below freezing and the water droplet freezes immediately as it collides with the ice particle. The air bubbles are "frozen" in place, leaving cloudy ice.

11.1.5 Ice and Snow Storms

The National Weather Service defines an ice storm as a storm that results in the accumulation of at least 0.25 inches of ice on exposed surfaces. Ice storms occur when rain falls from a warm, moist, layer of atmosphere into a below freezing, drier layer near the ground. The rain freezes on contact with the cold ground and exposed surfaces, causing damage to trees, utility wires, and structures (see Figure 11-5).

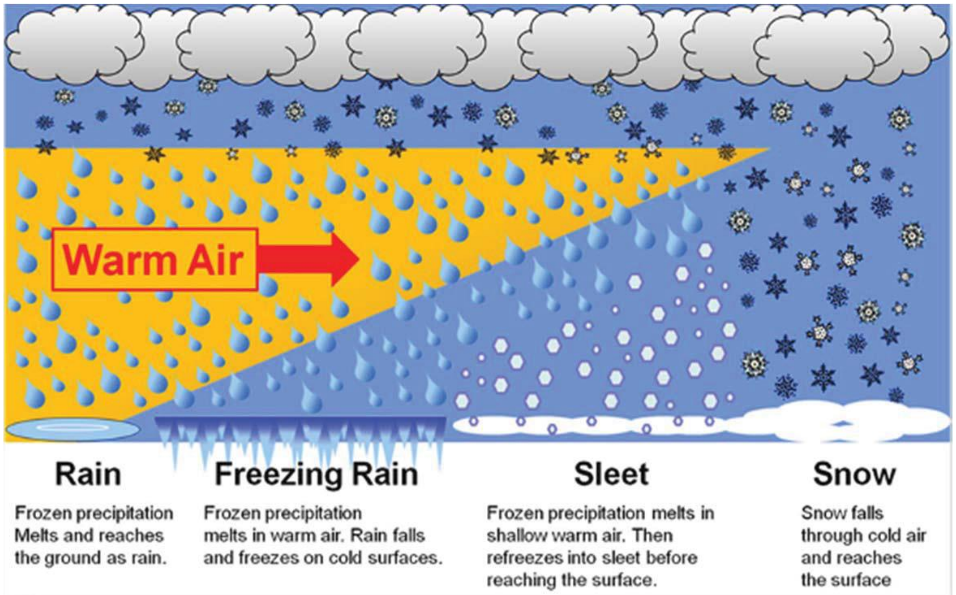


Figure 11-5 Types of Precipitation

Precipitation falls as snow when air temperature remains below freezing throughout the atmosphere. In many climates, precipitation that forms in wintertime clouds starts out as snow because the top layer of the storm is usually cold enough to create snowflakes. Snowflakes are just collections of ice crystals that cling to each other as they fall toward the ground. Precipitation continues to fall as snow when the temperature remains at or below 0 degrees Celsius from the cloud base to the ground. The following are used to define snow events:

- Snow Flurries. Light snow falling for short durations. No accumulation or light dusting is all that is expected.
- Snow Showers. Snow falling at varying intensities for brief periods of time. Some accumulation is possible.
- Snow Squalls. Brief, intense snow showers accompanied by strong, gusty winds. Accumulation may be significant. Snow squalls are best known in the Great Lakes Region.
- Blowing Snow. Wind-driven snow that reduces visibility and causes significant drifting. Blowing snow may be snow that is falling and/or loose snow on the ground picked up by the wind.
- Blizzards. Winds over 35mph with snow and blowing snow, reducing visibility to 1/4 mile or less for at least 3 hours.

Portions of the planning area do experience a significant amount of snow on a regular basis, particularly in those areas abutting the mountainous regions.

11.1.6 Extreme Temperatures

Extreme temperature includes both heat and cold events, which can have a significant impact on human health, commercial/agricultural businesses, and primary and secondary effects on infrastructure (e.g., burst pipes and power failure). What constitutes “extreme cold” or “extreme heat” can vary across different areas of the country, based on what the population is accustomed to within the region (CDC, 2014).

Extreme Cold

Extreme cold events are when temperatures drop well below normal in an area. In regions relatively unaccustomed to winter weather, near freezing temperatures are considered “extreme cold.” Extreme cold can often accompany severe winter storms, with winds exacerbating the effects of cold temperatures by carrying away body heat more quickly, making it feel colder than is indicated by the actual temperature (known as wind chill). Figure 11-6 demonstrates the value of wind chill based on the ambient temperature and wind speed.

Exposure to cold temperatures, whether indoors or outside, can lead to serious or life-threatening health problems such as hypothermia, cold stress, frostbite or freezing of the exposed extremities such as fingers, toes, nose, and ear lobes. Hypothermia occurs when the core body temperature is <95ºF. If persons exposed to excessive cold are unable to generate enough heat (e.g., through shivering) to maintain a normal core body temperature of 98.6ºF, their organs (e.g., brain, heart, or kidneys) can malfunction. Extreme cold also can cause emergencies in susceptible populations, such as those without shelter, those who are stranded, or those who live in a home that is poorly insulated or without heat. Infants and the elderly are particularly at risk, but anyone can be affected.

Extremely cold temperatures often accompany a winter storm, so individuals may have to cope with power failures and icy roads. Although staying indoors as much as possible can help reduce the risk of car crashes and falls on the ice, individuals may also face indoor hazards. Many homes will be too cold—either due to a power failure or because the heating system is not adequate for the weather. The use of space heaters and fireplaces to keep warm increases the risk of household fires and carbon monoxide poisoning.

	Temperature (ºF)																	
Wind (mph) / Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

$$\text{Wind Chill (ºF)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (ºF) V= Wind Speed (mph)

Effective 11/01/01

Figure 11-6 NWS Wind Chill Index

During cold months, carbon monoxide may be high in some areas because the colder weather makes it difficult for car emission control systems to operate effectively. Carbon monoxide levels are typically higher during cold weather because the cold temperatures make combustion less complete and cause inversions that trap pollutants close to the ground (USEPA, 2009).

Extreme Heat[12]

Temperatures that hover 10 degrees or more above the average high temperature for the region and last for several days or weeks are defined as extreme heat (FEMA, 2006; CDC, 2006). An extended period of extreme heat of three or more consecutive days is typically called a heat wave and is often accompanied by high humidity (Ready America, Date Unknown; NWS, 2005). There is no universal definition of a heat wave because the term is relative to the usual weather in a particular area. The term heat wave is applied both to routine weather variations and to extraordinary spells of heat which may occur only once a century (Meehl and Tebaldi, 2004). A basic definition of a heat wave implies that it is an extended period of unusually high atmosphere-related heat stress, which causes temporary modifications in lifestyle and which may have adverse health consequences for the affected population (Robinson, 2000). Figure 11-7 identifies some of those consequences and associated temperatures. [13]

Certain populations are considered vulnerable or at greater risk during extreme heat events. These populations include, but are not limited to the following: the elderly age 65 and older, infants and young children under five years of age (see Figure 11-8), pregnant woman, the homeless or poor, the overweight, and people with mental illnesses, disabilities and chronic diseases (NYS HMP, 2008).

[12] Photo of Order of St. Benedict Nuns Accessed 30 Nov 2017. Available at: http://www.historylink.org/File/5630
[13] NCDC, 2000

Relative Humidity (%)	Temperature (°F)															
	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Category	Heat Index	Health Hazards
Extreme Danger	130 °F – Higher	Heat Stroke / Sunstroke is likely with continued exposure.
Danger	105 °F – 129 °F	Sunstroke, muscle cramps, and/or heat exhaustion possible with prolonged exposure and/or physical activity.
Extreme Caution	90 °F – 105 °F	Sunstroke, muscle cramps, and/or heat exhaustions possible with prolonged exposure and/or physical activity.
Caution	80 °F – 90 °F	Fatigue possible with prolonged exposure and/or physical activity.

Figure 11-7 Heat Stress Index

Wind-Chill Factor Chart (in Fahrenheit)

Air Temperature	Wind Speed in mph: Calm	5	10	15	20	25	30	35	40
40	40	36	34	32	30	29	28	28	27
30	30	25	21	19	17	16	15	14	13
20	20	13	9	6	4	3	1	0	-1
10	10	1	-4	-7	-9	-11	-12	-14	-15
0	0	-11	-16	-19	-22	-24	-26	-27	-29
-10	-10	-22	-28	-32	-35	-37	-39	-41	-43

Comfortable for out door play   Caution   Danger

Heat Index Chart (in Fahrenheit %)

Air Temperature (F)	Relative Humidity (Percent): 40	45	50	55	60	65	70	75	80	85	90	95	100
80	80	80	81	81	82	82	83	84	84	85	86	86	87
84	83	84	85	86	88	89	90	92	94	96	98	100	103
90	91	93	95	97	100	103	105	109	113	117	122	127	132
94	97	100	103	106	110	114	119	124	129	135			
100	109	114	118	124	129	130							
104	119	124	131	137									

Figure 11-8 Heat and Wind Chill Index for Children

11.1.7 Tornado

A tornado is a violently rotating column of air extending between, and in contact with, a cloud and the surface of the earth. Tornadoes are often (but not always) visible as a funnel cloud. Tornadoes are rated by their intensity and damage to vegetation and property. There are two common rating scales, the Fujita scale (F-Scale) and the Enhanced Fujita Scale (EF-Scale). The Fujita scale is a tornado scale introduced in 1971 by Tetsuya Fujita and the scale evaluates total damage. In the United States the Fujita scale was replaced with the Enhanced Fujita scale, which is now the primary scale used the United Sites and Canada. The Enhanced Fujita scale not only considers damage, but also takes into account wind speed. Figure 11-9 illustrates the two tornado rating scales.

On a local-scale, tornadoes are the most intense of all atmospheric circulations and wind can reach destructive speeds of more than 300 mph. A tornado's vortex is typically a few hundred meters in diameter, and damage paths can be up to 1 mile wide and 50 miles long. Figure 11-10, adapted from FEMA, illustrates the potential impacts and damage from tornadoes of different magnitudes. Tornadoes can occur throughout the year at any time of day but are most frequent in the spring during the late afternoon. As shown in Figure 11-11, Washington has a low risk compared to states in the Midwestern and Southern U.S.; however, the area does have recorded Tornadoes. The Wind Zone Map illustrated in Figure 11-12 illustrates the variations in wind speeds, which correlate to the building code requirements.

Figure 11-9 Tornado Ratings

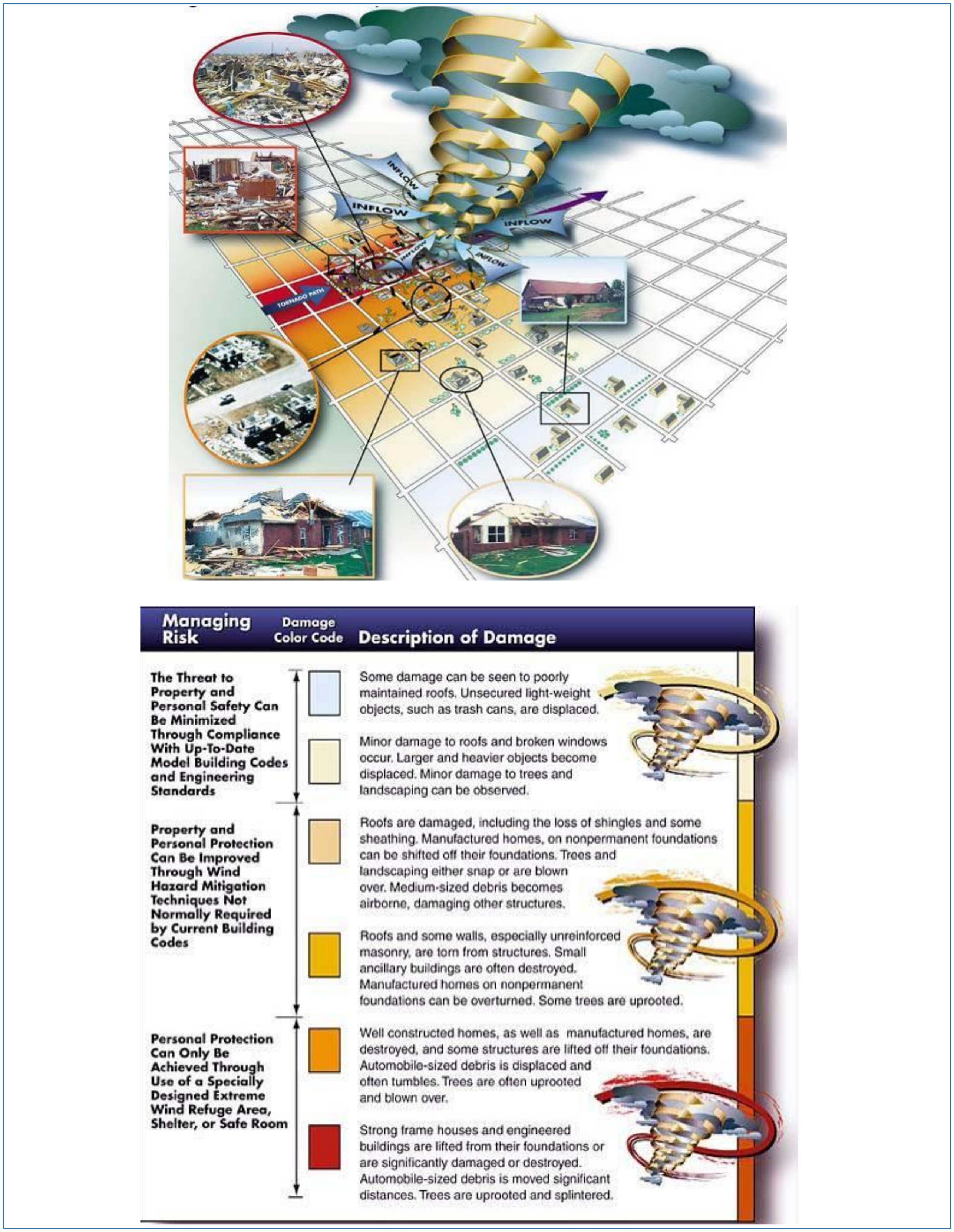


Figure 11-10 Potential Impact and Damage from a Tornado

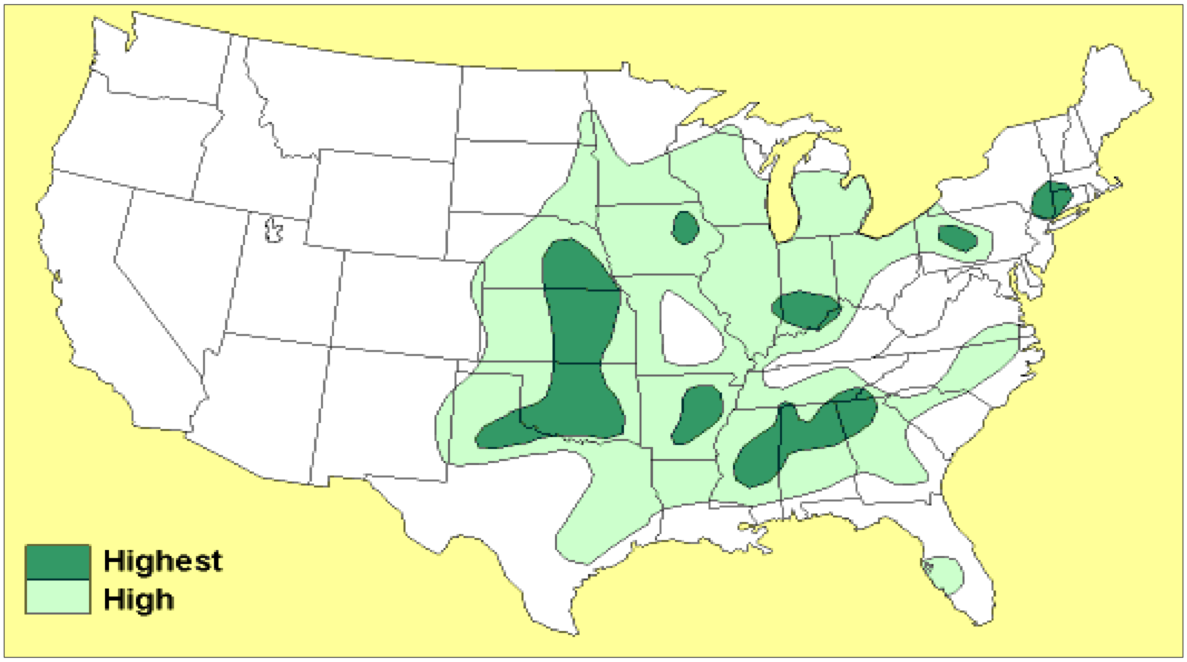


Figure 11-11 Tornado Risk Areas in the United States

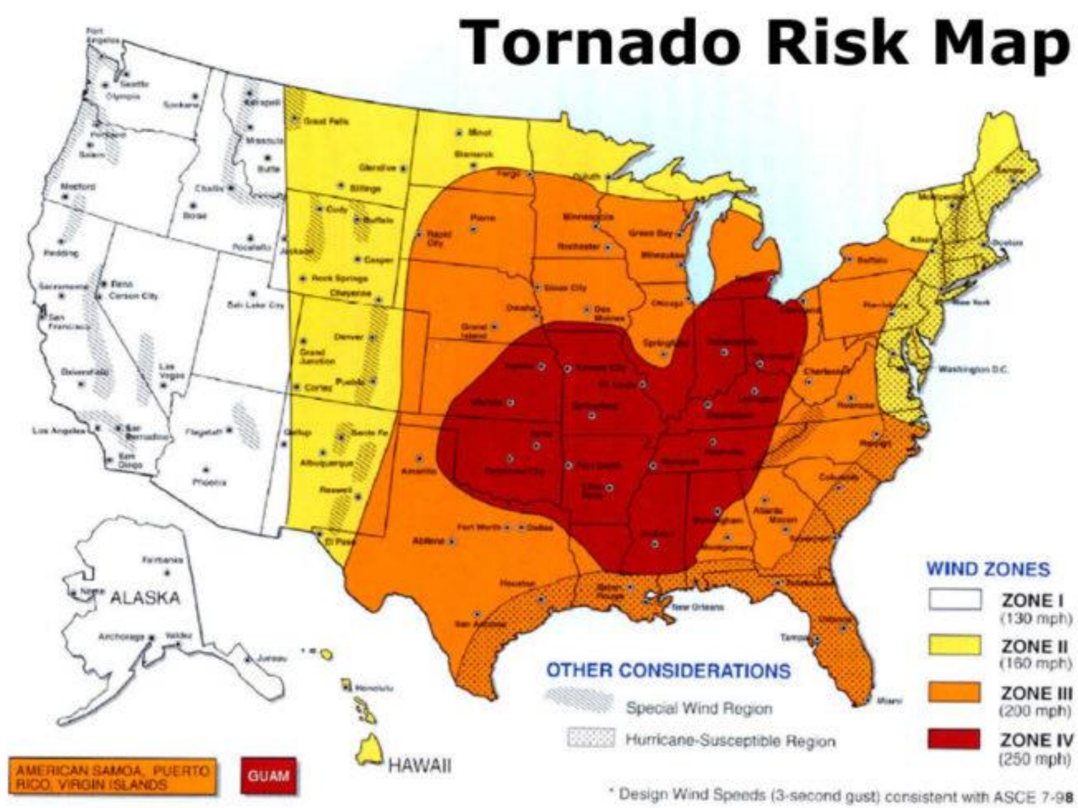


Figure 11-12 Wind Zone Map of U.S.

Figure 11-13 identifies the number of weather fatalities based on 10-year and 30-year averages.[14] Extreme heat is the number one weather-related cause of death in the U.S. over the 30-year average. On average, more than 1,500 people die each year from excessive heat. Heat again ranked highest in causes of weather-related deaths for the 30-year average, followed by flood.

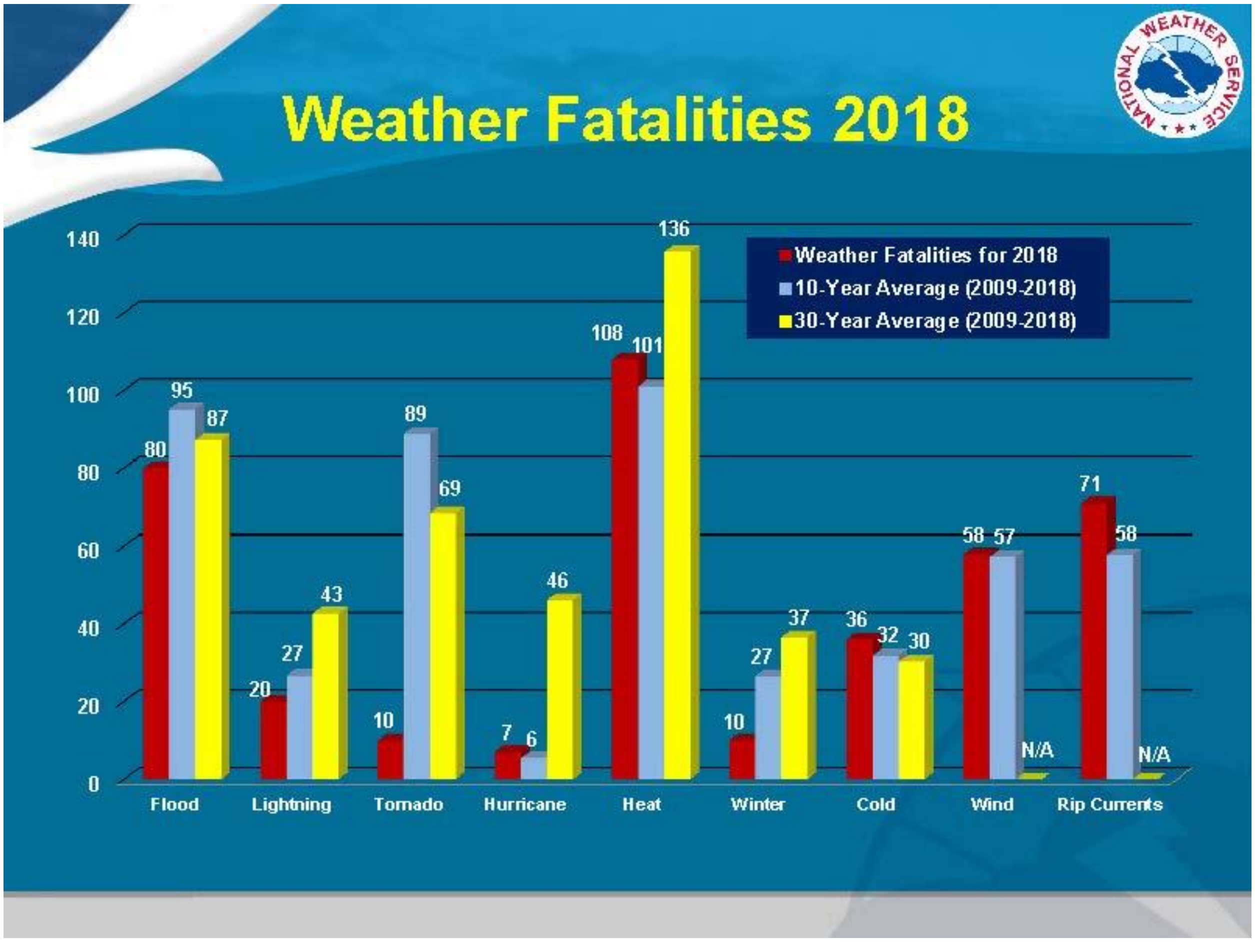


Figure 11-13 Average Number of Weather Related Fatalities in the U.S.

Depending on severity, duration, and location, extreme heat events can create or provoke secondary hazards including, but not limited to: dust storms, droughts, wildfires, water shortages and power outages (FEMA, 2006; CDC, 2006). This could result in a broad and far-reaching set of impacts throughout a local area or entire region. Impacts could include significant loss of life and illness; economic costs in transportation; agriculture; production; energy and infrastructure; and losses of ecosystems, wildlife habitats, and water resources (Adams, Date Unknown; Meehl and Tebaldi, 2004; CDC, 2006; NYSDPC, 2008).

11.2 HAZARD PROFILE

11.2.1 Extent and Location

The entire planning area is susceptible to the impacts of severe weather. Severe weather events customarily occur during the months of October to March, although they have occurred year-round. When reviewing

[14] NOAA, 2018. Accessed 2 July 2019. Available online at https://www.nws.noaa.gov/om/hazstats.shtml

NOAA and FEMA data, the months of March, January and December have the highest severe weather occurrences, with four, three and two events occurring, respectively, in each of those months. May, October, and November have each experienced one declared severe weather event.

The area has been impacted by strong winds, rain, snow, or other precipitation, and have experienced thunder or lightning storms, although rare. Considerable snowfall does not customarily occur throughout the entire region, but does occur more regularly and significantly in the foothills of the mountains, with higher accumulations occurring.

Communities in low-lying areas next to coastlines, rivers, streams, or lakes are more susceptible to flooding as a result of storm surge. Wind events are damaging to the planning area. Winds coming off of the Pacific Ocean can have a significant impact on the planning region as a result of both the wind and associated storm surge and increased precipitation. For the planning region as a whole, wind events are one of the most common weather-related incidents to occur, often times leaving the area without power, although customarily not for long extended periods. Due to the geologic makeup of the area, winds can be accelerated in small areas.

Severe storms and weather also affect transportation. Access is sometimes unpredictable as roads are vulnerable to damage from severe storms, storm surges, flooding, and landslide/erosion. Severe storms and storm surges also cause flooding and channel migration, and can travel inland for many miles along waterways.

Average snowfall in the area is 12 inches per year, higher than the state-wide average, with precipitation falling approximately 168 days per year. Annual average temperature is 51 degrees, with the average daily high in July is ~74 degrees, with the January lows at approximately 25 degrees. On average, the area experiences only one or two days when the temperature is over 90 degrees, which is cooler than many places in Washington. Annually, the area experiences slightly over 40 days per year when nighttime low temperatures fall below freezing. Seldom does the area experience zero or negative temperatures.

November is the wettest month, and the driest month is July with 1.3 inches. The wettest season is Spring with 34 percent of yearly precipitation (~43 inches) and 11percent occurs in Autumn, which is the driest season. The annual rainfall of ~49 inches means that it is wetter than most places in Washington, which average ~39 inches. Windspeeds vary by month, with January and October customarily gaining highest speeds, and August lowest speeds.

A tornado is the smallest and potentially most dangerous of local storms. A tornado is formed by the turbulent mixing of layers of air with contrasting temperature, moisture, density, and wind flow. This mixing accounts for most of the tornadoes occurring in April, May, and June, when cold, dry air moving into the Puget Sound region from the north or northwest meets warm, moister air moving up from the south. If a major tornado struck a populated area, damage could be widespread. Businesses could be forced to close for an extended period or permanently, fatalities could be high, many people could be homeless for an extended period, and routine services such as telephone or power could be disrupted. In the case of extremely high winds, some buildings may be damaged or destroyed. Due to the (often) short warning period, livestock are commonly the victims of a tornado or windstorm.

11.2.2 Previous Occurrences

Since 1960, 13 severe weather events have been declared in Snohomish County, four of those events include high wind. Snowstorms in the planning area have also occurred, including snowstorms in 1969, 1971, 1980, 2008, 2009, and 2019.

In addition to the federally declared events identified in Table 11-1, the area also sustains impact from severe wind events which do not rise to the level of a declaration, but have significant impact on the area. Wind and associated storm effects impact a much greater area than incidents associated only with floods in most instances, and also occur more regularly.

Planning Team Members indicate that over the past 15+ years, there have been (at least) annual instances where portions of the Reservation have lost power, but customarily such events a short-term, lasting less than ~2 days. The incidents customarily revolve around high winds knocking down trees over power lines, although heavy snow has also caused power outages. Portions of the Reservation do have back-up power supplies via generators, although not all facilities. The Tribe has identified the potential of seeking additional generators as a potential mitigation strategy.

The lack of power will become more of an issue as the Tribe continues to expand and include residential structures on the Reservation, particularly since its intent over the next few years is to develop elder housing, who are more vulnerable to the impacts of power outages.

Due to the rural nature of the reservation, the downed trees do have the potential to impact ingress and egress to the reservation. The primary roadway onto the reservation is county-owned. After a significant windstorm event, the tribe regularly assists the County to help clear debris from the area.

The following provides a brief synopsis of a few of the severe weather events occurring in the area, some of which did not rise to the level of a disaster declaration, but had significant impact.

- January 1950 – Snow: Heavy accumulations of snow fell throughout western Washington.
- October 1962 – Wind: Columbus Day Windstorm (discussed in detail below) affected areas from northern California to British Columbia and is the windstorm all others since are compared to. Recorded wind gusts between 88 and 150 miles per hour were recorded in Washington State; damage in the area ranged from downed trees, broken windows to collapsed barns.
- February 1979 – Wind: A series of windstorms caused damage throughout western Washington, and in some areas caused more damage than the Columbus Day windstorm due to sustained winds of 25 to 30 miles per hour over a long period of time.
- January 1993 – Wind: Inauguration Day Windstorm caused damage throughout western Washington. Large areas of the state were without electrical power for several days.
- November 2006 – Wind: A sustained windstorm with high peak gusts caused significant blow-down of large trees throughout the area.

The area has also been subject to impact from tornadoes, as follows:

- 1971 - Lake Roesinger
- January 2, 1997 - Granite Falls
- May 31, 1997 – Lake Stevens
- June 8, 1997 – Darrington
- July 6, 1997 – Snohomish
- December 8, 1997 – Snohomish
- September 1, 1998 - Monroe

- April 22, 2000 – Stanwood

Figure 11-14 further identifies both the magnitude and number of tornadoes occurring within the planning area since 1950.[15]

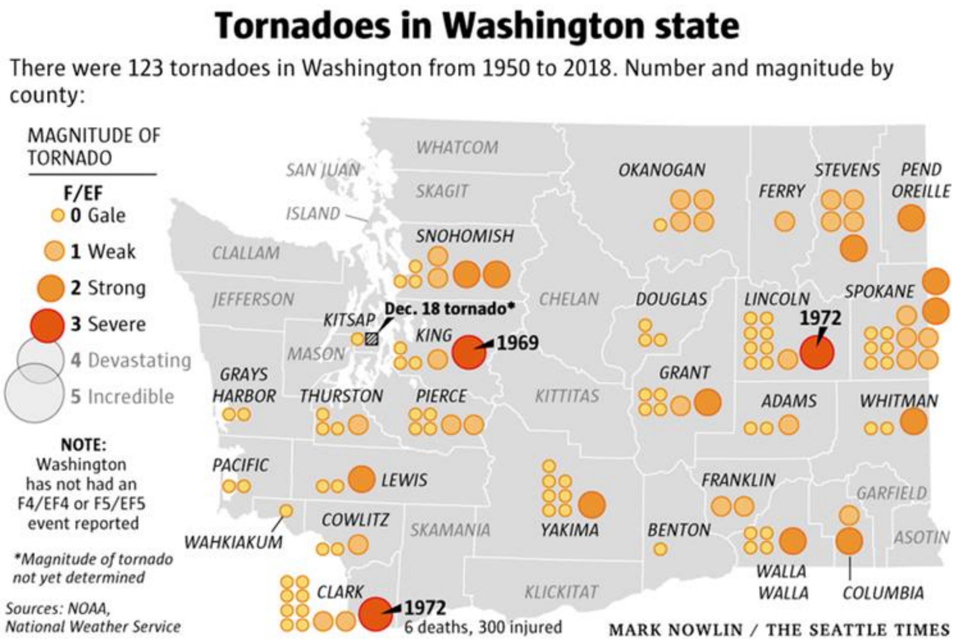


Figure 11-14 Tornado History in Washington 1950-2018

TABLE 11-1 SEVERE WEATHER EVENTS IMPACTING PLANNING AREA SINCE 1960			
Incident Date	Type	Deaths or Injuries	Property Damage
January 1993 (Disaster 981)	Severe storm and high winds	Unknown	Unknown
Description: A powerful low-pressure system swept through central Western Washington, causing great destruction, numerous injuries, and the loss of five lives. Winds averaging 50 miles per hour with gusts to over 100 miles per hour caused trees to fall and knocked out power to 965,000 customers.			
November 1995 (Disaster 1079)	Flooding, severe storm, and high winds	Unknown	Unknown
Description: Heavy rains lead to flooding throughout the region.			
Dec. 1996—Jan. 1997 (Disaster 1159)	Severe winter storm, flooding, landslides, and mudslides.	24 deaths statewide	Statewide losses $140 million statewide

[15] https://www.seattletimes.com/seattle-news/weather/tornado-touches-down-on-kitsap-peninsula-rips-roof-off-home-weather-service-says/ *NOAA National Weather Service as cited in the Seattle Times*

TABLE 11-1
SEVERE WEATHER EVENTS IMPACTING PLANNING AREA SINCE 1960

Incident Date	Type	Deaths or Injuries	Property Damage
Description: Saturated ground combined with snow, freezing rain, rain, rapid warming, and high winds within a five-day period produced flooding and landslides. 37 counties were impacted, with large power outages throughout the impacted counties. Heavy accumulations of snow fell, with some areas receiving 5 feet of snow. This snow event was followed several days later by high winds and rain. Many roads were impassable and road crews worked 24-hour days to plow snow.			
October 2003 (Disaster 1499)	Severe Storm and Flooding	Unknown	Statewide losses PA >$9 million; IA >$5.5 million
Description: Heavy rains, severe storms.			
January 2006 (Disaster 1641)	Severe winter storm, flood, landslide, mudslide, tidal surge	Unknown	Statewide PA >$29 million; IA >$5M
Description: Heavy rains from January 27 – February 4, 2006 along with high tidal surge caused flooding in several Western Washington counties.			
November 2006 (Disaster 1671)	Severe winter storm, flood, landslide, and mudslide	Unknown	Statewide PA >$29 million; IA >$5M
Description: Heavy rains from November 2 – 11, 2006 surge caused flooding in several Western Washington counties.			
December 2006 DR 1682	Severe winter storm, wind, landslides, and mudslides	One fatality in McCleary	Unknown
Description: Areas of the state experienced hurricane-force winds and heavy rains with over one million people without power in the State. The "Hanukkah Eve Windstorm of 2006" downed power lines, trees, and building debris which caused many road closures and left the county in a state of emergency. Injuries were reported statewide.			
December 2007 (Disaster 1734)	Severe storm, flooding, landslides, and mudslides	Unknown	Unknown
Description: Severe winter storm, including record and near record snowfall and heavy rains and winds. The great Coastal Gale of December 1-3, 2007 impacted the entire western coastline from northern California to Canada. Over a period of three days, two separate storms lashed the area with hurricane-force gusts and heavy rain. The region between Newport, OR and Hoquiam, WA received the strongest gale since the great Columbus Day Storm of 1962.			
December 2008 (Disaster 1825)	Severe winter storm, record and near record snow	Unknown	Public Assistance to all declared counties was over $5.5 million
Description: Severe winter storm, including record and near record snowfall and heavy rains and winds.			
January 2012 (Disaster 4056)	Severe winter storm, flooding, landslides, and mudslides	Unknown	PA $30,545,487 Statewide
Description: Severe winter storm, including flooding, land and mudslides occurred during the period of January 14-23, 2012, impacting much of Snohomish County, along with 11 other counties in Western Washington.			
August 2015 (Disaster 4242)	Severe windstorm	2 deaths	$6.3 million in PA over all counties declared

TABLE 11-1
SEVERE WEATHER EVENTS IMPACTING PLANNING AREA SINCE 1960

Incident Date	Type	Deaths or Injuries	Property Damage
Description: Severe windstorm impacted much of the state with wind and rain, knocking down utility poles and trees across western Washington. A 36-year old man was struck and killed by a falling tree in Gig Harbor while driving down a local road; his three-year-old daughter was also in the car at the time, but was uninjured. In Federal Way, a falling tree branch killed a 10-year-old girl. NWS issued high wind warnings for much of the region, with sustained winds of 20-35 mph, and gusts up to 50+ in some areas. Highest gusts recorded were on the coast.			
November 2015 (Disaster 4249)	Severe storm, straight-line winds, flooding, landslides, and mudslides	Unknown	PA $25M statewide
Description: Severe winter storm, including winds, land and mudslides. This weather pattern stretched across much of the United States, impacting areas with wind gusts over 100 mph. Locally, the storm's winds downed trees, knocking out power and caused major road closures. Winds were reported at 119 mph at White Pass, and 116 mph at Mission Ridge Summit. In eastern Washington, Spokane International Airport gusted to 71 mph shortly before 4 p.m. Tuesday. The National Weather Service said that was the strongest non-thunderstorm wind gust ever recorded at that location. According to the National Weather Service, widespread rainfall amounts of 3 to 6 inches with local totals of 9 to 11 inches were recorded in the mountains of western Washington in the three days preceding the storm. In the rain shadow of the Olympic Mountains, rainfall at Seattle-Tacoma International Airport saw 4.45 inches of rain over the three-day period. Rivers swelled above flood stage in western Washington thanks to this deluge, with the worst flooding occurring north and northeast of Seattle. The Skykomish River in Snohomish County near Gold Bar crested at its third highest level on record, over 7 feet above flood stage, the highest level since the record-setting November 2006 flood. Flood waters swamped the town of Sultan, about six miles downstream from Gold Bar, prompting of a rescue of one woman forced to climb out her front window. Flooding along the Stillaguamish River near Arlington prompted a shutdown of state route 530 east of the city, and flooded several homes. The river crested at its highest level in almost five years, 6.5 feet above flood stage.			
December 2018 (Disaster 4418)	Severe winter storm, straight-line winds, flooding, landslides, mudslides, and tornado	Unknown	Unknown
Description: Severe winter storm, including winds, land and mudslides, tornado			

11.2.3 Severity

The most common problems associated with severe storms are immobility and loss of utilities. Roads become impassable due to flooding, downed trees, ice or snow, or a landslide, increasing the potential for injuries or death.

Power lines may be downed due to high winds, and services such as water or phone may not be able to operate without power. Lightning can cause severe damage and injury, although no such injuries have been reported within the tribal planning area. Physical damage to homes and facilities caused by wind do occur, although unless it is a significant windstorm, the impact is usually limited in nature.

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

Due to the amount of snow customarily received in the region, even a small accumulation of ice or snow can, and has, caused havoc on transportation systems due to terrain, the level of experience of drivers to maneuver in snow and ice conditions, and the lack of snow clearing equipment and resources within the region.

Ice storms, especially when accompanied by high winds, can have an especially destructive impact within the planning region, with both being able to close major transportation corridors and bridges, and also its impact on the densely wooded areas. Accumulation of ice on trees, power lines, communication towers and wiring, or other utility services can be crippling, and create additional hazards for residents, motorists, and pedestrians. The Tribe has received no disaster declarations for an ice storm event.

During the last 30 years, Western Washington has had an average annual snowfall of 11.4 inches per year, with the snowfall customarily occurring during November through March, although snow has fallen as late as April. Historical records in Western Washington are as follows:

- January 1950 – One day record for snow accumulation – 21 inches
- January 1950 – One month record for snow accumulation – 57 inches
- 1968-1969 – Winter season record for snow accumulation – 67 inches

Windstorms are common in the planning area, occurring many times throughout the year. The predicted wind speed given for wind warnings issued by the National Weather Service is for a one-minute average, during which gusts may be 25 to 30 percent higher. Windstorms are a threat within the planning area due, in part, to the densely wooded areas, and the potential for falling trees. Windstorm events have included straight-line winds, tornado, and winter storms. The County has sustained two windstorm declarations within ~14 weeks of one another during 2015.

Routine services could be disrupted, and businesses could be forced to close for an extended period, impacting availability of commodities. As a result of the heavily forested areas, debris accumulations would be high, causing additional difficulties with access along major arterials connecting the area to other parts of the area, further impacting logistical support and commodities.

The extent (severity or magnitude) of extreme cold temperatures are generally measured through the wind chill temperature index. Wind Chill Temperature is the temperature that people and animals feel when outside and it is based on the rate of heat loss from exposed skin by the effects of wind and cold. As the wind increases, the body is cooled at a faster rate causing the skin's temperature to drop (NWS, 2009).

On November 1, 2001, the NWS implemented a new wind chill temperature index. It was designed to more accurately calculate how cold air feels on human skin. Figure 11-6 shows the new wind chill temperature index[16]. The Index includes a frostbite indicator, showing points where temperature, wind speed and exposure time will produce frostbite to humans. The chart shows three shaded areas of frostbite danger. Each shaded area shows how long a person can be exposed before frostbite develops (NWS, 2009).

The extent of extreme temperatures is generally measured through the heat index (shown above). Created by the NWS, the Heat Index accurately measures apparent temperature of the air as it increases with the relative humidity. The Heat Index can be used to determine what effects the temperature and humidity can have on the population (NCDC, 2000).

[16] NWS, 2008

11.2.4 Frequency

The severe weather events are often related to high winds and associated other winter storm-type events such as heavy rains and landslides, and snow. Severe storms (which include flooding) are the most declared event for the Tribe. The Tribe experiences some form of a severe storm annually, although in most cases, such events do not rise to the level of a declared disaster. While snow events do occur, they customarily are not significant, nor last for extended periods of time.

The National Weather Service reports that Washington state averages 2.5 tornadoes per year, which ranks in the bottom ten states.[17] Washington State Department of Ecology has estimated frequency intervals for wind speed as follows:

WIND SPEEDS EXCEED	FREQUENCY
55 MPH	Annually
76 MPH	~ 5 years
83 MPH	~10 years
92 MPH	~25 years
100 MPH	~50 years
108 MPH	~100 years

11.3 VULNERABILITY ASSESSMENT

11.3.1 Overview

Severe weather incidents can and regularly do occur throughout the entire planning area. Similar events impact areas within the planning region differently, even though they are part of the same system. While in some instances some type of advanced warning is possible, as a result of climatic differences, topographic and relative distance to the coastline, the same system can be much more severe in certain areas than others. Therefore, preparedness plays a significant contributor in the resilience of the citizens to withstand such events.

Warning Time

Meteorologists can often predict the likelihood of some severe storms. In some cases, this can give several days of warning time. However, meteorologists cannot predict the exact time of onset or severity of the storm, and the rapid changes which can also occur significantly increasing the impact of a weather event.

11.3.2 Impact on Life, Health, and Safety

The entire planning area is susceptible to severe weather events. Populations living at higher elevations with large stands of trees or above-ground power lines may be more susceptible to wind damage and black out conditions, while populations in low-lying areas are at risk for possible flooding and landslides associated with the flooding as a result of heavy rains. Increased levels of precipitation in the form of snow also vary by area, with higher elevations being more susceptible to increased accumulations. Resultant secondary impacts from power outages during cold weather event, when combined with the high population elderly residents significantly impacts response capabilities and the risk factor associated with such weather

[17] http://mynorthwest.com/1220169/common-tornadoes-washington-state/

incidents. Within the densely wooded areas, increased fire danger during extreme heat conditions increases the likelihood of fire, which increases fire danger.

Particularly vulnerable populations are the elderly and very young, low income, linguistically isolated populations, people with life-threatening illnesses, and residents living in areas that are isolated from major roads. Extreme temperature variations, either heat or cold, are of significant concern for both the elderly and the young, increasing vulnerability of those populations.

The National Severe Storms Laboratory states that of injuries related to ice and snow[18]:

    - About 70% occur in automobiles.
    - About 25% are people caught out in the storm.
    - Majority are males over 40 years old.
- Of injuries related to exposure to cold:
    - 50% are people over 60 years old.
    - Over 75% are males.
    - About 20% occur in the home.

Due to the limited access to the reservation via its primary transportation routes, even minor incidents have the potential to impact ingress and egress. Such issues are of concern as a result of limited access for evacuation purposes by first responder if vital ALS is required, as well as for general evacuation purposes during a period where power is out, and individuals attempt to leave the area. While there currently are no residential structures falling within the Reservation boundary, over the course of the life cycle of this plan, the Tribe is constructing new residential facilities specifically for the Tribal Elders. As such, accessibility during severe weather events will become an even greater concern.

11.3.3 Impact on Property

Loss estimations for severe weather hazards are not based on modeling utilizing damage functions, as no such functions have been generated. For planning purposes, all properties and buildings within the planning area are considered to be exposed to the severe weather hazard, but structures in poor condition or in particularly vulnerable locations (hilltops or exposed open areas, or low-lying coastal areas) may be at risk for the most damage. Loss estimations for structure value only is $217 million.

The frequency and degree of damage will depend on specific locations and severity of the weather pattern impacting the region. It is improbable to determine the exact number of structures susceptible to a weather event, and therefore emergency managers and public officials should establish a maximum threshold, or worst-case scenario, of susceptible structures.

11.3.4 Impact on Critical Facilities and Infrastructure

It should be assumed that all critical facilities are vulnerable to some degree, with the older structures built pre-code being more susceptible to impact from a severe weather event. As many of the severe weather events include multiple hazards, information such as that identifying facilities exposed to flooding or landslides (see Flood and Landslide profiles) are also likely exposed to severe weather. Additionally, 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.

[18] http://www.nssl.noaa.gov/education/svrwx101/winter/

Within the planning region, hydroelectric energy from dams produce a significant amount of power to areas falling well outside of the planning area. Major power lines travel from the dam through a large swath of the area in general. As such, wind events also have the potential to impact power supplies in large metropolitan areas well outside of the tribal planning area.

In addition to power, phone, water, and sewer systems may also not function properly during severe weather events. While the water on the reservation is supplied by tribally owned infrastructure, tribal members who live off of the reservation rely on municipal water/wastewater providers, which also face impact.

Roads may become impassable due to ice or snow or from secondary hazards such as landslides. Incapacity and loss of roads are the primary transportation failures, most of which are associated with secondary hazards. Landslides that block roads are caused by heavy prolonged rains. High winds can cause significant damage to trees and power lines, with obstructing debris blocking roads, incapacitating transportation, isolating population, and disrupting ingress and egress. Snowstorms at higher elevations can impact the transportation system, impacting not only commodity flow, but also the availability of public safety services into impacted areas. Of particular concern are roads providing access to isolated areas and to the elderly.

Severe windstorms, downed trees, and ice can create serious impacts on power and above-ground communication lines. Freezing of power and communication lines can cause them to break, disrupting both electricity and communication for households. Loss of electricity and phone connection would result in isolation because some residents will be unable to call for assistance.

11.3.5 Impact on Economy

Prolonged obstruction of major routes due to severe weather can disrupt the shipment of goods and other commerce, both on and off the reservation. With a large portion of the economic base for the Tribe being the casino, severe weather would impact the economy of the Tribe.

Severe windstorms, downed trees, and ice can create serious impacts on power and above-ground communication lines. Freezing rain/snow on power and communication lines can cause them to break, disrupting electricity and communication, further impacting business within the region. Prolonged outages would impact consumer spending as a result of lost revenue, (food) spoilage, lack of production/manufacturing, etc. Large, prolonged storms can have negative economic impacts for an entire region. All severe weather events have the potential to also impact tourism, including visitors to the various business ventures owned by the Tribe.

Accommodation and food services account for a large percentage of the Tribe's economy, both employee-based and as the employer/owner, with entertainment and recreation also a significant contributor. Retail sales from the smoke shops and retail trade would also be potentially impacted.

Combined, these categories account for the majority of the Tribe's economy. Each of these occupation classes are highly vulnerable to impacts from severe weather events, and as such, would have a significant impact on the economy, particularly if an event lasted for several days, or the resulting impacts continued for significant periods of time.

11.3.6 Impact on Environment

The environment is highly exposed to severe weather events. Natural habitats such as streams and trees are exposed to the elements during a severe storm and risk major damage and destruction. Prolonged rains can saturate soils and lead to slope failure. Flooding events caused by severe weather or snowmelt can produce river channel migration or damage riparian habitat, also impacting spawning grounds and fish populations for many years. The Tribe does maintain an active fish hatchery, which could also be potentially impacted by various severe weather events. Storm surges can erode bluffs and redistribute sediment loads. Extreme heat can raise temperatures of rivers, impacting oxygen levels in the water, threatening aquatic life.

11.3.7 Impact from Climate Change

Climate change presents a challenge for risk management associated with severe weather. The frequency of severe 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. According to the EPA, "Since 1901, the average surface temperature across the contiguous 48 states has risen at an average rate of 0.14°F per decade. Average temperatures have risen more quickly since the late 1970s (0.36 to 0.55°F per decade). Seven of the top 10 warmest years on record for the contiguous 48 states have occurred since 1998, and 2012 was the warmest year on record (U.S. EPA, 2013)." This increase in average surface temperatures can also lead to more intense heat waves that can be exacerbated in urbanized areas by what is known as urban heat island effect. Additionally, the changing hydrograph caused by climate change could have a significant impact on the intensity, duration, and frequency of storm events. All of these impacts could have significant economic consequences.

With the increase in average ambient temperatures, since the 1980s, unusually cold temperatures have become less common in the contiguous 48 states (U.S. EPA, 2013). This trend is expected to continue, and the frequency of winter cold spells will likely decrease. As ambient temperatures increase, more water evaporates from land and water sources. The timing, frequency, duration, and type of precipitation events will be affected by these changes. In general, more precipitation will fall as rain rather than snow.

11.4 FUTURE 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 Tribe does have land use regulations in place, which includes implementation of the International Building Codes as well as additional land use authority under which it operates. These codes are equipped to deal with the impacts of severe weather incidents by identifying construction standards which address wind speed, roof load capacity, elevation, and setback restrictions.

While under the Growth Management Act, public power utilities are required by law to supply safe, cost effective and equitable service to everyone in the service area requesting service, most lines in the area are above-ground, causing them to be more susceptible to high winds or other severe weather hazards. However, growth management is also a constraint, which could possibly lead to increased outages or even potential shortages, as while most new development expects access to electricity, they do not want to be in close proximity to substations. The political difficulty in sighting these substations makes it difficult for the utility to keep up with regional growth. The Tribe does not generate its own power, although some facilities do have generators for emergency use. As such, the Tribe must rely on public infrastructure to provide this to them.

Land use policies currently in place, when coupled with informative risk data such as that established within this mitigation plan will also address the severe weather hazard. With the land use tools currently in place, the Tribe will be well-equipped to deal with future growth and the associated impacts of severe weather.

11.5 ISSUES

Important issues associated with a severe weather in the planning area include the following:

- Older building stock in the planning area are built to low code standards or none at all. These structures could be highly vulnerable to severe weather events such as windstorms. All structures on the Reservation are newer, and built to higher code standards; however, tribal members living off the Reservation could be impacted as a result of the lower building code standards.
- Redundancy of power supply must be evaluated and increased planning-region wide in order to understand the vulnerabilities more fully in this area.
- The capacity for backup power generation is limited and should be enhanced, especially in areas of potential isolation due to impact on major thoroughfares or evacuation routes.
- Isolated population centers exist.
- Climate change may increase the frequency and magnitude of winter flooding or storm surges, thus exacerbating severe winter events.
- Proximity to the coastline enhances flooding potential through storm surges, erosion, and severe storms in general.

11.6 IMPACT AND RESULTS

Based on review and analysis of the data, the Planning Team has determined that the probability for impact from a severe weather event throughout the area is highly likely, but the impact is more limited when removing resulting flood and landslide events from the severe weather category (those hazards are analyzed separately).

The entire area experiences some severe storm or weather event annually, be it wind, rain, snow, fog, extreme heat, or thunderstorms. When severe weather events occur, the storms do have the ability to impact the area, posing a danger to life and property, as well as possibly causing economic losses. While snow and ice do occur, impact and duration are somewhat limited, reducing life safety dangers as advanced warning many times allow residents to take precautionary measures (extra food, not driving, etc.).

Wind is a very significant factor, which can cause power outages, as well as impacting transportation to transport citizens and goods. While the local PUD/utilities maintain excellent records for low incidents of long-term power outages, the possibility does exist. Historically, severe weather events that occur are of a relatively short duration, with more localized impacts, and thankfully, power outages have not been for extended periods of time, but shorter in duration.

Based on the potential impact, the Planning Team determined the CPRI score to be 3.05, with overall vulnerability determined to be a high level.

CHAPTER 12.
VOLCANO

The Cascade Range of Washington, Oregon, and California places volcanoes in close proximity. The primary effect of the Cascade volcanic eruptions would be potential lahar inundation and ash fall, with additional disruption of service due to impact on surrounding counties. Mount Baker lies to the North in Whatcom County and Glacier Peak lies in Snohomish County. Tribal lands are located in the lahar zone of Glacier Peak.

The distribution of ash from a violent eruption is a function of wind direction and speed, atmospheric stability, and the duration of the eruption. As the prevailing wind in this region is generally from the west, ash is usually spread eastward from the volcano. Exceptions to this rule do, however, occur. Ash fall, because of its potential widespread distribution, suggests some limited volcanic hazards.

DEFINITIONS

Ash—Ash is a harsh acidic with a sulfuric odor, consisting of small bits of pulverized rock and glass, less than 2 millimeters (0.1 in) in diameter. 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.

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—The least hazardous threat posed by volcanoes. Cascades volcanoes are normally associated with slow moving andesite or dacite lava.

Stratovolcano—Typically steep-sided, symmetrical cones of large dimension built of alternating layers of lava flows, volcanic ash, cinders, blocks, and bombs, rising as much as 8,000 feet above their bases. The volcanoes in the Cascade Range are all stratovolcanoes.

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

Volcano—A vent in the planetary crust from which magma (molten or hot rock) and gas from the earth's core erupts.

12.1 GENERAL BACKGROUND

Hazards related to volcanic eruptions are distinguished by the different ways in which volcanic materials and other debris are emitted from the volcano (see Figure 12-1). The molten rock that erupts from a volcano (lava) forms a hill or mountain around the vent. The lava may flow out as a viscous liquid, or it may explode from the vent as solid or liquid particles. Ash and fragmented rock material can become airborne and travel far from the erupting volcano to affect distant areas.

Monitored volcanoes generally give signs of reawakening (volcanic unrest) before an eruption because it takes time for magma to move from its storage area, several miles beneath the volcano, to the surface. As magma moves to the surface, it breaks open a pathway, which produces earthquakes; it goes from higher to lower pressures, resulting in the release of volcanic gases; and as the amount of magma decreases in the storage area and temporarily pools at shallower levels it deforms the earth. All these processes can be monitored, although none can be measured directly.

Volcanic events often differ from other natural hazards because the duration of unrest and eruptive activity are generally longer. Although volcanic unrest prior to eruptions can be only hours, these short timescales most frequently occur at volcanoes that have erupted in the recent past (years to decades). At volcanoes like Mount Baker and Glacier Peak, their conduit systems which convey magma to the surface have solidified and will have to be fractured and reopened for the next magma batch to reach the surface. Thus, it is anticipated that several days to weeks of warning will occur before an eruption, although hazardous events such as small steam and ash explosions and expulsion of water to form lahars may occur before an eruption begins. While Mount St. Helens has continued to emit steam on occasion since its last eruption, scientists feel that advanced warning of a significant magnitude would provide some level of advanced notice.

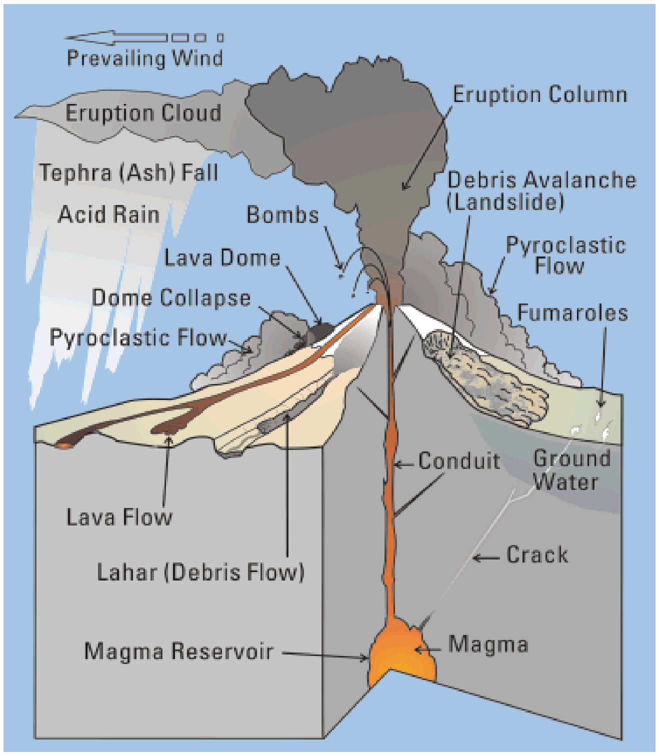


Figure 12-1 Volcano Hazard

The most recent eruption in Washington State, the eruption of Mount St. Helens in 1980, is identified as a Plinian eruption, which are the most violent of types, including violent ejection of very large columns of ash, followed by a collapse of the central portion of the volcano. It should be noted that a volcano has the potential to exhibit various styles of eruption at different intervals, changing from one form or type to another as the eruption progresses.

12.2 HAZARD PROFILE

12.2.1 Extent and Location

The Cascade Range extends more than 1,000 miles from southern British Columbia into northern California and includes 13 potentially active volcanic peaks in the U.S. Figure 12-2 shows the location of the Cascade Range volcanoes, most of which have the potential to produce a significant eruption.

Geologic evidence indicates that both Mount Baker and Glacier Peak have erupted in the past and will no doubt erupt again in the foreseeable future. Due to the topography of the region and the location of drainage basins and river systems, eruption events on either Mount Baker or Glacier Peak resulting in lahar's, pyroclastic flows, tephra or ash fall, and lava flows could impact the tribal planning area. While not in the direct flow from Mount Baker's lahar zone, the watershed(s) in the area and the various streams and tributaries would be impacted. The Glacier Peak lahar zone would significantly impact the planning area. Ash from either Mount Baker or Glacier Peak would also impact the area.

Mt. Baker is one of the youngest volcanoes in the Cascade Range. Glacier Peak is the most remote of the five active volcanoes in Washington, not visibly prominent from any major population center, although in previous times, it produced some of the largest and most explosive eruptions in the state.

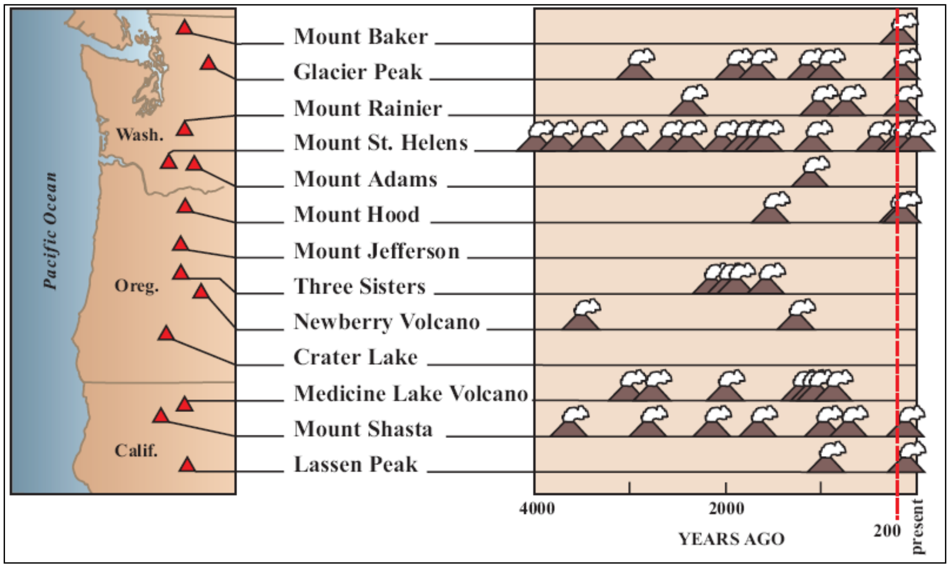


Figure 12-2 Past Eruptions of Cascade Volcanoes

Mount Baker

Figure 12-3 Mount Baker
(Source: Schurlock, 2002-2014)

Mount Baker is an ice-clad stratovolcano located in Whatcom County. USGS research in the last decade shows Mount Baker to be one of the youngest volcanoes in the Cascade Range. At 10,781 feet it is the third highest volcano in Washington State. After Mount Rainier, Mount Baker is the most heavily glaciated of the Cascade volcanoes: the volume of snow and ice on Mount Baker (about 0.43 cubic miles) is greater than that of all the other Cascades volcanoes (except Rainier) combined. Isolated ridges of lava and hydrothermally altered rock, especially in the area of Sherman Crater, are exposed between glaciers on the upper flanks of the volcano; the lower flanks are steep and heavily vegetated. The volcano rests on a foundation of non-volcanic rocks in a region that is largely non-volcanic in origin.

Historical activity at Mount Baker includes several explosions during the mid-19th century, which were witnessed from the Bellingham area. Sherman Crater (located just South of the summit) probably originated with a large hydrovolcanic explosion. In 1843, explorers reported a widespread layer of newly fallen rock fragments and several rivers south of the volcano were clogged with ash. A short time later, two collapses of the East side of Sherman Crater produced two lahars, the first and larger of which flowed into the natural Baker Lake, raising its water level at least 10 feet.

In 1975, increased fumarolic activity in the Sherman Crater area caused concern that an eruption might be imminent. Additional monitoring equipment was installed, and several geophysical surveys were conducted to try to detect the movement of magma. The level of the present day Baker Lake reservoir (located to the east and south of the mountain) was lowered and people were restricted from the area due to concerns that an eruption-induced debris avalanche or debris flow might enter Baker Lake and displace enough water to either cause a wave to overtop the Upper Baker Dam or cause complete failure of the dam. However, few anomalies other than the increased heat flow were recorded during the surveys nor were any other precursory activities observed to indicate that magma was moving up into the volcano. This volcanic activity gradually declined over the next two years but stabilized at a higher level than before 1975. Several small lahars formed from material ejected onto the surrounding glaciers and acidic water was discharged into Baker Lake for many months.

Glacier Peak

Figure 12-4 Glacier Peak from the Northeast
Source: Schurlock, Glacier Peak, 2007

Glacier Peak is a small stratovolcano and is the most remote of the five active volcanoes in Washington State. At 10,541 feet elevation, it is, next to Mount St Helens, the shortest of the major Washington volcanoes. Glacier Peak is not prominently visible from any major population center, and so its hazards tend to be over-looked. Erupting more than 6 times, this volcano has produced some of the largest and most explosive eruptions in the continuous United States since the last ice age.

Glacier Peak and Mount St. Helens are the only volcanoes in Washington State that have generated large, explosive eruptions in the past 15,000 years. Their violent behavior results from the type of magma they produce which is too viscous to flow easily out of the eruptive vent and must be pushed out under high pressure. As the magma approaches the surface, expanding gas bubbles within the magma burst and break into countless fragments of tephra and ash. The largest of these eruptions occurred about 13,000 years ago and ejected more than five times as much tephra as the May 18, 1980, eruption of Mount St. Helens.

During most of Glacier Peak's eruptive episodes, lava domes have extruded onto the volcano's summit or steep flanks. Parts of these domes collapsed repeatedly to produce pyroclastic flows and ash clouds. The remnants of prehistoric lava domes make up Glacier Peak's main summit as well as its "false summit" known as Disappointment Peak. Pyroclastic flow deposits cover the valley floors east and west of the volcano. Deposits from ash clouds mantle ridges East of the summit.

There is definite evidence that pyroclastic flows have mixed with melted snow and glacial ice to form lahars that have severely affected river valleys that head on Glacier Peak. Approximately 13,000 years ago, dozens of eruption-generated lahars descended down the White Chuck, Suiattle, and Sauk Rivers, inundating valley floors.

Geologic evidence indicates that lahars flowed down both the North Fork Stillaguamish (then an outlet of the upper Sauk River) and the Skagit River to Puget Sound. These lahars deposited more than seven feet of material as far away as 60 miles from Glacier Peak. The Sauk River's course via the Stillaguamish was abandoned and the Sauk River began to drain only into the Skagit River as it still does today. The Town of Darrington and much of northeast Snohomish County could be affected by a large flow following the White Chuck and Sauk River drainage channels (Snohomish County HMP, 2015).

12.2.2 Previous Occurrences

Table 12-1 summarizes past eruptions in the Cascades. During the 1980 Mount St. Helens eruption, 23 square miles of volcanic material buried the North Fork of the Toutle River and there were 57 human fatalities. During the last 4,000 years, Mount St. Helens has erupted more frequently than any other volcano in the Cascade Range (see Figure 12-2).

Geologic evidence indicates that both Mount Baker and Glacier Peak have erupted in the past and will no doubt erupt again in the foreseeable future. Due to the topography of the region and the location of drainage basins and river systems, eruption events on either Mount Baker or Glacier Peak resulting in lahar's, pyroclastic flows, tephra or ash fall, and lava flows could severely impact the area.

TABLE 12-1
PAST ERUPTIONS IN WASHINGTON

Volcano	Number of Eruptions	Type of Eruptions
Mount Adams	3 in the last 10,000 years, most recent between 1,000 and 2,000 years ago	Andesite lava
Mount Baker	5 eruptions in past 10,000 years; mudflows have been more common (8 in same time period)	Pyroclastic flows, mudflows, ash fall in 1843.
Glacier Peak	8 eruptions in last 13,000 years	Pyroclastic flows and lahars
Mount Rainier	14 eruptions in last 9000 years; also 4 large mudflows	Pyroclastic flows and lahars
Mount St Helens	19 eruptions in last 13,000 years	Pyroclastic flows, mudflows, lava, and ash fall

12.2.3 Severity

Eruption durations are quite variable, ranging from hours to decades. At present, when an eruption begins scientists cannot foretell when it will end or whether the activity will be intermittent or continuous. Worldwide, the average eruption duration is about two months, although the most recent eruptions in the Cascades have been of greater duration (Mount St. Helens, Washington: intermittent activity from 1980 to 1986 and continuous activity from late 2004 to early 2008; Lassen Peak, California: intermittent activity from 1914 to 1917).

The explosive disintegration of Mount St. Helens' north flank in 1980 vividly demonstrated the power that Cascade volcanoes can unleash. The thickness of tephra sufficient to collapse buildings depends on construction practices and on weight of the tephra (tephra is much heavier wet than dry). Past experience in several countries shows that tephra accumulation near 10 cm is a threshold above which collapses tend to escalate. A 1-inch deep layer of ash weighs an average of 10 pounds per square foot, causing danger of structural collapse.

Ash is harsh, acidic, and gritty, and it has a sulfuric odor. 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. Westerly winds dominate in the Pacific Northwest sending volcanic ash east and north–eastward about 80–percent of the time, though ash can blow in any direction.

Figure 12-5 shows probabilities of tephra accumulation from Cascade volcanoes in the Pacific Northwest (tephra is fragmented rock material ejected by a volcanic explosion). Wind in western Washington blows to the west, northwest and southwest only 10 percent of the time, so tephra from eruptions of Mount St. Helens or Mt. Rainier customarily would be far more likely on the east side of the volcano. Glacier Peak, due to its location, would impact the tribal planning area if the winds maintained their westerly direction. Even a relatively small amount of ash could have a significant impact with respect to individuals with health or breathing issues, mechanical or motorized devices, fish and other natural wildlife, and the forest and plant life, particularly within agricultural areas.

Based on USGS analysis, the area has a 0.1 to 0.02 percent probability of ash or tephra collection in any given year (see Figure 12-5). Figure 12-6 shows areas of the U.S. that have been covered by volcanic ash.

The degree of volcanic hazard from the volcanoes of the Cascade Range depends on the type, size, and origin of the eruption. While the possibility of a large volcanic eruption exists, these types of events are typically separated by several hundred to a few thousand years and it is unlikely that we will see such an event in our lifetimes. Clearly, persons, property, and infrastructure closest to the volcano at the time of the eruption are most vulnerable.

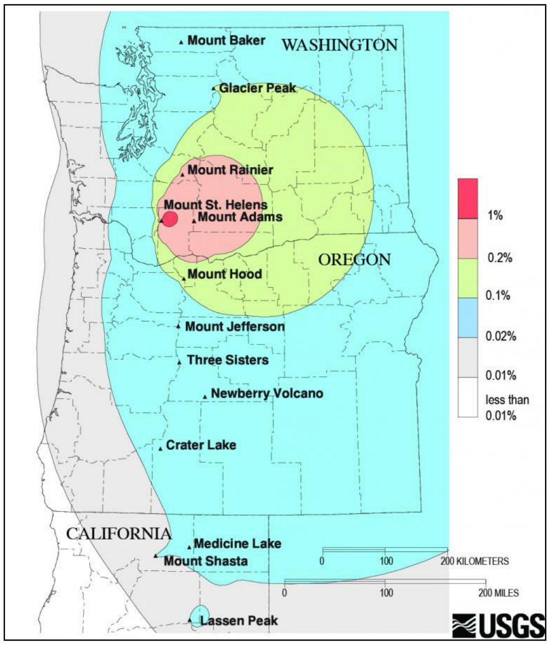


Figure 12-5 Probability of Tephra Accumulation in Pacific Northwest

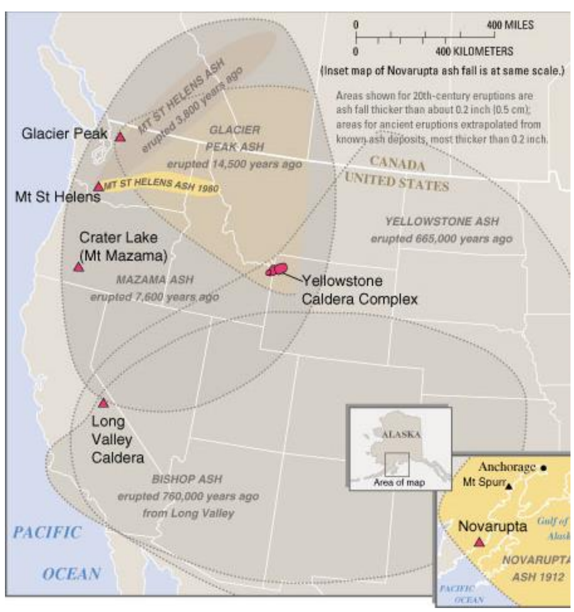


Figure 12-6 Defined Tephra Layers Associated with Historical Eruptions
Source: USGS. http://volcanoes.usgs.gov/vsc/multimedia/cvo_hazards_maps_gallery.html

While ash is of some concern, a lahar is also a significant probability within the planning area. Geologic evidence indicates that both Mount Baker and Glacier Peak have erupted in the past and will no doubt erupt again in the foreseeable future. Due to the topography of the region, potential variations in wind directions, and the location of drainage basins and river systems, eruption events on either Mount Baker or Glacier Peak resulting in lahar's, pyroclastic flows, tephra or ash fall, and lava flows could severely impact the area. Figure 12-7 and Figure 12-8 illustrate the volcano hazard zones as identified by the USGS. Figure 12-9 illustrates potential impact from the Glacier Peak Lahar Inundation Zone to the Stillaguamish Watershed.

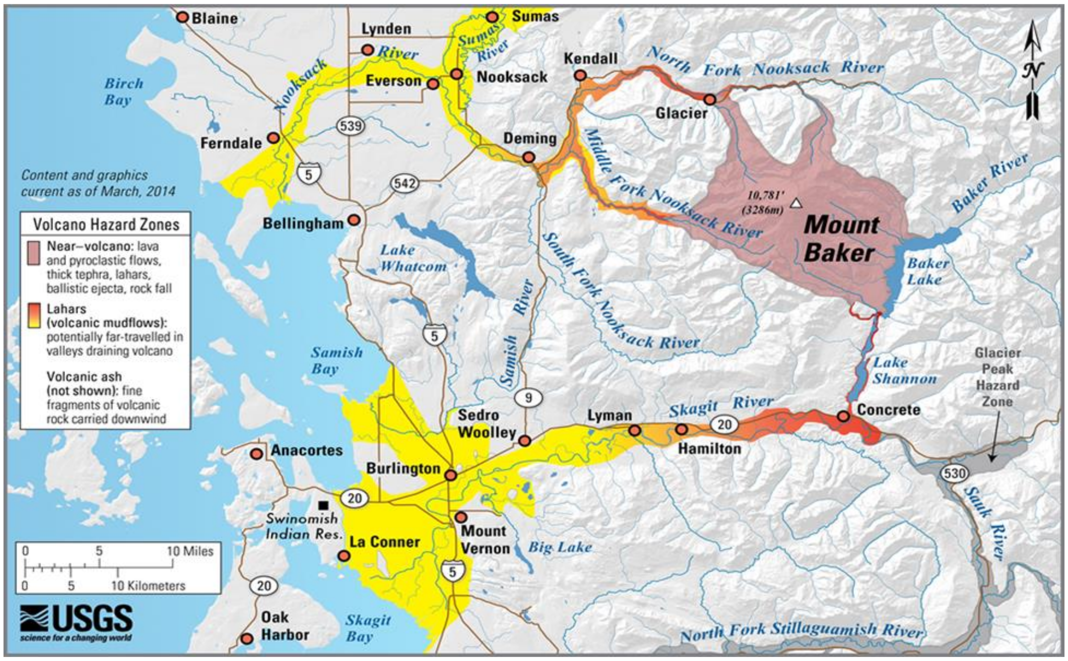


Figure 12-7 Volcano Hazard Zones From Mount Baker
Source: USGS. http://volcanoes.usgs.gov/vsc/multimedia/cvo_hazards_maps_gallery.html

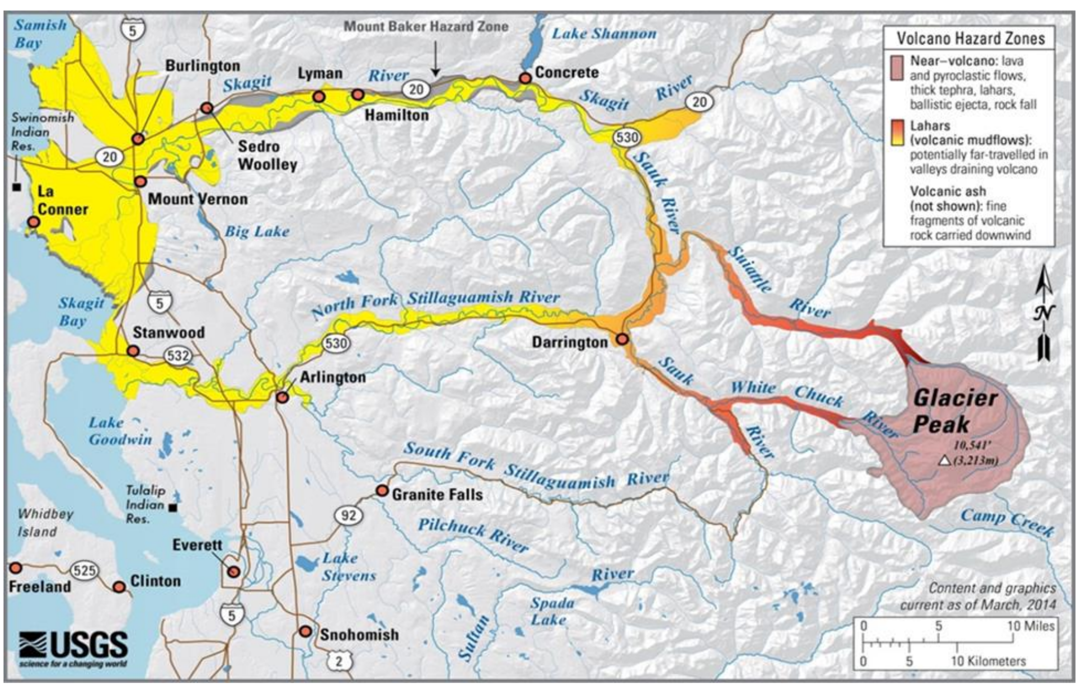


Figure 12-8 Volcano Hazard Zones from Glacier Peak

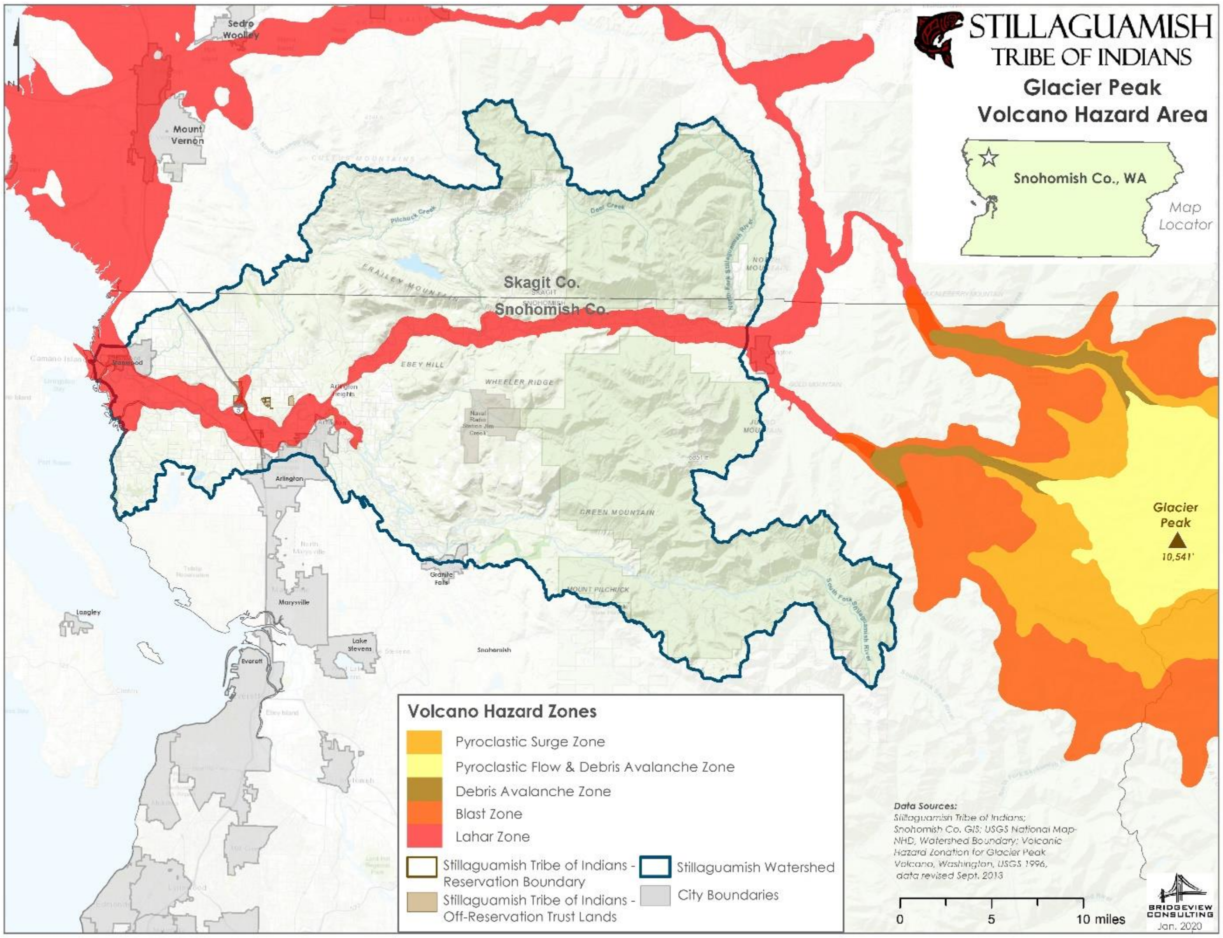


Figure 12-9 Lahar Impact to Stillaguamish Watershed Area from Glacier Peak

12.2.4 Frequency

Many Cascade volcanoes have erupted in the recent past and will be active again in the foreseeable future. Given an average rate of one or two eruptions per century during the past 12,000 years, these disasters are not part of everyday experience; however, in the past hundred years, California's Lassen Peak and Washington's Mount St. Helens have erupted with terrifying results. The U.S. Geological Survey classifies Glacier Peak, Mt. Adams, Mt. Baker, Mt. Hood, Mt. St. Helens, and Mt. Rainier as potentially active volcanoes in Washington State. Mt. St. Helens is by far the most active volcano in the Cascades, with four major explosive eruptions in the last 515 years. There is a one (1) in 500 probability that portions of two counties in the state will receive four (4) inches or more of volcanic ash from any Cascade volcano in any given year. The probability increases to one (1) in 1,000 that parts, or all, of three or more counties will receive same quantity. There is a one (1) in 100 annual probability that small lahars or debris flows will impact river valleys below Mount Baker and Mount Rainier, with a less than 1:1,000 annual probability that the largest destructive lahars would flow down Glacier Peak, Mount Adams, Mount Baker or Mount Rainier.

12.3 VULNERABILITY ASSESSMENT

12.3.1 Overview

The closest Cascade volcanoes to the planning area are Mount Baker and Glacier Peak. Because of the location of Mount Baker and Glacier Peak and the flow direction of prevailing winds, the majority of airborne ash would most likely be carried to the northeast or east should an ash eruption occur. According to the USGS analysis, westerly winds dominate in the Pacific Northwest sending volcanic ash east and north–eastward about 80–90 percent of the time, though ash can blow in any direction. However, even 10 percent of ash reaching the planning area could have a negative impact on the natural resources and the agricultural economy. In addition, regardless of wind direction, there would still be considerable amount of ash fall in the immediate vicinity of the volcano during and immediately flowing an explosive tephra and ash eruption. In addition, large amounts of ash would be carried by moving vehicles traveling into the area as well. The potential for fire danger also increases as a result of static charge contained within the ash.

The 1980 eruption of Mount St. Helens produced enough ash fall to reduce the maximum flow capacity of the Cowlitz River from 76,000 cubic feet per second to less than 15,000 cubic feet per second and also reduced the channel depth of portions of the Columbia River from 40 feet to 14 feet. Should a St. Helens-type event occur from either Mount Baker or Glacier Peak, large portions of the Skagit and Stillaguamish Rivers would be severely impacted.

Ash and chemical products in the any of the rivers in the area could contaminate water supply to the area. Transportation for ships, boats, and vehicles traveling into the area could carry additional ash into the region, washing off during rains and contaminating the ground and water bodies, or potentially being impacted by ash with respect to visibility, and mechanically if large amounts of ash accumulate in engines' air intake systems. In addition, transportation interruptions as a consequence of eruption and impact on surrounding communities could cause moderate to high impact in the region as a whole, as commodity flows would decrease, as well as interruptions to power transmission, telecommunications outages, and potentially medical services. Residents with health issues, especially those with breathing difficulties, would also be impacted, even by small amounts of ash.

Warning Time

Constant monitoring by the USGS and the Pacific Northwest Seismograph Network (PNSN) at the University of Washington of all active volcanoes means that there will be more than adequate warning time before an event. Newly standardized Alert Levels issued by USGS volcano observatories are based on a volcano's level of activity. These levels are intended to inform people on the ground and are issued in conjunction with the Aviation Color Code. The highest two alert levels (Watch and Warning) are National Weather Service terms for notification of hazardous meteorological events, terms already familiar to emergency managers that are becoming increasingly more familiar to the public.

The U.S. Geological Survey (USGS) volcanic alert-level system provides the framework for the preparedness activities of local jurisdictions, tribal governments and state and federal agencies. The USGS ranks the level of activity at a U.S. volcano using the terms "Normal", for typical volcanic activity in a non-eruptive phase; "Advisory", for elevated unrest; "Watch", for escalating unrest or a minor eruption underway that poses limited hazards; and, "Warning", if a highly hazardous eruption is underway or imminent. These levels reflect conditions at a volcano and the expected or ongoing hazardous volcanic phenomena. When an alert level is assigned by an observatory, accompanying text will give a fuller explanation of the observed phenomena and clarify hazard implications to affected groups. The USGS Cascade Volcano Observatory works in conjunction with PNSN to provide constant monitoring and notification when activities increase. Figure 12-10 depicts one of the sensors used by USGS and PNSN for monitoring purposes. Figure 12-11 identifies the various types of remote sensing devises available.

Based on past events and especially the 1980 eruption of Mount St. Helens, future eruptions from either Mount Baker or Glacier Peak will almost certainly be preceded by an increase in seismic (earthquake) activity, and possibly by measured swelling of the volcano and emission of volcanic gases. The University of Washington Geophysics Program, in cooperation with the USGS, monitors seismic activity at Mount Baker and other Cascade Range volcanoes that could signal a possible future eruption. In addition, the USGS monitors gas emissions from Sherman Crater on Mount Baker to detect possible changes in the volcano that may be a warning of impending magma activity or an increase in hydro-volcanic activity in an effort to predict the likelihood of an eruption event. This ability to monitor seismic and other types of activity at Mount Baker and Glacier Peak provides a warning system of sorts for volcanic eruptions that could impact the planning area.

Furthermore, the 1980 Mount St. Helens eruption made it clear that preparing for and responding to a large-scale volcanic eruption must involve a wide variety of agencies and jurisdictions. For this reason, emergency managers from Skagit, Snohomish, and Whatcom Counties, the State of Washington, and the Province of British Columbia, as well as personnel from the United States Forest Service developed the Mount Baker-Glacier Peak Coordination Plan. The plan was adopted in April 2001, and updated in 2011 and the plan provides a tool to coordinate the actions that various agencies must take to minimize loss of life and damage to property before, during, and after a hazardous geologic event occurring at either volcano.

Figure 12-10 Monitoring Equipment

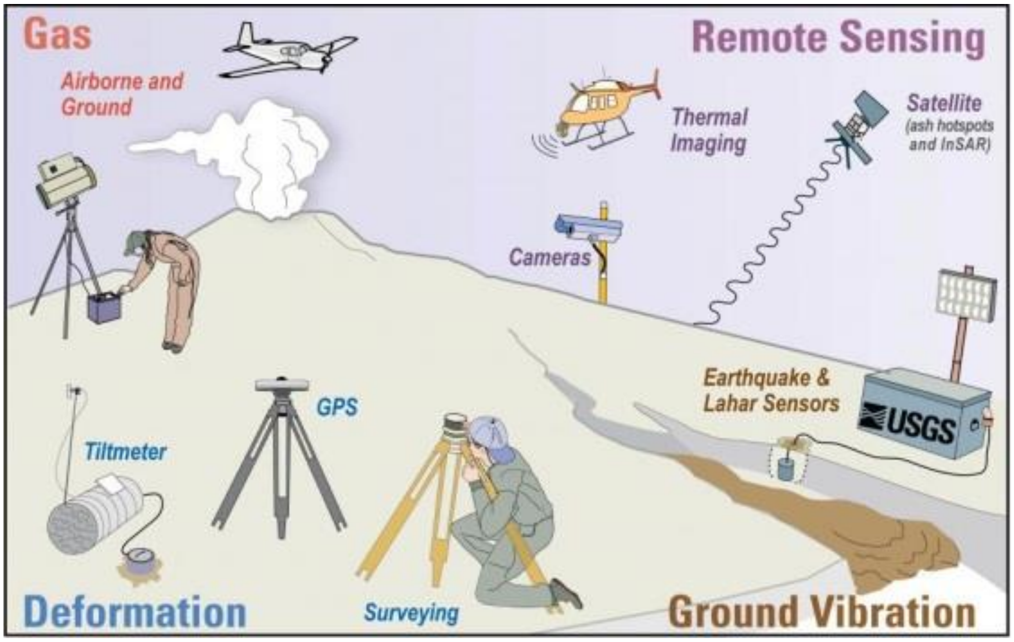


Figure 12-11 Remote Sensing Devices

12.3.2 Impact on Life, Health, and Safety

The entire population of the planning area, as well as any tourists traveling through the area could be exposed to ash and its side effects. As a result of the river drainage basins and the topography of the planning area, an ensuing lahar would also be of significant impact.

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. Given the high amount of annual rainfall and the mist occurring from waves, this increases the potential impact on the population. The elderly, very young and those who experience ear, nose and throat problems are especially vulnerable to the tephra hazard, as well as the ash itself causing respiratory issues. In addition, the high number of tourists who annually visit the area would potentially increase the number of people to which the region would have to provide emergency services, housing, and associated support.

12.3.3 Impact on Property

All of the property in the planning area to some degree would be exposed to ash fall and tephra accumulation in the event of a volcanic eruption. A limited amount of tribal owned property in the Stillaguamish Watershed is within the lahar zone, as are properties off the Reservation on which tribal members reside (non-tribal owned structures) based on current USGS projections of the lahar zone. The Reservation itself falls outside of the lahar zone.

Current building codes and regulations in place do have increased snow- and wind-load capacities, which does increase the ability to withstand the weight of ash for more recently constructed buildings. The ash itself is harsh, acidic, and gritty, and may carry a high static charge for up to two days after being ejected from a volcano. This static charge has the potential for igniting forest fires in the densely forested areas.

The 1980 eruption of Mount St. Helens produced enough ash fall to reduce the maximum flow capacity of the Cowlitz River from 76,000 cubic feet per second to less than 15,000 cubic feet per second and also reduced the channel depth of portions of the Columbia River from 40 feet to 14 feet. Should a St. Helens-type event occur from either Mount Baker or Glacier Peak, large portions of the various rivers in the area and the floodplains themselves could be severely impacted by flooding and associated debris in addition to the direct effects of the ash eruption.

The river valleys and associated floodplains within the Stillaguamish Watershed are all especially vulnerable to the effects of large-scale lahars and associated flooding that will no doubt result from a large lahar.

As demonstrated during the 1980 Mount St. Helens eruption, the hydraulic power of fast-moving lahars and debris flows is astonishing. Sandbags and other “normal” flood fight measures will not be effective to provide any type of protection for such an event.

Furthermore, problems related to lahar debris could last for years and even decades because of the tremendous volume of loose rock and ash that has could potentially have been added to the ground surface near the volcano. This debris could provide a source of material that would no doubt flow downstream during flood events for many years following the eruption event.

12.3.4 Impact on Critical Facilities and Infrastructure

While exposure analysis was conducted on the critical facilities to the Lahar Zone, the ability of the structure to withstand impacts cannot be determined as specific building data was not available, and exceeds the scope of this project. It is estimated that eight (8) of the critical facilities owned by the tribe assessed during this HMP process would be impacted by a lahar. Total building and content value of those structures exceed $26 million.

In addition to the lahar inundation, all critical facilities and infrastructure would also be exposed to the weight of ash. Due to the age of some of the building stock, some structures may fail to withstand the weight of the ash. All transportation routes in the area would be exposed to ash fall and tephra accumulation, which could create hazardous driving conditions on roads and highways and hinder evacuations and response. Utilities, including water treatment plants and wastewater treatment plants are vulnerable to contamination from ash fall, as well as impact from the ash itself that could damage motors.

12.3.5 Impact on Economy

A severe lahar event from Glacier Peak could impact most of the region, resulting in a catastrophic disaster and long-term economic impacts throughout the area. In addition to the economic losses associated with the critical facilities and infrastructure, economic impact could also result from the potential losses to natural resources, the loss of tourism due to suspended travel and visitors to the area, structural losses, including businesses and governmental offices/buildings. Structures containing hazardous materials within the lahar inundation zone would also cause significant economic loss, including the potential clean-up costs if a point source location cannot be identified. Lost revenues from businesses disrupted by structural damage or as a result of fewer patrons would also impact the tribe’s economy.

12.3.6 Impact on 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, the watersheds, lakes, rivers, and tributaries are vulnerable to damage due to ash fall since ash fall can be carried throughout the area by its rivers. A volcanic blast would expose the local environment to other effects, such as lower air quality, and many elements that could harm local vegetation and water quality, adversely impact wildlife and fish habitat. The sulfuric acid contained in volcanic ash could be very damaging to area vegetation, increasing the risk of wildfire danger, as well as wildlife. The potential release from any of the hazardous materials sites countywide would be a significant environmental impact. The lahar itself would also cause significant impact to the river drainage basins, and influence the topography of the area as the lahar continues out to sea. Glaciers could melt resulting in mudflows and flooding throughout the area.

12.3.7 Impact from Climate Change

Climate change is not likely to affect the risk associated with volcanoes; however, volcanic activity can affect climate change. Volcanic clouds absorb terrestrial radiation and scatter a significant amount of incoming solar radiation. By reducing the amount of solar radiation reaching the Earth's surface, large-scale volcanic eruptions can lower temperatures in the lower atmosphere and change atmospheric circulation patterns. Such effects can last from two to three years following a volcanic eruption. The massive outpouring of gases and ash can influence climate patterns for years following a volcanic eruption as sulfuric gases convert to sub-micron droplets containing about 75 percent sulfuric acid. These particles can linger three to four years in the stratosphere.

12.4 FUTURE DEVELOPMENT TRENDS

Building codes utilized by the Tribe during development currently include stringent regulations with respect to support and payload structuring of facilities. Building codes with respect to load capacity does influence the ability to withstand impact. The Tribe does adhere to current building codes in place.

12.5 ISSUES

In the event of a volcanic eruption, there would be enough advanced warning that there hopefully would be no direct loss of life in the planning area as a direct result of the eruption. However, there could be significant health issues related to ash fall and health concern (especially for the young, elderly and those with breathing issues). In addition, there is also the potential for the increased potential for motor vehicle accidents; and potential structural damage if large amounts of ash accumulate as a result of the weight of the ash on structures. The potential exists for impact on the agricultural community, which would have an economic impact on the planning region. There would also be the possibility of severe environmental impacts due to ash within area lakes and streams, with the water supply potentially impacted by ash. One of the most significant impacts would be on the area's environment and the water supply. Both of these elements would have a significant impact on the Tribe.

12.6 IMPACT AND RESULTS

Although the probability of a volcanic eruption is low, if an eruption were to occur, the greatest threat to life, property, infrastructure, and the environment would be from lahars or debris avalanches. Based on past events and especially the 1980 eruption of Mount St. Helens, future eruptions from either Mount Baker or Glacier Peak will almost certainly be preceded by an increase in seismic (earthquake) activity, and possibly by measured swelling of the volcano and emission of volcanic gases.

The river valleys and associated floodplains are particularly vulnerable to the effects of large-scale lahars and associated flooding that will no doubt result from a large lahar. Problems related to lahar debris could last for years and even decades because of the tremendous volume of loose rock and ash that has could potentially have been added to the ground surface near the volcano. This debris could provide a source of material that would no doubt flow downstream during flood events for many years following the eruption event.

Based on review and analysis of the data, the Planning Team has determined that the probability for a future event is low; however, the impact at some level could be significant based on the lahar inundation zone, the topography of the area, the impact to the river drainage basins, and ashfall. The Tribe has eight structures that fall within the lahar zone for Glacier Peak.

Implementation of mitigation strategies which help increase load capacities on roofs would help reduce the number of structures at risk due to ashfall accumulations, but the environmental and economic impact cannot be so easily mitigated. Based on the potential impact, the Planning Team determined the CPRI score to be 1.90, with overall vulnerability determined to be a medium level.

CHAPTER 13.
WILDFIRE

13.1 GENERAL BACKGROUND

A wildfire is any uncontrolled fire on undeveloped land that requires fire suppression. Wildfires can be ignited by lightning or by human activity such as smoking, campfires, equipment use and arson. Wildfires occur when all of the necessary elements of a fire come together in a wooded or grassy area: an ignition source is brought into contact with a combustible material such as vegetation that is subjected to sufficient heat and has an adequate supply of oxygen from the ambient air.

A wildfire front is the portion of a wildfire sustaining continuous flaming combustion, where unburned material meets active flames. As the front approaches, the fire heats both the surrounding air and woody material through convection and thermal radiation. First, wood is dried as water in it is vaporized at a temperature of 212ºF. Next, the wood releases flammable gases at 450ºF. Finally, wood can smolder at 720ºF, and ignite at 1,000ºF. Before the flames of a wildfire arrive at a particular location, heat transfer from the wildfire front can warm the air to 1,470ºF, which pre-heats and dries flammable materials, causing them to ignite faster and allowing the fire to spread faster. High temperature and long-duration surface wildfires may encourage flashover or *torching*: the drying of tree canopies and their subsequent ignition from below.

Large wildfires may affect air currents by the stack effect: air rises as it is heated, so large wildfires create powerful updrafts that draw in new, cooler air from surrounding areas in thermal columns. Great vertical differences in temperature and humidity encourage fire-created clouds, strong winds and fire whirls with the force of tornadoes at speeds of more than 50 mph. Rapid rates of spread, prolific crowning or spotting, the presence of fire whirls, and strong convection columns signify extreme conditions.

13.1.1 Wildland-Urban Interface Areas

The wildland urban-interface (WUI) is the area where development meets wildland areas. This can mean structures built in or near natural forests, or areas next to active timber and rangelands. The federal definition of a WUI community is an area where development densities are at least three residential, business, or public building structures per acre. For less developed areas, the wildland-intermix community has development densities of at least one structure per 40 acres.

DEFINITIONS

Brush fire—A fast-moving fire that ignites grass, shrubs, bushes, scrub oak, chaparral, marsh grass (cattails), and grain fields. This is the type of wildfire most likely to affect Whitman County.

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, when many individual fires grow together. Temperatures may exceed 1000°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. Lethal concentrations of carbon monoxide, combined with the intense heat, poses a serious life threat to responding fire forces. In very large events, the rising column of heated air carries enough particulate matter into the upper atmosphere to cause cloud nucleation, creating a thunderstorm and the hazard of lightning strikes.

Interface Area—An area where vegetation susceptible to wildfires and urban or suburban development occur together.

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 can cause a great deal of destruction.

In 2001, Congress mandated the establishment of a Federal Register which identifies all urban wildland interface communities within the vicinity of Federal lands, including Indian trust and restricted lands that are at high-risk from wildfire. The list assimilated information provided from states and tribes, and is intended to identify those communities considered at risk. Review of the Federal Registry lists several communities within Skagit and Snohomish Counties at high-risk within the vicinity of Federal lands.[19]

When identifying areas of fire concern, in addition to the Federal Register, the Washington Department of Natural Resources and its federal partners also determine communities at risk based on fire behavior potential, fire protection capability, and risk to social, cultural and community resources. These risk factors include areas with fire history, the type and density of vegetative fuels, extreme weather conditions, topography, number and density of structures and their distance from fuels, location of municipal watersheds, and likely loss of housing or business. The criteria for making these determinations are the same as those used in the National Fire Protection Association's *NFPA 299 Standard for Protection of Life and Property from Wildfire*.

Skagit and Snohomish Counties do have identified WUI Communities in both the medium and medium-high risk areas identified as interface communities. Figure 13-1 illustrates those areas considered to be at high risk throughout the Stillaguamish Watershed.

13.1.2 Wildfire Types

Wildfires generally can be characterized by their fuels as follows:

- **Ground fires** are fed by subterranean roots, duff and other buried organic matter. This fuel type is especially susceptible to ignition due to spotting. Ground fires typically burn by smoldering, and can burn slowly for days to months.
- **Crawling** or **surface fires** are fueled by low-lying vegetation such as leaf and timber litter, debris, grass, and low-lying shrubbery.
- **Ladder** fires consume material between low-level vegetation and tree canopies, such as small trees, downed logs and vines. Invasive plants that scale trees may encourage ladder fires.
- **Crown, canopy** or **aerial fires** burn suspended material at the canopy level, such as tall trees, vines and mosses. The ignition of a crown fire, termed *crowning*, is dependent on the density of the suspended material, canopy height, canopy continuity, and sufficient surface and ladder fires to reach the tree crowns.

[19] https://www.federalregister.gov/documents/2001/01/04/01-52/urban-wildland-interface-communities-within-the-vicinity-of-federal-lands-that-are-at-high-risk-from

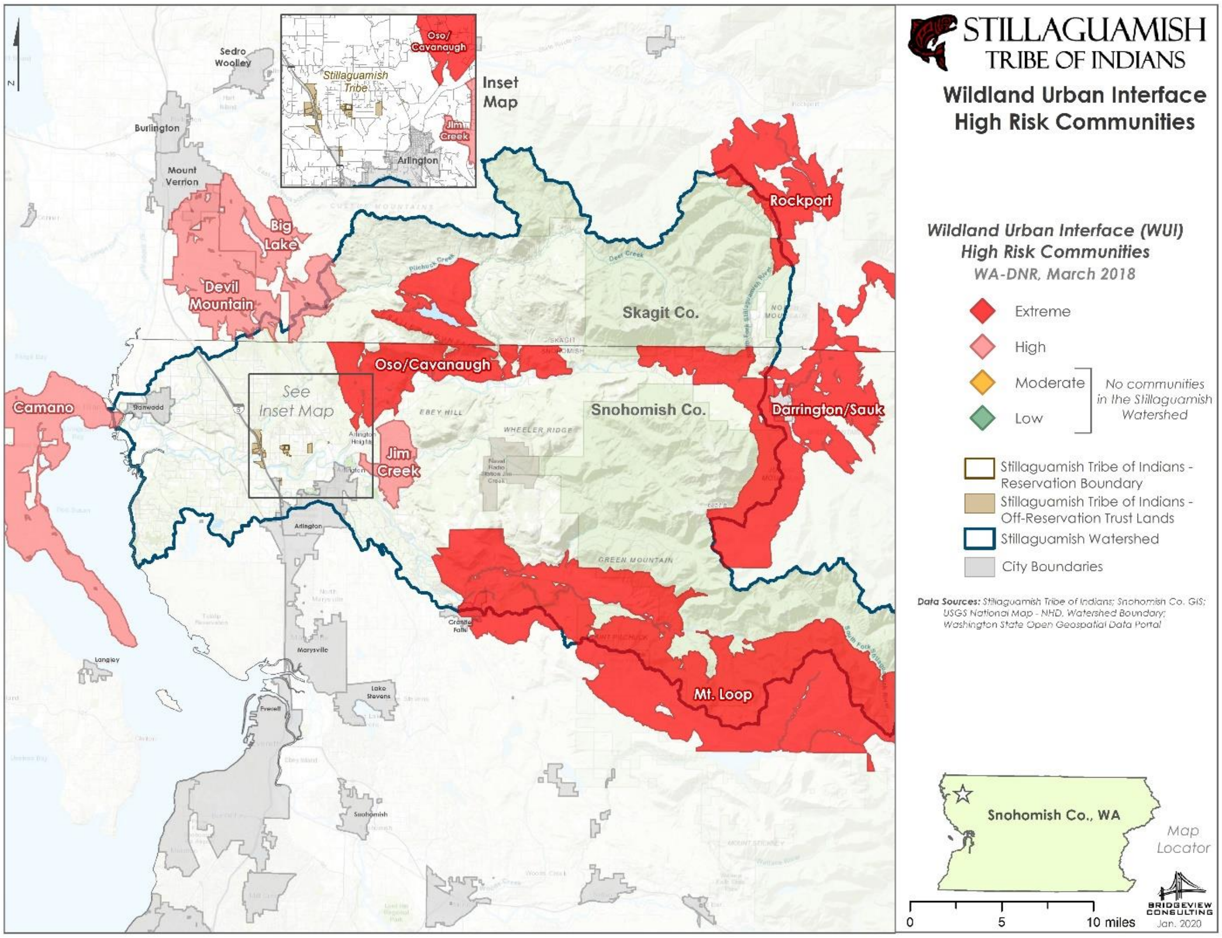
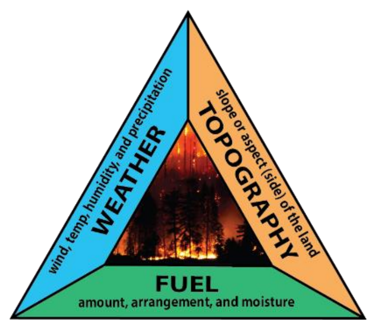


Figure 13-1 Wildland Urban Interface High Risk Communities (DNR, 2018)

13.1.3 Identifying Wildfire Risk



Fire Behavior Triangle

Risk to communities is generally determined by the number, size and types of wildfires that have historically affected an area; topography; fuel and weather; suppression capability of local and regional resources; where and what types of structures are in the WUI; and what types of pre-fire mitigation activities have been completed. Identifying areas most at risk to fire or predicting the course a fire will take requires precise science. The following are most useful in assessing risk in the area:

Topography

Topography can have a powerful influence on wildfire behavior. The movement of air over the terrain tends to direct a fire's course. Gulches and canyons can funnel air and act as a chimney, intensifying fire behavior and inducing faster rates of spread. Saddles on ridge tops offer lower resistance to the passage of air and will draw fires. Solar heating of drier, south-facing slopes produces upslope thermal winds that can complicate behavior.

Slope is an important factor. If the percentage of uphill slope doubles, the rate of spread of wildfire will likely double. On steep slopes, fuels on the uphill side of the fire are closer physically to the source of heat.

Radiation preheats and dries the fuel, thus intensifying fire behavior. Fire travels downslope much more slowly than it does upslope, and ridge tops often mark the end of wildfire's rapid spread.

Fuels

Fuels are classified by weight or volume (fuel loading) and by type. Fuel loading, often expressed in tons per acre, can be used to describe the amount of vegetative material available. If fuel loading doubles, the energy released also can be expected to double. Each fuel type is given a burn index, which is an estimate of the amount of potential energy that may be released, the effort required to contain a fire in a given fuel, and the expected flame length. Different fuels have different burn qualities. Some fuels burn more easily or release more energy than others. Grass, for instance, releases relatively little energy, but can sustain very high rates of spread.

Continuity of fuels is expressed in terms of horizontal and vertical dimensions. Horizontal continuity is what can be seen from an aerial photograph and represents the distribution of fuels over the landscape. Vertical continuity links fuels at the ground surface with tree crowns via ladder fuels.

Another essential factor is fuel moisture. Fuel moisture is expressed as a percentage of total saturation and varies with antecedent weather. Low fuel moistures indicate the probability of severe fires. Given the same weather conditions, moisture in fuels of different diameters changes at different rates. A 1,000-hour fuel, which has a 3- to 8-inch diameter, changes more slowly than a 1- or 10-hour fuel.

Weather

Of all the factors influencing wildfire behavior, weather is the most variable. Extreme weather leads to extreme events, and it is often a moderation of the weather that marks the end of a wildfire's growth and the beginning of successful containment. High temperatures and low humidity can produce vigorous fire activity. The cooling and higher humidity brought by sunset can dramatically quiet fire behavior.

Fronts and thunderstorms can produce winds that are capable of radical and sudden changes in speed and direction, causing similar changes in fire activity. The rate of spread of a fire varies directly with wind velocity. Winds may play a dominant role in directing the course of a fire. The radical and devastating effect that wind can have on fire behavior is a primary safety concern for firefighters. The most damaging firestorms are usually marked by high winds.

13.1.4 Historic Fire Regime Condition Classification

Land managers need to understand historical fire regimes (that is, fire frequency and fire severity prior to significant human settlement) to be able to define ecologically appropriate goals and objectives for an area. This understanding must include knowledge of how historical fire regimes vary across the landscape. Five historical fire regimes are classified based on average number of years between fires (fire frequency) and the severity of the fire (amount of replacement) on the dominant overstory vegetation:

- 0- to 35-year frequency and low (surface fires most common) to mixed severity (less than 75 percent of the dominant overstory vegetation replaced)

- 0- to 35-year frequency and high (stand replacement) severity (greater than 75 percent of the dominant overstory vegetation replaced)

- 35- to 100-year frequency and mixed severity (less than 75 percent of the dominant overstory vegetation replaced)

- 35- to 100-year frequency and high (stand replacement) severity (greater than 75 percent of the dominant overstory vegetation replaced)
- >200-year frequency and high (stand replacement) severity.

Understanding ecosystem departures (how ecosystems have changed over time) provides a context for managing sustainable ecosystems. Broad-scale alterations of historical fire regimes and vegetation conditions have occurred in many landscapes in the U.S. through the combined influence of land management practices, fire prevention, livestock grazing, insect and disease outbreaks, climate change, and invasion of non-native plant species. These departures result in changes to one or more of the following ecological components:

- Vegetation characteristics (species composition, structural stages, stand age, canopy closure and mosaic pattern)
- Fuel composition
- Fire frequency, severity, and pattern
- Associated disturbances (e.g. insect and disease mortality, grazing, and drought).

Characteristic vegetation and fuel conditions are those that occurred within the historical fire regime. *Uncharacteristic* conditions are those that did not occur within the historical fire regime, such as invasive species (e.g. weeds, insects, and diseases), “high graded” forest composition and structure (e.g. large trees removed in a frequent surface fire regime), or repeated annual grazing that reduces grassy fuels across relatively large areas to levels that will not carry a surface fire.

The fire regime condition class (FRCC) is a classification of a given area’s amount of departure from the historical fire regime. The classifications categorize wildland vegetation and fuel conditions into one of the three condition classes, based on the degree of departure. The three classes indicate low (FRCC 1), moderate (FRCC 2) and high (FRCC 3) departure from the historical fire regime. Low departure is considered to be within the historical range of variability, while moderate and high departures are outside. Determination of the amount of departure is based on comparison of a composite measure of fire regime attributes to the central tendency of the historical fire regime. The amount of departure is then classified to determine the fire regime condition class. Table 13-1 presents a simplified description of the fire regime condition classes and associated potential risks.

TABLE 13-1
FIRE REGIME CONDITION CLASS DEFINITIONS

Description	Potential Risks
Fire Regime Condition Class 1	
Within the historical range of variability.	• Fire behavior, effects and other associated disturbances are similar to those that occurred prior to fire exclusion (suppression) and other types of management that do not mimic the natural fire regime and associated vegetation and fuel characteristics. • Composition and structure of vegetation and fuels are similar to the natural (historical) regime. • Risk of loss of key ecosystem components (e.g. native species, large trees, and soil) is low.
Fire Regime Condition Class 2	

TABLE 13-1
FIRE REGIME CONDITION CLASS DEFINITIONS

Description	Potential Risks
Moderate departure from the historical regime of variability.	• Fire behavior, effects, and other associated disturbances are moderately departed (more or less severe). • Composition and structure of vegetation and fuel are moderately altered. • Uncharacteristic conditions range from low to moderate. • Risk of loss of key ecosystem components is moderate.
Fire Regime Condition Class 3	
High departure from the historical regime of variability.	• Fire behavior, effects, and other associated disturbances are highly departed (more or less severe). • Composition and structure of vegetation and fuel are highly altered. • Uncharacteristic conditions range from moderate to high. • Risk of loss of key ecosystem components is high.

13.2 HAZARD PROFILE

Since 1979, Snohomish County has experienced only two forest fires of 100 acres or more. A 750-acre fire in the Marblemount area during the El Niño summer of 1997 was attributed to a lengthened growing season, warmer than normal temperatures and heavy windfalls from the previous year’s storms. There is no record of any large wildland fires (greater than 1,500 acres) in the county since 1900. The Washington Department of Natural Resources (DNR) has records of 905 wildland fire starts dating back to 1970.

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. Fires historically burn on a fairly regular cycle, recycling carbon and nutrients stored in the ecosystem, and strongly affecting the species within the ecosystem.

The burning cycle in western Washington is every 100 to 150 years. Controlled burns have also been conducted because the fire cycle is an important aspect of management for many ecosystems. These are not considered hazards unless they get out of control. None of Washington State’s most significant wildland fires have occurred in the planning area.

Population growth rates have been steadily increasing throughout the region. The growing appreciation for seclusion has led to significant development in the most accessible forestland areas, particularly along rivers and waterbodies. Frequently, this development is in the dry forested areas where grass, needle and brush surface litter create forest fuel conditions that are at a high propensity for fire occurrence. Human use is strongly correlated with fire frequency, with increasing numbers of fires as use increases. Discarded cigarettes, tire fires and hot catalytic converters increase the potential for fire starts along roadways. Careless and unsupervised use of fireworks also contributes to unwanted and unexpected wildland fires. Further contributing to ignition sources are the debris burners (burn barrels) and “sport burners” who use fire to rid ditches of weeds and other burnable materials. Farming and logging equipment have also been a source of accidental ignitions. The increased potential for fire starts and the fire- prone landscapes in which homes have been constructed greatly increases the potential for fires in interface areas.

13.2.1 Extent and Location

LANDFIRE is a shared program between the wildland fire management programs of the U.S. Forest Service and the U.S. Department of the Interior, under the direction of the Wildland Fire Leadership Council. Together, those entities assist in developing maps to help identify the various components of the wildfire hazards. For planning purposes, the Fire Regime Mapping and Fire Behavior Fuel Models are illustrated to help identify potential areas at risk to wildfire based on the historic fire regime events.

Fire Behavior Fuel Model Classifications

Thirteen standard fire behavior fuel models (FBFM), referred to as Anderson 13, serve as input to a mathematical model of surface fire behavior and spread. The fire behavior fuel model layer (FBFM13) represents the distribution of fuel loading among live and dead surface fuel components, size classes, and fuel types, all of which contribute to the type and severity of a wildfire.

The fuel models are described by the most common fire-carrying fuel type (grass, brush, timber litter, or slash), loading and surface area-to-volume ratio by size class and component, fuel bed depth, and moisture of extinction. The FBFM13 layer was produced by fire and fuels specialists based on vegetation type, cover and height. The 13 classes, shown on Figure 13-2, are defined as follows:

- FBFM 1—Surface fires that burn fine herbaceous fuels, cured and curing fuels, little shrub or timber present, primarily grasslands and savanna.
- FBFM 2—Burns fine, herbaceous fuels, stand is curing or dead, may produce fire brands on oak or pine stands.
- FBFM 3—Most intense fire of grass group, spreads quickly with wind, one third of stand dead or cured, stands average 3 feet tall.
- FBFM 4—Fast spreading fire, continuous overstory, flammable foliage and dead woody material, deep litter layer can inhibit suppression.
- FBFM 5—Low intensity fires, young, green shrubs with little dead material, fuels consist of litter from understory.
- FBFM 6—Broad range of shrubs, fire requires moderate winds to maintain flame at shrub height, or will drop to the ground with low winds.
- FBFM 7—Foliage highly flammable, allowing fire to reach shrub strata levels, shrubs generally 2 to 6 feet high.
- FBFM 8—Slow, ground burning fires, closed canopy stands with short needle conifers or hardwoods, litter consisting mainly of needles and leaves, with little undergrowth, occasional flares with concentrated fuels.
- FBFM 9—Longer flames, quicker surface fires, closed canopy stands of long-needles or hardwoods, rolling leaves in fall can cause spotting, dead-down material can cause occasional crowning.
- FBFM 10—Surface and ground fire more intense, dead-down fuels more abundant, frequent crowning and spotting causing fire control to be more difficult.

- FBFM 11—Fairly active fire, fuels consist of slash and herbaceous materials, slash originates from light partial cuts or thinning projects, fire is limited by spacing of fuel load and shade from overstory.

- FBFM 12—Rapid spreading and high intensity fires, dominated by slash resulting from heavy thinning projects and clear-cuts, slash is mostly 3 inches or less.

- FBFM 13—Fire spreads quickly through smaller material and intensity builds slowly as large material ignites, continuous layer of slash larger than 3 inches in diameter predominates, resulting from clear-cuts and heavy partial cuts, active flames sustained for long periods of time, fire is susceptible to spotting and weather conditions.

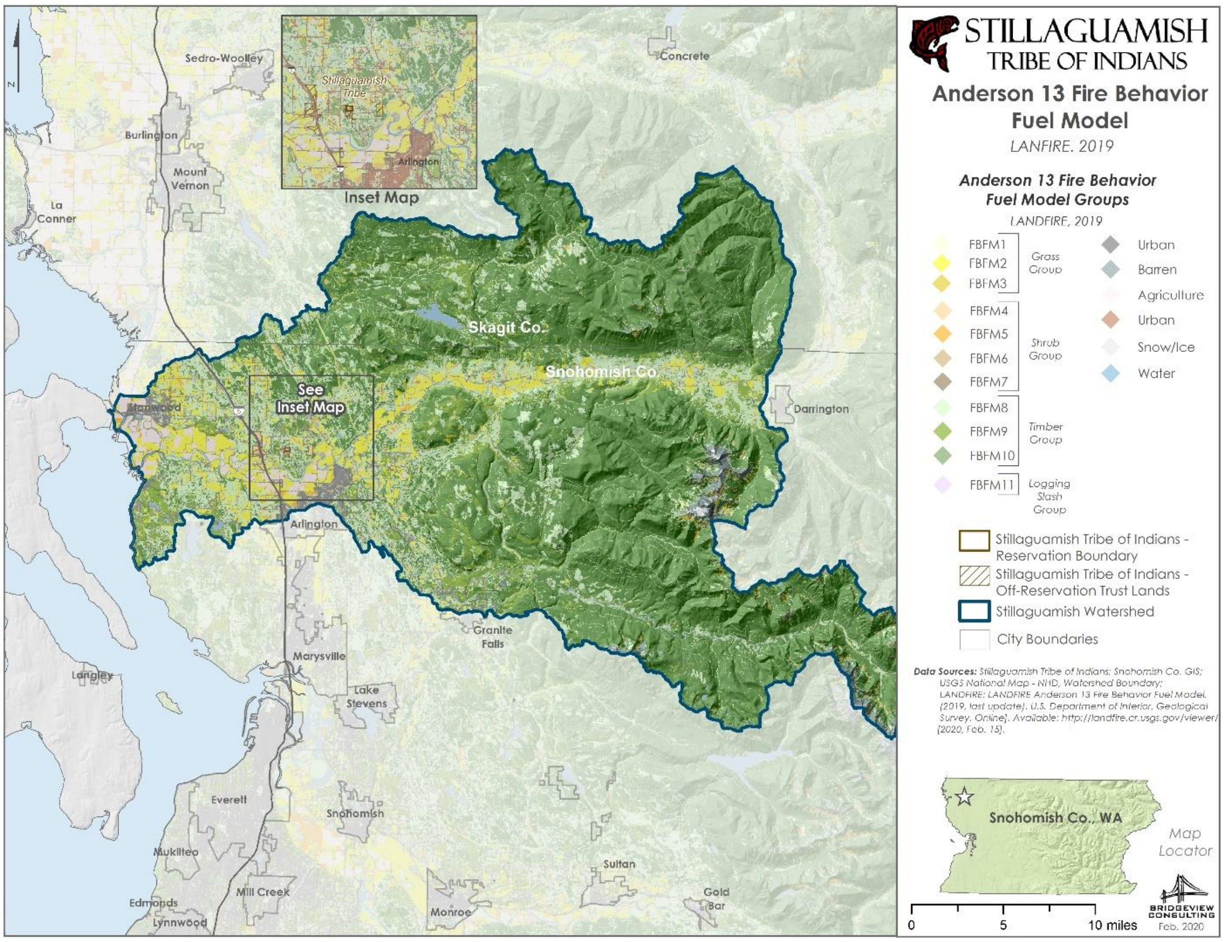


Figure 13-2 LANDFIRE Fire Behavior Fuel Model - Anderson 13 Fuel Classes

13.2.2 Previous Occurrence

The Washington Department of Natural Resources (DNR) database was used in this analysis. Review of the data and the Snohomish County HMP shows that no large-scale fires have occurred on the reservation boundary, or on Tribal lands. According to the data tracked by DNR, since 1970, Snohomish County as a whole has had approximately 1,000 wildfire incidents. Thankfully, most fires were very small in nature. Planning Team Members cannot remember a wildfire occurring on the Reservation, nor any tribal structures being impacted by wildfire.

13.2.3 Frequency

The LANDFIRE Project produces maps of simulated historical fire regimes and vegetation conditions using the LANDSUM landscape succession and disturbance dynamics model. The LANDFIRE Project also produces maps of current vegetation and measurements of current vegetation departure from simulated historical reference conditions. These maps support fire and landscape management planning outlined in the goals of the National Fire Plan, Federal Wildland Fire Management Policy, and the Healthy Forests Restoration Act.

The simulated historical mean fire return interval data layer quantifies the average number of years between fires under the presumed historical fire regime. This data is derived from simulations using LANDSUM. LANDSUM simulates fire dynamics as a function of vegetation dynamics, topography, and spatial context, in addition to variability introduced by dynamic wind direction and speed, frequency of extremely dry years, and landscape-level fire characteristics. The historical fire regime groups simulated in LANDFIRE categorize mean fire return interval and fire severities into five regimes defined in the Interagency Fire Regime Condition Class Guidebook:

- Regime 1: 0-35-year frequency, low to mixed severity
- Regime II: 0-35-year frequency, replacement severity
- Regime III: 35-200-year frequency, low to mixed severity
- Regime IV: 35 -200-year frequency, replacement severity
- Regime V: 200+ year frequency, any severity

Natural fire rotation is defined as the number of years necessary for fires to burn over an area equal to that of the study area. Natural fire rotation is calculated from the historical record of fires by dividing the length of the record period in years by the percentage of total area burned during that period. It represents the average period between fires under a presumed historical fire regime.

Figure 11-4 shows the Fire Regimes for the planning area.

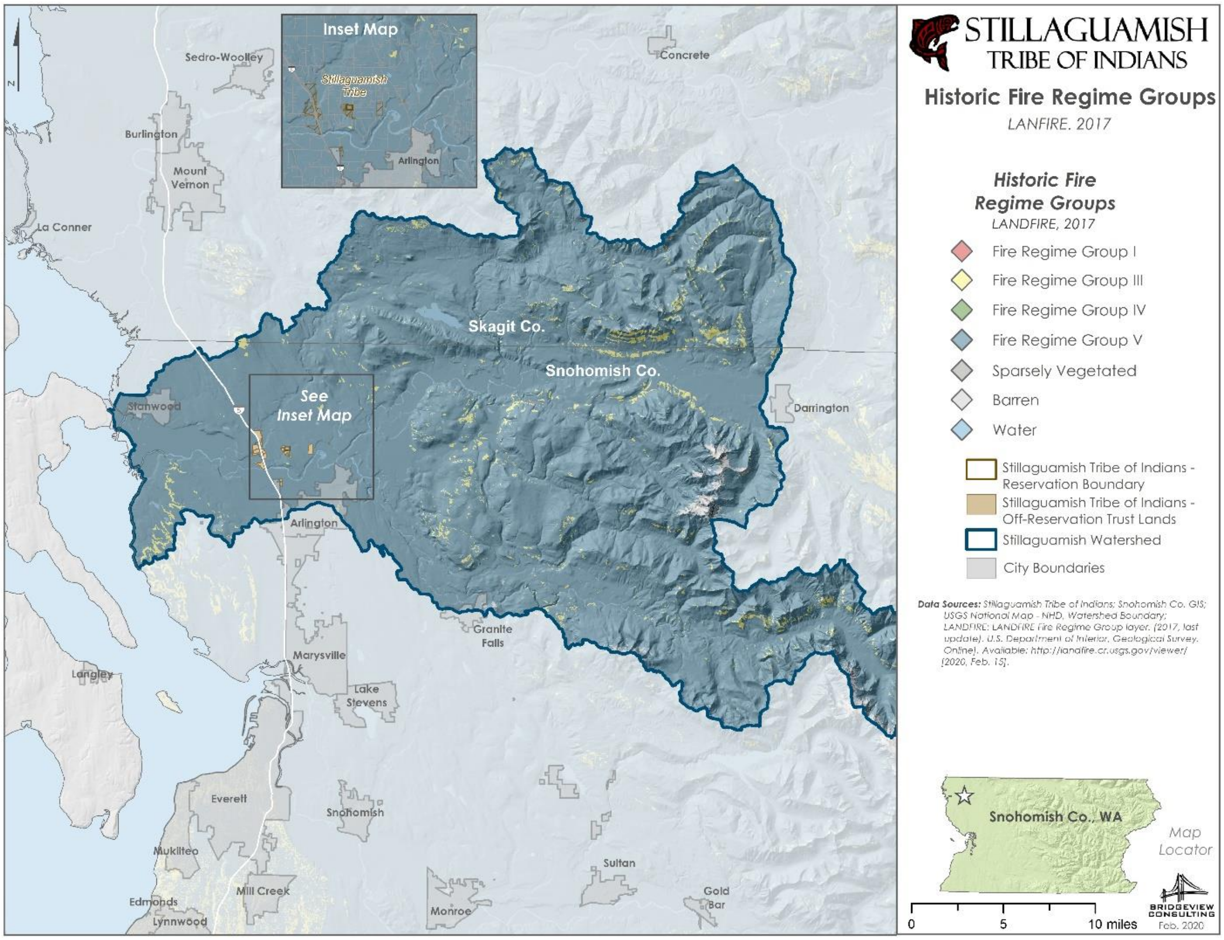


Figure 13-3 LandFire Fire Regime Groups (2017)

13.2.4 Severity

The severity of a fire season can usually be determined in the spring by how much precipitation is received, which in turn, determines how much fine fuel growth there is and how long it takes this growth to cure out. These factors, combined with annual wind events in late summer, drastically increase the chance a fire start will grow and resist suppression activities. Furthermore, harvest is also occurring at this time. Occasionally, harvesting equipment causes an ignition that can spread into populated areas and timberlands.

Historically, wildfires in the area have tended to be small and usually confined to remote areas. There is no record of property or infrastructure being damaged by wildfires by the Tribe, nor in the County. The majority of recorded fires covered 1 acre or less.

Given the fast response times to fires, the likelihood of injuries and casualties is minimal. Smoke and air pollution from wildfires can be a health hazard, especially for sensitive populations including children, the elderly and those with respiratory and cardiovascular diseases. Wildfire 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, wildfire can lead to ancillary impacts such as landslides in steep ravine areas and flooding due to the impacts of silt in local watersheds.

13.2.5 Warning Time

Wildfires are often caused by humans, intentionally or accidentally. There is no way to predict when one might break out. Since fireworks often cause brush fires, extra diligence is warranted around the Fourth of July when the use of fireworks is highest. Dry seasons and droughts are factors that greatly increase fire likelihood. Dry lightning may trigger wildfires. Severe weather can be predicted, so special attention can be paid during weather events that may include lightning. Reliable National Weather Service lightning warnings are available on average 24 to 48 hours prior to a significant electrical storm. If a fire does break out and spread rapidly, residents may need to evacuate within days or hours. Once a fire has started, fire alerting is reasonably rapid in most cases. The spread of cellular and two-way radio communications has contributed to a significant improvement in warning time.

13.3 SECONDARY HAZARDS

Wildfires can generate a range of secondary effects, which in some cases may cause more widespread and prolonged damage than the fire itself. Fires can cause direct economic losses in the reduction of harvestable timber and indirect economic losses in reduced tourism. Wildfires cause the contamination of reservoirs, destroy transmission lines and contribute to flooding. They 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 wildfire. Most wildfires burn hot and for long durations that can bake soils, especially those high in clay content, thus increasing the imperviousness of the ground. This increases the runoff generated by storm events, thus increasing the chance of flooding.

13.4 VULNERABILITY ASSESSMENT

13.4.1 Overview

Structures, above-ground infrastructure, critical facilities, and natural environments are all vulnerable to the wildfire hazard.

13.4.2 Impact on Life, Health, and Safety

The entire reservation would be at risk to wildfire depending on the location and variables associated with the wildfire (wind, weather, moisture content, etc.). This impact would include guests, employees and individuals traveling through the area. Smoke and air pollution from wildfires can be a severe health hazard, especially for sensitive populations, including children, the elderly and those with respiratory and cardiovascular diseases. Smoke generated by wildfire consists of visible and invisible emissions that contain particulate matter (soot, tar, water vapor, and minerals), gases (carbon monoxide, carbon dioxide, nitrogen oxides), and toxics (formaldehyde, benzene). Emissions from wildfires depend on the type of fuel, the moisture content of the fuel, the efficiency (or temperature) of combustion, and the weather. Public health impacts associated with wildfire include difficulty in breathing, odor, and reduction in visibility. Wildfire 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.

13.4.3 Impact on Property

Loss estimations for the wildfire hazard are not based on damage functions, because no such damage functions have been generated. Property damage from wildfires can be severe and can significantly alter entire communities. Based on review of the various Fire Regimes in the area, it appears that the Reservation is almost entirely within Fire Regime V, with a very small portion within Fire Regime III; however, within the watershed, there are areas that also fall within Fire Regime Group I, in addition to groups III and V.

All structures owned by the Tribe on the Reservation are within Fire Regime Group V. Almost half of the structures assessed for this update are of wood construction, 17 total. Of the 17, six were built pre-1985; the remaining are newer in nature built after 2000. The structures identified include (but are not limited to) the Youth Townhomes, the Togstad Apartments, the Elders Cottages, and the Elders Longhouse.

13.4.4 Impact on Critical Facilities and Infrastructure

Critical facilities of wood frame construction are especially vulnerable during wildfire events. In the event of wildfire, there would likely be little damage to most infrastructure. Most roads and railroads would be without damage except in the worst scenarios. Power lines are the most at risk from wildfire because most poles are made of wood and susceptible to burning. Fires can create conditions that block or prevent access and can isolate residents and emergency service providers. Wildfire typically does not have a major direct impact on bridges, but it can create conditions in which bridges are obstructed. Many bridges in areas of high to moderate fire risk are important because they provide the only ingress and egress to large areas and in some cases to isolated neighborhoods.

For this update, all properties assessed were considered to be critical assets, and are exposed to Fire Regime V. As indicated, a limited number of structures are older in nature. In addition to those discussed above, there are three medical-related facilities and a water treatment facility that are of wood construction identified within Regime V. There are also three cultural structures, also wood construction identified.

Also for consideration on the reservation is the potential impact from hazardous materials and propane tanks, which are utilized in place of natural gas. During a wildfire event, these materials could rupture due to excessive heat and act as fuel for the fire, causing rapid spreading and escalating the fire to unmanageable levels. The Tribe does have a fueling station on the reservation. Should a situation impact the gas pumps, the materials could leak into surrounding areas, saturating soils and seeping into surface waters, having a disastrous effect on the environment. The Tribe does have personnel for hazmat response cleanup to help mitigate any potential spill issue.

In the event of wildfire, there would likely be little damage to the majority of infrastructure. Most roads would be without damage except in the worst scenarios. Power or above-ground communications lines are the most at risk to wildfire because most are made of wood and susceptible to burning. The Tribe has generators for some structures, but not all. If power lines were impacted, portions of the reservation and the watershed could be without power for a period of time. In the event of a wildfire, pipelines around the Reservation on non-tribal lands could provide a source of fuel and lead to a catastrophic explosion; however, as indicated there currently are no pipelines leading onto the reservation, but there are propane tanks.

13.4.5 Impact on Economy

Wildfire impact on the economy can be far reaching, ranging from damage to transportation routes to non-use of facilities, impacting revenue. Secondary hazards associated with wildfire, such as increased landslides and flooding potential, would further impact the economy. The lack of power to the Reservation and its various commercial enterprises would have a significant impact.

13.4.6 Impact on Environment

Fire is a natural and critical ecosystem process in most terrestrial ecosystems, dictating in part the types, structure and spatial extent of native vegetation. However, wildfires can cause severe environmental impacts:

- Damaged Fisheries—Critical fisheries 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.

Many ecosystems are adapted to historical patterns of fire occurrence. These patterns, called “fire regimes,” include temporal attributes (e.g., frequency and seasonality), spatial attributes (e.g., size and spatial complexity), and magnitude attributes (e.g., intensity and severity), each of which have ranges of natural variability. Ecosystem stability is threatened when any of the attributes for a given fire regime diverge from its range of natural variability. The fire regimes are identified in Section 13.1.4.

13.4.7 Climate Change Impacts

Fire in western ecosystems is determined by climate variability, local topography, and human intervention. Climate change has the potential to affect multiple elements of the wildfire system: fire behavior, ignitions, fire management, and vegetation fuels. Hot dry spells create the highest fire risk. Increased temperatures may intensify wildfire danger by warming and drying out vegetation. When climate alters fuel loads and fuel moisture, forest susceptibility to wildfires changes. Climate change also may increase winds that spread fires. Faster fires are harder to contain, and thus are more likely to expand into residential neighborhoods.

Historically, drought patterns in the West are related to large-scale climate patterns in the Pacific and Atlantic oceans. The El Niño–Southern Oscillation in the Pacific varies on a 5- to 7-year cycle, the Pacific Decadal Oscillation varies on a 20- to 30-year cycle, and the Atlantic Multidecadal Oscillation varies on a 65- to 80-year cycle. As these large-scale ocean climate patterns vary in relation to each other, drought conditions in the U.S. shift from region to region. El Niño years bring drier conditions to the Pacific Northwest and more fires.

Climate scenarios project summer temperature increases between 2ºC and 5°C and precipitation decreases of up to 15 percent. Such conditions would exacerbate summer drought and further promote high-elevation wildfires, releasing stores of carbon and further contributing to the buildup of greenhouse gases. Forest response to increased atmospheric carbon dioxide—the so-called “fertilization effect”—could also contribute to more tree growth and thus more fuel for fires, but the effects of carbon dioxide on mature forests are still largely unknown. High carbon dioxide levels should enhance tree recovery after fire and young forest regrowth, as long as sufficient nutrients and soil moisture are available, although the latter is in question for many parts of the western United States because of climate change.

13.5 FUTURE TRENDS IN DEVELOPMENT

The reservation is in a forested area. As the Tribe continues to grow and expand, increasing its land mass, it will continue to do so in a manner which least impacts the natural resources of the area. It is well equipped to manage development through application of its own land use authority and through the application of appropriate building codes, as it has always done, including the utilization of construction materials which reduce the potential impact from wildfires, as well as landscaping techniques for defensible space such as those examples identified in Figure 13-4. Such activities will help mitigate the potential for increased wildfire danger.

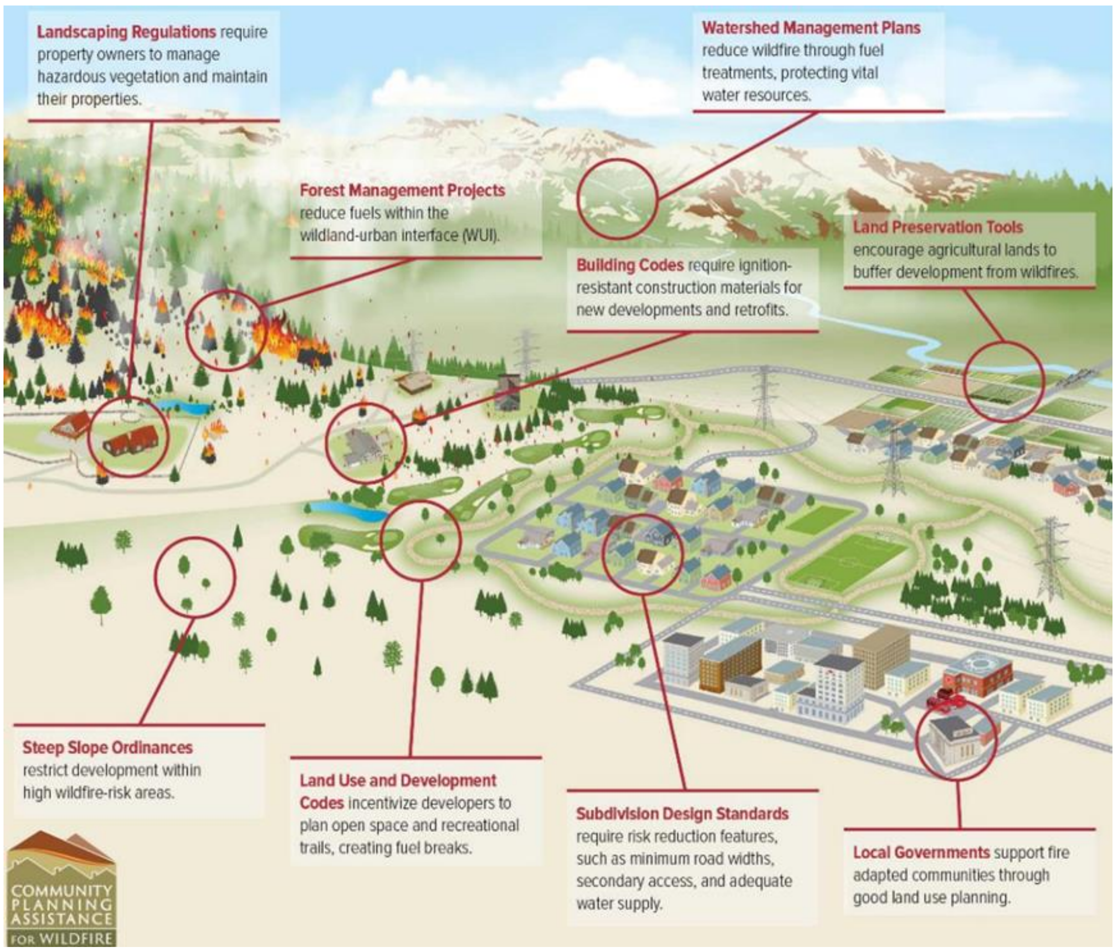


Figure 13-4 Potential Land Use Mitigation Activities to Reduce Wildfire Impact

13.6 ISSUES

The major issues for wildfire are the following:

- There is a need for better hazard mapping within the planning area. Mapping assessments such as the National Fire Protection Administration 299 risk assessment program would be a significant enhancement to the wildfire risk assessment.
- Public education and outreach to people living in or near fire hazard zones should include information about and assistance with mitigation activities such as defensible space and advance identification of evacuation routes and safe zones.

- Wildfires could cause landslides as a secondary natural hazard.
- Climate change could affect the wildfire hazard.
- Future growth into interface areas should continue to be managed.
- Area fire districts need to continue to train on wildland-urban interface events.
- Vegetation management activities should include enhancement through expansion of the target areas as well as additional resources.
- Regionally consistent higher building code standards are needed, such as residential sprinkler requirements and prohibitive combustible roof standards.
- Fire department water supply must be maintained in high-risk wildfire areas.
- Certifications and qualifications for fire department personnel should be expanded. All firefighters should be trained in basic wildfire behavior and basic fire weather, and all company officers and chief level officers should be trained to the wildland command and strike team leader level.

13.7 IMPACT AND RESULTS

Based on review and analysis of the data, the Planning Team has determined that the probability for impact from Wildfire throughout the area is possible. While the Tribe itself has never experienced a significant wildfire on the Reservation, the general area does experience some wildfires annually. While for the most part the acreage burned has, thankfully, been low due in large part to response activities, wildfires can spread quickly. The Tribe has never experienced a loss to a structure as a result of a wildfire. With continued urbanization, the increased number of fires throughout not only the planning area but the state as a whole will continue to increase. If such occurs, resources may become more limited in nature if an active wildfire season were to again exist, such as those within the last few years. That, when coupled with the existing drought situations occurring statewide, and the continued impact from climate change, it is anticipated that the wildfire risk will only continue to increase with time.

Limitations along the roadways leading onto and off of the reservation could restrict first responders from gaining access to reservation, and also impact evacuation of the area. The Tribe does have trained personnel to assist with hazmat response should such need arise, and has an exceptional relationship with its supporting fire district.

Based on the potential impact, the Planning Team determined the CPRI score to be 2.05, with overall vulnerability determined to be a medium-low level.

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CHAPTER 14.
HAZARD RANKING

The risk ranking process conducted by Planning Team members assessed the probability of each hazard's occurrence, as well as its likely impact on the people, property, and economy of the planning area. Also of significant concern to the Stillaguamish People is the impact of these hazards on the environment, which factor was also taken into consideration during this plan update.

For some hazards, estimates of risk were generated with data from Hazus, using methodologies promoted by FEMA. For other hazards, citizens, and Planning Team members (who have an extensive historic perspective and knowledge base concerning the impact of hazards on the Tribe) provided invaluable information during this process. That information had a significant impact on the risk ranking process.

In ranking the hazards, the Planning Team completed a Calculated Priority Risk Index worksheet for each hazard (Figure 14-1). The Index examines the various criteria for each hazard (probability, magnitude/severity, geographic extent and location, warning time, and duration) as discussed in Chapter 6, defines a risk index for each criterion according at four levels (1-4), and then applies a weighting factor.

The result is a score that has been used to rank the hazards for the Tribe. Table 14-1 presents the results of the Calculated Priority Risk Index (CPRI) scoring for the hazards of concern. Once the hazard ranking was completed, the Planning Team also assigned a qualitative assessment to identify the level of significance based on the CPRI score and rank, assigning a low-to-high rating of concern or significance. Those ratings are categorized into the following levels, with Table 14-2 presenting the overall results:

- Extremely Low—The occurrence and potential cost of damage to life and property is very minimal to nonexistent.
- Low—Minimal potential impact. The occurrence and potential cost of damage to life and property is minimal.
- Medium—Moderate potential impact. This ranking carries a moderate threat level to the general population and/or built environment. Here the potential damage is more isolated and less costly than a more widespread disaster.
- High—Widespread potential impact. This ranking carries a high threat to the general population and/or built environment. The potential for damage is widespread. Hazards in this category may have occurred in the past.
- Extremely High—Very widespread with catastrophic impact.

CPRI Category	Degree of Risk: Impact/ Level ID	Degree of Risk: Description	Degree of Risk: Impact Factor	Assigned Weighting Factor
Probability	Unlikely	• Rare with no documented history of occurrences or events. • Annual probability of less than 1% (~100 years or more).	1	40%
	Possible	• Infrequent occurrences; at least one documented or anecdotal historic event. • Annual probability that is between 1% and 10% (~10 years or more).	2	
	Likely	• Frequent occurrences with at least two or more documented historic events. • Annual probability that is between 10% and 90% (~10 years or less).	3	
	Highly Likely	• Common events with a well-documented history of occurrence. • Annual probability of occurring. (1% chance or 100% Annually).	4	
Magnitude/ Severity	Negligible	• People – Injuries and illnesses are treatable with first aid; minimal hospital impact; no deaths. Negligible impact to quality of life. • Property – Less than 5% of critical facilities and infrastructure impacted and only for a short duration (less than 24-36 hours such as for a snow event); no loss of facilities, with only very minor damage/clean-up. • Economy – Negligible economic impact. • Continuity of government operating at 90% of normal operations with only slight modifications due to diversion of normal work for short-term response activity. Disruption lasts no more than 24-36 hours. • Special Purpose Districts: No Functional Downtime.	1	25%
	Limited	• People – Injuries or illness predominantly minor in nature and do not result in permanent disability; some increased calls for service at hospitals; no deaths; 14% or less of the population impacted. Moderate impact to quality of life. • Property – Slight property damage -greater than 5% and less than 25% of critical and non-critical facilities and infrastructure. • Economy – Impact associated with loss property tax base limited; impact results primarily from lost revenue/tax base from businesses shut down during duration of event and short-term cleanup; increased calls for emergency services result in increased wages. • Continuity of government impacted slightly; 80% of normal operations; most essential services being provided. Disruption lasts >36 hours, but <1 week. • Special Purpose Districts: Functional downtime 179 days or less.	2	
	Critical	• People – Injuries or illness results in some permanent disability or significant injury; hospital calls for service increased significantly; no deaths. 25% to 49% of the population impacted. • Property – Moderate property damages (greater than 25% and less than 50% of critical and non-critical facilities and infrastructure). • Economy - Moderate impact as a result of critical and non-critical facilities and infrastructure impact, loss of revenue associated with tax base, lost income. • Continuity of government ~50% operational capacity; limited delivery of essential services. Services interrupted for more than 1 week, but <1 month. • Special Purpose Districts: Functional downtime 180-364 days.	3	
	Catastrophic	• People - Injuries or illnesses result in permanent disability and death to a significant amount of the population exposed to a hazard. >50% of the population impacted. • Property – Severe property damage >50% of critical facilities and non-critical facilities and infrastructure impacted. • Economy – Significant impact - loss of buildings /content, inventory, lost revenue, lost income. • Continuity of government significantly impacted; limited services provided (life safety and mandated measures only). Services disrupted for > than 1 month. • Special Purpose Districts: Functional Downtime 365 days or more.	4	
Geographic Extent and Location	Limited	Less than 10% of area impacted.	1	20%
	Moderate	10%-24% of area impacted.	2	
	Significant	25%-49% of area impacted.	3	
	Extensive	50% or more of area impacted.	4	
Warning Time / Speed of Onset	<6 hours	Self-explanatory.	4	10%
	6 to 12 hours	Self-explanatory.	3	
	12 to 24 hours	Self-explanatory.	2	
	> 24 hours	Self-explanatory.	1	
Duration	< 6 hours	Self-explanatory.	1	5%
	< 24 hours	Self-explanatory.	2	
	<1 week	Self-explanatory.	3	
	>1 week	Self-explanatory.	4	

Figure 14-1 Calculated Priority Risk Index

TABLE 14-1
CALCULATED PRIORITY RANKING SCORES

Hazard	Probability	Magnitude and/or Severity	Geographic Extent and Location	Warning Time	Duration	Calculated Priority Risk Index Score
Drought	3	1	2	1	4	2.15
Earthquake	4	3	4	4	1	3.65
Flood	3	2	2	1	2	2.25
Landslide	2	2	1	4	2	2.1
Severe Weather	4	2	4	1	2	3.05
Volcano	1	3	3	1	3	1.9
Wildfire	2	1	2	4	1	2.05

The Calculated Priority Risk Index scoring method has a range from 0 to 4. "0" being the least hazardous and "4" being the most hazardous situation.

TABLE 14-2
HAZARD RANKING

Hazard in Ranked Order	CPRI Score	Level of Concern and Significance
Earthquake	3.65	High
Severe Weather	3.05	High
Flood	2.25	Medium
Drought	2.15	Medium
Landslides	2.1	Medium
Wildfire	2.05	Medium
Volcano	1.90	Medium

CHAPTER 15.
MITIGATION STRATEGY

The development of a mitigation strategy allows the community to create a vision for preventing future disasters. This is accomplished by establishing a common set of mitigation goals and objectives, a common method to prioritize actions, and evaluation of the success of such actions.

Once identified, the goals and objectives establish an overall mitigation strategy by which the Tribe will enhance resiliency of the planning area. When combined with the Risk Assessment data developed during this plan update, the Planning Team identified a set of mitigation action items (sometimes referred to as initiatives or strategies) which, when implemented, will help reduce the impact of the hazards on the Stillaguamish Tribe.

15.1 GOALS AND OBJECTIVES

Hazard mitigation plans must identify goals and objectives for reducing long-term vulnerabilities to identified hazards (44 CFR Section 201.7(c)(3)(i)). The established goals and objectives for this plan were based on data developed during the risk assessment portion of this process, and the results of the public involvement strategy.

15.2 GOALS

In identifying the goals, the Planning Team reviewed the goals from the previous Hazard Mitigation Plan, and confirmed same to be relevant for this 2020 update, as follows:

Goal 1—Reduce natural hazard-related injury and loss of life.

Goal 2—Reduce property damage.

Goal 3—Promote a sustainable economy.

Goal 4—Maintain, enhance, and restore the natural environment's capacity to absorb and reduce the impacts of natural hazard events.

Goal 5—Increase public awareness and ability to respond to disasters.

15.3 OBJECTIVES

Objectives from the previous plan were reviewed; however, the Planning Team determined that some modifications were necessary. The objectives identified for the 2020 update are listed in the Table 15-1. The effectiveness of a mitigation strategy is assessed by determining how well the goals are achieved. Each identified objective meets multiple goals, serving as a measure of the effectiveness of a mitigation action, rather than as a subset of a goal. The objectives are measurable in nature, and are used to help establish priorities.

TABLE 15-1
OBJECTIVES

Objective Number	Objective Statement	Goals for which it can be applied
O-1	Acquire (purchase), retrofit, or relocate structures in high hazard areas.	1, 2, 3, 4
O-2	Encourage open space uses in hazardous areas or ensure that if building occurs in these high-risk areas that it is done in such a way as to minimize risk.	1, 2, 3, 4, 5
O-3	Use best available data, science and technologies to improve understanding of location and potential impacts of hazards, and to promote disaster resilient communities that minimize risk.	1, 2, 3, 4, 5
O-4	Consider the impacts of natural hazards in all planning mechanisms that address current and future land uses in the Tribal Planning Area.	1, 2, 4, 5
O-5	Preserve the Cultural Resources of the Stillaguamish Tribe.	1, 2, 3 ,4, 5
O-6	Establish a partnership among the Tribal Government and Tribal business leaders with surrounding area government and business community to improve and implement methods to protect life, property, and the environment.	1, 2, 3, 4, 5
O-7	Enhance community emergency management capabilities to prepare for, protect from, respond to, recover from, and mitigate the impact of hazards.	1, 2, 3, 4, 5
O-8	Encourage hazard mitigation measures that result in the least adverse effect on the natural environment and that use natural processes, while preserving and maintaining the cultural elements of the Stillaguamish Tribe.	2, 3, 4

15.4 MITIGATION ACTION ITEM IDENTIFICATION AND ANALYSIS

FEMA’s 2013 *Catalog of Mitigation Ideas* was presented to the planning team and served as the beginning point in the development of the Tribe’s initiatives. The FEMA document includes a broad range of alternatives for consideration in the planning area, in compliance with 44 CFR (Section 201.7.c.3.ii). Many of the action items or initiatives can be applied to both existing structures and new construction, as identified below. The catalog provides a baseline of mitigation initiatives that are backed by a planning process, are consistent with the planning partners’ goals and objectives, and are within the capabilities of the Tribe to implement.

The Planning Team developed strategies/action items that are categorized and assessed in several ways:

- By what the alternative would impact – new or existing structures, to include efforts which:
  - Manipulate/mitigate a hazard;
  - Reduce exposure to a hazard;
  - Reduce vulnerability to a hazard;
- By who would have responsibility for implementation:
  - Individuals;
  - Businesses;

- Government (Tribal, County, Local, State and/or Federal).

- By the timeline associated with completion of the project, based on the following parameters:
  - Short Term = to be completed in 1 to 5 years
  - Long Term = to be completed in greater than 5 years
  - Ongoing = currently being funded and implemented under existing programs.
- By the type of mitigation activity involved (most of which also coincide with CRS activities):
  - **Prevention -** Government, administrative or regulatory actions that influence the way land and buildings are developed to reduce hazard losses. This includes planning and zoning, floodplain laws, capital improvement programs, open space preservation, and stormwater management regulations.
  - **Public Information and Education -** Public information campaigns or activities which inform citizens and elected officials about hazards and ways to mitigate them – a public education or awareness campaign, including efforts such as: real estate disclosure, hazard information centers, and school-age and adult education, all of which bring awareness of the hazards of concern.
  - **Structural Projects** —Efforts taken to secure against acts of terrorism, manmade, or natural disasters. Types of projects include levees, reservoirs, channel improvements, or barricades which stop vehicles from approaching structures to protect.
  - **Property Protection** – Actions taken that protect the properties. Types of efforts include: structural retrofit, property acquisition, elevation, relocation, insurance, storm shutters, shatter-resistant glass, sediment and erosion control, stream corridor restoration, etc. Protection can be at the individual homeowner level, or a service provided by police, fire, emergency management, or other public safety entities.
  - **Emergency Services / Response** —Actions that protect people and property during and immediately after a hazard event. Includes warning systems, emergency response services, and the protection of essential facilities (e.g., sandbagging).
  - **Natural Resource Protection** – Wetlands and floodplain protection, natural and beneficial uses of the floodplain, and best management practices. These include actions that preserve or restore the functions of natural systems. Includes sediment and erosion control, stream corridor restoration, watershed management, forest and vegetation management, and wetland restoration and preservation.
  - **Recovery** —Actions that involve the construction or re-construction of structures in such a way as to reduce the impact of a hazard, or that assist in rebuilding or re-establishing a community after a disaster incident. It also includes advance planning to address recovery efforts which will take place after a disaster. Efforts are focused on re-establishing the planning region in such a way as enhance resiliency and reduce impacts to future incidents. Recovery differs from response, which occurs during, or immediately after an incident. Recovery views long-range, sustainable efforts.
- Benefit: By who the strategy benefits:
  - A specific structure or facility;
  - A local community;
  - County-level efforts;

– Regional level benefits.

During development of these strategies, the initial starting point was review of the previous action items. As this current plan update is of a new format and organizational structure, the Planning Team elected to use this opportunity to modify the structure of the action items previously identified to eliminate those which are no longer relevant, combine the strategies as appropriate, and to reword existing strategies to make them more viable. Those projects which remain valid have been included within Table 15-2, and referenced as having been previously identified. The status of the previous action items are discussed in detail in Table 15-4.

In addition to the referenced Catalog, many of the hazard mitigation initiatives recommended in this plan were selected from among the examples presented from other planning and strategic documents – integrating various planning efforts already in existence to the greatest extent possible.

TABLE 15-2
HAZARD MITIGATION ACTION PLAN MATRIX

Applies to new or existing assets	Hazards Mitigated	Objectives Met	Lead Agency (listed first) and others potentially involved	Estimated Cost	Sources of Funding	Timeline	Included in Previous Plan?	Initiative Type: Emergency Services, Property Protection, Prevention, Recovery, Structural Projects, Public Info., Natural Resources	Who or What Benefits from Action? Facility, Tribal, Local, County, Region
1. Retrofit or move tribal facilities to better withstand impact from a natural hazard event. This includes structures within the floodplain, or areas impacted by flood events. This would include land acquisition and removal of structures to allow for open space and the return to natural environments.									
New and Existing	All	1, 2, 3, 4, 5, 6, 7, 8	Planning, Facilities	High	General Fund, PDM, HMGP, HUD	Long-Term	Y – Modified Previously Strategy 2	Structural, Natural Resource Protection, Recovery, Property Protection	Tribal
2. Evaluate and enhance the current capital improvements program for drainage projects to provide better flood control in known flood problem areas. This would include working with Snohomish County as the Tribe deems appropriate.									
New and Existing	CC, F, LS, SW, T	1, 2, 3, 4, 5, 7, 8	Planning, Transit, Facilities	High	State Ecology FCAAP, PDM, HMGP, HUD, USACE, EPA	Long-Term	N	Protection, Prevention, Natural Resources	Tribal, Local, County, Region
3. Working with county and state agencies as appropriate, seek steep slope stability project funding or relocation funding for roads with histories of instability to ensure accessibility to the Reservation.									
Existing	EQ, F, LS, SW	3, 4, 5, 6, 7, 8	Planning, NR, County and local jurisdictions	High	PDM, HMGP, USDOT, WADOT	Long-Term	N	Emergency Services, Protection, Prevention	Tribal, Local, County, Region
4. Seek grant funding for acquisition of properties within high-hazard areas to help restore the natural habitat of the area/watershed.									

TABLE 15-2
HAZARD MITIGATION ACTION PLAN MATRIX

Applies to new or existing assets	Hazards Mitigated	Objectives Met	Lead Agency (listed first) and others potentially involved	Estimated Cost	Sources of Funding	Timeline	Included in Previous Plan?	Initiative Type: Emergency Services, Property Protection, Prevention, Recovery, Structural Projects, Public Info., Natural Resources	Who or What Benefits from Action? Facility, Tribal, Local, County, Region
Existing	All	1, 2, 3, 4, 5, 7, 8	Natural Resources	High	PDM, HMGP	Long-Term	Y – Modified	All	Facility, Tribal
5. Identify facilities such as the community centers which require generators to maintain use of structure for long-term incidents. In addition, work with local businesses to develop a database of grocery stores in the immediate area who have generators in order to determine the availability of food sources in the event of a disaster.									
New and Existing	All	3, 4, 5, 6, 7	Planning, Facilities	Low	General Fund	On-Going	N	Recovery	Facility, Tribal, Local
6. Conduct a needs assessment to determine logistical requirements for equipment and parts for wells, water storage facilities, purification systems, and water distribution sources to ensure for continued supply of water after a major event.									
Existing	All	3, 4, 5, 7,	Planning, Facilities	Low	General Fund	Short-Term	N	Emergency Services, Protection	Tribal, Local, County
7. Seek grant funding to construct a new police facility which can also serve as an emergency operations center to support Tribal efforts during disaster events.									
New	All	1, 2, 3, 4, 5, 7, 8	Public Safety and Tribal Administra-tion	High	HLS	Long-Term	Y-Modified	All	Tribal
8. Continue to design and build facilities to meet or exceed seismic (or load) standards, including redundant essential equipment. Apply current IBC standards to all renovation or replacement of existing facilities, structures, and/or equipment.									
New and Existing	EQ, LS, SW, V	1, 2, 3, 4, 7, 8	Planning, Facilities	Medium	PDM, HMGP	Long-Term	N	Prevention	Tribal
9. Implement various activities that support mitigation efforts to reduce the negative influence of natural hazards impacting the Tribal Planning Area and the watershed as a whole.									
New and Existing	All	All	Natural Resources	High	General Fund, HLS, Health	On-Going	Y – Modified	All	All
10. Utilize data gathered during risk assessment to identify capital projects that, when modified, increase the resilience of the Tribal structures and conveyances to damage, or that allow a more expedited process for recovery from the impact of disaster incidents.									
New and Existing	All	All	EM, Tribal Administra-tion, Facilities	Low	General Funds, Grants	Long-Term	N	Recovery, Prevention, Structural	Tribal

TABLE 15-2
HAZARD MITIGATION ACTION PLAN MATRIX

Applies to new or existing assets	Hazards Mitigated	Objectives Met	Lead Agency (listed first) and others potentially involved	Estimated Cost	Sources of Funding	Timeline	Included in Previous Plan?	Initiative Type: Emergency Services, Property Protection, Prevention, Recovery, Structural Projects, Public Info., Natural Resources	Who or What Benefits from Action? Facility, Tribal, Local, County, Region
11. Consider projects enhancing resistance of tribal structures to impact from hazards of concern, such as seismic bracing of equipment, piping and fixtures, removal of high hazard beams; increased load capacity from wind, snow, and volcanic ash; or access road reinforcement.									
New and Existing	EQ, LS, SW, V	1, 2, 3, 4, 7	Facilities, Planning	High	General Funds, OR DOT, US DOT, PDM, HMGP	Long-Term	N	Emergency Services, Recovery, Prevention, Structural	Tribal
12. Implement a recovery system to ensure maximum FEMA reimbursement for disaster response, repair, mitigation and recovery, which will capture and track damages sustained, emergency activities, associated expenses (mileage, supplies, expendables, outside vendors, etc.), employee time, and dedicated resources.									
New and Existing	All	7	EM, Finance, Tribal Administra-tion	Medium	EMPG, General Fund	On-Going	N	Emergency Services, Response, Recovery	Tribal
13. Utilize data from the current risk assessment to update GIS capacity and capabilities.									
New and Existing	All	3, 7	GIS/NR	Low	General Fund, HMGP	On-Going	N	Emergency Services, Prevention, Protection	Tribal
14. Identify and train Tribal staff, youth, and volunteers that will be utilized for emergency management efforts. Training to be considered includes ICS classes for NIMS compliance, ATC 20/45, Disaster Site Worker Training, Emergency Response Training, Hazmat Response, and Damage Assessment.									
New	All	3, 6, 7	EM, HR, Facilities, LE	Medium	General Fund, HLS	On-Going	N	Emergency Services	Tribal
15. Work with Tribal and local transit organizations to develop an exercise related to evacuation of residents.									
New	All	3, 5, 7	Tribal Transport.	Medium	DOT, HMEP, EMPG, Fire Grants, HUD, DOH	Short-Term	N	Emergency Services, Recovery	Tribal, Local, County
16. Leverage resources and partnerships to train and exercise together to ensure continuity during real world events.									
New	All	7	EM, Planning, LE	Medium	General Budget, HLS, DOJ Grants	On-Going	N	Emergency Services, Prevention	All
17. Develop (or update) plans to ensure response and recovery efforts. This includes working with the county and local municipalities to look at communications and interoperability issues.									

TABLE 15-2 HAZARD MITIGATION ACTION PLAN MATRIX									
Applies to new or existing assets	Hazards Mitigated	Objectives Met	Lead Agency (listed first) and others potentially involved	Estimated Cost	Sources of Funding	Timeline	Included in Previous Plan?	Initiative Type: Emergency Services, Property Protection, Prevention, Recovery, Structural Projects, Public Info., Natural Resources	Who or What Benefits from Action? Facility, Tribal, Local, County, Region
New and Existing	All	7	EM, Planning	Medium	Various depending on plan	On-Going	N	Prevention, Emergency Services, Recovery	All
18. Conduct public outreach on risk-reduction techniques for communicable diseases through public education campaigns which increase awareness of healthy behaviors, including during times when shelters are established.									
New	All	3, 6, 7	Tribal Health, County Health Department, Human Services, Casino	Low	General Fund	Short-Term	N	Public Education, Response, Recovery, Emergency Services	All
19. Considering developing programs and public outreach efforts which supports community participation in incentive-based programs, such as FireWise, StormReady Programs, and potentially the NFIP (should the Tribe elect to enroll in the program).									
New and Existing	Drought, F, LS, SW, WF	3, 6, 7	EM, Planning	Low	General Fund	Short-Term	N	Emergency Services, Public Education	Tribal, Local, County
20. Adopt the Tribal Hazard Mitigation Plan as an element of any comprehensive plan that the Tribe will create in order to ensure linkage between the various documents.									
New and Existing	All	All	Tribal Council, Planning	Low	General Fund	Long-Term	N	Prevention, Public Information, Property Protection, Emergency Services, Natural Resource Protection	Tribal
21. Utilizing data from this HMP, update the Emergency Operations Plan (EOP) to include all hazards of concern to establish management and operations during emergency or disaster situations.									
New and Existing	All	All	EM, LE, Planning, NR	Low	General Fund, THLS	Short-Term	N	Emergency Services, Recovery	Tribal
22. Develop a post-disaster action plan for all hazards of concern that addresses debris management, cultural/historical data gathering, substantial damage assessment, and grant management.									
New and Existing	All	All	EM, Planning, Cultural Heritage	Low	General Fund, BIA, THLS	Long-Term	N	Emergency Services, Recovery	Tribal

TABLE 15-2 HAZARD MITIGATION ACTION PLAN MATRIX									
Applies to new or existing assets	Hazards Mitigated	Objectives Met	Lead Agency (listed first) and others potentially involved	Estimated Cost	Sources of Funding	Timeline	Included in Previous Plan?	Initiative Type: Emergency Services, Property Protection, Prevention, Recovery, Structural Projects, Public Info., Natural Resources	Who or What Benefits from Action? Facility, Tribal, Local, County, Region
23. Consider codes and ordinances which positively influence the resiliency of the tribe from the hazards of concern, such as land use development; landscaping ordinance for fuel reduction; building codes for minimum seismic stability; flood damage prevention ordinance to cumulatively track substantial improvements and damage, etc.									
New and Existing	D, F, LS, SW, WF	All	Tribal Council, Planning	Low	General Fund	Long-Term	N	Prevention, Natural Resources, Structural	Tribal, Local, County
24. Secure funding to acquire generators to maintain critical infrastructure, including for water systems.									
New and Existing	CC, EQ, F, LS SW, WF	6, 7	Facilities	Medium	HMGP, THLS, BIA, DOH, General Fund	Short-Term	N	Emergency Services, Recovery	Facilities, Tribal
25. Continue working with Watershed Enhancement Board for various watershed improvement activities.									
New and Existing	Drought, F, LS, SW, WF	All	Natural Resources	Medium	WEB Grants	Long-Term	N	Prevention, Protection, Natural Resources	Region
26. Construct shelter facility for use during disaster incident. Facility can also be used as a warming, cooling, or feeding shelter during extreme weather events. Shelter should be constructed large enough to enable sheltering of citizens visiting the Tribal Planning Area, including Casino guests who may be stranded as a result of sudden-onset incident (e.g., earthquake).									
New	All	3, 4, 5, 6, 7, 8	EM	High	HUD Block Grants, General Fund, HMGP, PDM, HLS, Fire Grants	Short-Term	N	Prevention, Structural, Protection, Natural Resources	Tribal, Local, County, Region
27. Work with state to obtain spill response trailers to allow Tribe to respond to hazardous materials spills occurring in the Tribal Planning Area.									
New and Existing	All	4, 5, 6, 7	EM	High	State Grants/ Programs	Short-Term	N	Emergency Services, Protection, Prevention, Recovery, Structural, Natural Resources	Regional

15.5 BENEFIT/COST REVIEW

Once established, the action plan must then be prioritized according to some form of a benefit/cost analysis of the proposed projects and their associated costs. The benefits of proposed projects were weighed against estimated costs as part of the project prioritization process. The benefit/cost analysis was not of the detailed variety required by FEMA for project grant eligibility under the Hazard Mitigation Grant Program (HMGP) and Pre-Disaster Mitigation (PDM) grant program. A less formal approach was used because some projects may not be implemented for up to 10 years, and associated costs and benefits could change dramatically in that time. Therefore, a review of the apparent benefits versus the apparent cost of each project was performed. Parameters were established for assigning subjective ratings (high, medium, and low) to the costs and benefits of these projects.

Cost ratings were defined as follows:

- **High**—Existing funding will not cover the cost of the project; implementation would require new revenue through an alternative source (for example, bonds or grants).
- **Medium**—The project could be implemented with existing funding but would require a re-apportionment of the budget or a budget amendment, or the cost of the project would have to be spread over multiple years. If partial funding is available, or the project is a joint project with other agencies, *Partial* is also identified as an option.
- **Low**—The project could be funded under the existing budget. The project is part of or can be part of an ongoing existing program.

Benefit ratings were defined as follows:

- **High—**Project will provide an immediate reduction of risk exposure for life and property.
- **Medium—**Project will have a long-term impact on the reduction of risk exposure for life and property, or project will provide an immediate reduction in the risk exposure for property.
- **Low—**Long-term benefits of the project are difficult to quantify in the short term.

Using this approach, projects with positive benefit versus cost ratios (such as high over high, high over medium, medium over low, etc.) are considered cost-beneficial and are prioritized accordingly.

For many of the strategies identified in this action plan, the Stillaguamish Tribe of Indians may seek financial assistance under the HMGP or PDM programs, both of which require detailed benefit/cost analyses. These analyses will be performed on projects at the time of application using the FEMA benefit-cost model. For projects not seeking financial assistance from grant programs that require detailed analysis, the Tribe reserve the right to define "benefits" according to parameters that meet the goals and objectives of this plan.

15.6 ACTION PLAN PRIORITIZATION

Table 15-3 lists the priority of each initiative, using the same parameters used in selecting the initiatives. A qualitative benefit-cost review was performed for each of these initiatives. The priorities are defined as follows:

- **High Priority**—A project that meets multiple objectives (i.e., multiple hazards), has benefits that exceed cost, has funding secured or is an ongoing project and meets eligibility requirements for the HMGP or PDM grant program. High priority projects can be completed in the short term (1 to 5 years).
- **Medium Priority**—A project that meets goals and objectives, that has benefits that exceed costs, and for which funding has not been secured but that is grant eligible under HMGP, PDM

or other grant programs. Project can be completed in the short term, once funding is secured. Medium priority projects will become high priority projects once funding is secured.

- **Low Priority**—A project that will mitigate the risk of a hazard, that has benefits that do not exceed the costs or are difficult to quantify, for which funding has not been secured, that is not eligible for HMGP or PDM grant funding, and for which the time line for completion is long term (1 to 10 years). Low priority projects may be eligible for other sources of grant funding from other programs.

TABLE 15-3
PRIORITIZATION OF MITIGATION INITIATIVES

Initiative #	# of Objectives Met	Benefits	Costs	Do Benefits Equal or Exceed Costs?	Is Project Grant Eligible?	Can Project be Funded Under Existing Programs/ Budgets? (Yes / No / Partial)	Priority (High, Med., Low)
1	8	H	H	Y	Y	P	H
2	7	H	H	Y	Y	P	H
3	6	H	M	Y	Y	N	H
4	7	H	H	Y	Y	P	H
5	5	H	M	Y	Y	P	M
6	4	M	L	Y	N	Y	M
7	7	H	H	Y	Y	P	H
8	6	H	H	Y	Y	Y	H
9	8	H	H	Y	Y	P	H
10	8	H	H	Y	Y	Y	H
11	5	H	M	Y	Y	Y	H
12	8	M	M	Y	M	Y	M
13	2	M	L	Y	N	Y	L
14	3	M	L	Y	N	Y	L
15	3	M	L	Y	N	Y	M
16	1	M	L	Y	Y	Y	M
17	1	M	M	Y	N	P	M

TABLE 15-3
PRIORITIZATION OF MITIGATION INITIATIVES

Initiative #	# of Objectives Met	Benefits	Costs	Do Benefits Equal or Exceed Costs?	Is Project Grant Eligible?	Can Project be Funded Under Existing Programs/ Budgets? (Yes / No / Partial)	Priority (High, Med., Low)
18	3	H	L	Y	Y	Y	H
19	3	M	L	Y	N	Y	L
20	8	H	L	Y	N	Y	H
21	8	H	M	Y	Y	P	H
22	8	H	L	Y	N	Y	H
23	8	H	L	Y	N	Y	H
24	2	H	H	Y	Y	N	H
25	8	H	L	Y	Y	Y	H
26	6	H	H	Y	Y	N	H
27	4	H	M	Y	N	N	M

15.7 2015 ACTION PLAN STATUS

In addition to establishing new action items for the 2020 update, a comprehensive review of the previous action plan was performed to determine which actions were completed, which should carry over to the updated plan, and which were no longer feasible and should be removed from the plan. Table 15-4 identifies the results of this review.

TABLE 15-4
STATUS OF PREVIOUS HAZARD MITIGATION ACTION PLAN

		Current Status			
Mitigation Strategy	Project Status	Completed	Continual /Ongoing Nature	Removed -/No Longer Relevant / No Action	Carried Over
Replace substandard police building with one more resilient to hazard events like flooding, severe weather, earthquake, wildfire, and climate change	No action was taken by the Tribe to move forward with this initiative; however, the planning team felt this was still a viable project and it will be carried forward to the currently, with some slight modifications. (Incorporated into Strategy #7 in 2020 Update.)				X
Move buildings used for work areas by the Stillaguamish Natural Resources out of the floodplain.	Carried forward; no action taken during the life cycle of the previous plan. (Incorporated into Initiative #1 in 2020 update.)				X
Place large engineered log jam in the North and South Fork of the Stillaguamish Rivers to split flow and create complex river habitat area, thereby reducing flood-flow energy.	A significant amount of work along the Rivers has been completed since the last plan; however, this project has not been completed in its entirety, and will be carried forward.				X
Restore wetland and beaver habitat throughout the Stillaguamish watershed.	The Tribe has completed several restoration projects which have helped return the natural environment throughout the watershed. The Tribe has purchased several structures within the floodplain and watershed, removing the structures and restoring the land to its former natural state. This project will be carried forward, as the Tribe finds this to be of vital importance to maintaining the watershed area.	X	X		X

15.8 ADDITIONAL HAZARD MITIGATION PROJECTS AND EFFORTS

In addition to the above project status, the Tribe has also completed other mitigation-related efforts since completion of the previous plan, which include, but are not limited to:

- Bank Stabilization Project
- Wetland Project
- Pipeline Irrigation System
- Fish Passage Restoration Project

The Tribe has have worked in partnership with a number of different agencies and organizations for various projects since completion of the 2015 plan.

Forest and Timber Harvesting Practices

As a result of the 1974 Boldt Decision, the Natural Resources Department conducts both field and office reviews of proposed Forest Practices Applications within the Stillaguamish watershed and adjacent areas that may affect Treaty resources. This process often involves collaboration with industry, regulators, and other local stakeholders to guarantee timber harvest will not detrimentally affect Tribal resources.

Regulatory Review

As a sovereign government and steward of the natural environment, the Tribe reviews several categories of permits and project proposals to ensure compliance with existing regulations. Documents reviewed include but are not limited to Hydrologic Permits (HPAs), Forest Practice Applications (FPAs), projects subject to the State Environmental Policy Act (SEPA), select project proposals from the U.S. Army Corps of Engineers, and proposed changes to local, county, or state code that could detrimentally affect salmon habitat.

Policy Partnerships

The Tribe participates in several policy organizations aimed at protecting natural resources within the Stillaguamish Watershed. By collaborating with various stakeholders, the Department is able to increase support for projects restoring and preserving resources important to the Tribe.

Protection

In addition to restoring and acquiring parcels for conservation, the Natural Resources Department also works to protect properties outside of Tribal control by ensuring existing regulations are properly implemented and enforced. This involves collaboration and occasionally confrontation with a variety of local, state, and federal rule-makers and enforcers. Fish and wildlife know no jurisdictional boundaries; therefore, it is critical to protect the environment on and off Tribal land.

Conservation

Habitat restoration is critical to maintaining and enhancing cultural opportunities for Tribal members, however projects on private land are often limited and have no guarantee of longevity. Thus, the Stillaguamish Tribe has begun to focus on land acquisition as a means of habitat conservation. Benefits of an acquisition strategy for conservation include:

- Ensuring protection from development in perpetuity;
- Allows for larger scale restoration projects that wouldn’t be practical on occupied land (e.g., bank armoring removal, floodplain reconnection); and
- Provides exclusive access to Tribal members to exercise their cultural practices (depending on the funding source).

Stillaguamish Tidal Wetland Acquisition

In partnership with the Washington State Department of Ecology, the Stillaguamish Tribe of Indians received a $1 million dollar grant from the National Coastal Wetlands Conservation to acquire 248 acres of former estuarine and marine wetlands in Snohomish County. The goal is to return coastal wetland acres back to tidal and riverine influence to benefit a wide range of fish and wildlife species in the Stillaguamish and Skagit rivers.

CHAPTER 16.
IMPLEMENTATION AND MAINTENANCE

16.1 PLAN ADOPTION

A hazard mitigation plan must document that it has been formally adopted by the governing body of the jurisdiction requesting federal approval of the plan (44 CFR Section 201.7(c)(5)). DMA compliance and its benefits cannot be achieved until the plan is adopted. This plan was adopted by the Tribal Board of Directors in May 2020, with language allowing for plan modification if requested by FEMA without the necessity of re-adoption by the Tribe. A copy of the resolution is provided in Figure 16-1.

INSERT RESOLUTION

Insert Plan Adoption Resolution

Figure 16-1 Resolution Adopting Hazard Mitigation Plan

16.2 PLAN MAINTENANCE STRATEGY

A hazard mitigation plan must present a plan maintenance process that includes the following (44 CFR Section 201.7(c)(4)):

- A section describing the method and schedule for monitoring, evaluating, and updating the mitigation plan over a 5-year cycle; a system for monitoring implementation of mitigation measures and project closeouts.
- A system for reviewing progress on achieving goals, as well as specific activities and projects identified in the mitigation plan.
- A process by which Tribal governments incorporate the requirements of the mitigation plan into other planning mechanisms, such as comprehensive or capital improvement plans, when appropriate.
- A discussion on how the community will continue public participation in the plan maintenance process.

This chapter details the formal process that will ensure that the Hazard Mitigation Plan remains an active and relevant document and that the Stillaguamish Tribe of Indians maintains its eligibility for applicable funding sources. The plan maintenance process includes a schedule for monitoring and evaluating the plan annually and producing an updated plan every five years. This chapter also describes how public participation will be integrated throughout the plan maintenance and implementation process. It also explains how the mitigation strategies outlined in this Plan will be incorporated into existing planning mechanisms and programs, such as comprehensive land-use planning processes, capital improvement planning, and building code enforcement and implementation. The Plan's format allows sections to be reviewed and updated when new data become available, resulting in a plan that will remain current and relevant.

16.2.1 Plan Implementation

The effectiveness of the hazard mitigation plan depends on its implementation and incorporation of its action items into existing local plans, policies, and programs. Together, the action items in the Plan provide a framework for activities that the Stillaguamish Tribe can implement over the next 5 years. The Planning Team has established goals and objectives, and has prioritized mitigation actions that will be implemented through existing plans, policies, and programs. Implementation of the long-term and short-term objectives/goals will be dependent on securing funding for each of the strategies identified in the plan. The Tribe will actively pursue a variety of funding opportunities identified in the various plans and prioritized by the various departments and programs under the direction of Tribal Board of Directors.

The Emergency Manager will have lead responsibility for overseeing the Plan implementation and maintenance strategy. Plan implementation and evaluation will be a shared responsibility among all departments and agencies identified as lead agencies in the mitigation action plan.

The implementation of all short-term mitigation actions will primarily be monitored by the Emergency Manager on an ongoing basis until implementation is complete, unless identified otherwise. Long-term actions being actively implemented will be monitored on an ongoing basis, or at least annually as needed. Long-term actions planned for the future will be reviewed during plan updates every five years.

The system for reviewing progress on achieving goals, objectives, and specific actions included in the mitigation strategy will be based on a progress report of all objectives and actions. This progress report will be reviewed annually by the Emergency Manager. As described in the previous section, progress on mitigation actions will be described in an annual report to Stillaguamish Board of Directors and in the five-year update of the Hazard Mitigation Plan.

Project Tracking

In addition to the work products described in approved work plans for projects funded by the Pre-Disaster Mitigation Program, the Hazard Mitigation Grant Program, or other grant programs, quarterly or semi-annual (depending on reporting requirements of funding agencies) performance reports that identify accomplishments toward completing the work plan commitments, a discussion of the work performed for all work plan components, a discussion of any existing or potential problem areas that could affect project completion, budget status, and planned activities for the subsequent quarter (and/or annual and/biannual basis depending on the funding agency requirements and Tribal regulations) will be submitted to the funding agency by the assigned Project Manager and Grant Coordinator. The agency-specific final grant closeout documents will also be prepared by the Project Manager and Grant Coordinator at the conclusion of the performance period and submitted to the funding agency.

16.2.2 Planning Team

The Planning Team, while all tribal staff, served on the team in a voluntary capacity that oversaw the development of the Plan and made recommendations on key elements of the plan, including the maintenance strategy. The principal role of the Planning Team in this plan maintenance strategy will be to review the annual progress report and provide input on possible enhancements to be considered at the next update. Future plan updates will be overseen by a Planning Team similar to the one that participated in this plan development process, so keeping an interim Planning Team intact will provide a head start on future updates. It will be the Planning Team’s role to review the progress report in an effort to identify issues needing to be addressed by future plan updates.

16.2.3 Annual Progress Report

The minimum task of the ongoing annual planning team meeting will be the evaluation of the progress of its individual action plan during a 12-month performance period. This review will include the following:

- Summary of any hazard events and the impact these events had on the planning area;
- Review of mitigation success stories;
- Review of continuing public involvement;
- Brief discussion about why targeted strategies were not completed;
- Re-evaluation of the action plan to determine if the timeline for identified projects needs to be amended (such as changing a long-term project to a short-term one because of new funding);
- Recommendations for new projects;
- Changes in or potential for new funding options (grant opportunities);
- Impact of any other planning programs or initiatives that involve hazard mitigation.

The planning team has created a template for preparing a progress report (see Appendix B). The planning team will then prepare a formal annual report on the progress of the plan. This report should be used as follows:

- Presented to Tribal Board of Directors to inform them of the progress of actions implemented during the reporting period.

Annual progress reporting is not a requirement specified under 44 CFR. However, it may enhance opportunities for funding. While failure to implement this component of the plan maintenance strategy will not jeopardize compliance under the DMA, it may jeopardize the opportunity to leverage funding opportunities with other agencies.

16.2.4 Plan Update

CFR 201.7 requires that tribal hazard mitigation plans be reviewed, revised if appropriate, and resubmitted for approval in order to remain eligible for benefits under the DMA (44 CFR, Section 201.7(d)(3)). The Stillaguamish Tribe intends to update the hazard mitigation plan on a 5-year cycle from the date of initial plan adoption. This cycle may be accelerated to less than 5 years based on the following triggers:

- A Presidential Disaster Declaration that impacts the planning area;
- A hazard event that causes loss of life; or
- New data becomes available which significantly changes the findings of the risk assessment.

It will not be the intent of future updates to develop a completely new hazard mitigation plan for the planning area. The update will, at a minimum, include the following elements:

- The update process will be convened through a planning team.
- The hazard risk assessment will be reviewed and, if necessary, updated using best available information and technologies.
- The action plan 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 policies identified under other planning mechanisms (such as the comprehensive 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.
- Tribal Council will adopt the updated plan.

16.2.5 Continuing Public Involvement

The public will continue to be apprised of the plan's progress through the Tribe's website and by providing copies of annual progress reports at various public outreach meetings. Copies of the plan will be shared with the various Tribal departments and tribal members as requested. Upon initiation of future update processes, a new public involvement strategy will be initiated based on guidance from a new Planning Team. This strategy will be based on the needs and capabilities of the Tribe at the time of the update. At a minimum, this strategy will include the use of local media outlets within the planning area.

16.2.6 Incorporation into Other Planning Mechanisms

The information on hazard, risk, vulnerability, and mitigation contained in this plan is based on the best science and technology available at the time this plan was prepared. The Stillaguamish Tribe, through its various on-going capital improvement projects has planned for the impact of natural hazards. The plan development process provided the opportunity to review and expand on policies in these planning mechanisms. The Emergency Operations Plan and land use regulations are complementary documents that work together to achieve the goal of reducing risk exposure.

The Stillaguamish Tribe will create a linkage between the hazard mitigation plan and the comprehensive land use plan by identifying a mitigation initiative as such and giving that initiative a high priority. Other planning processes and programs to be coordinated with the recommendations of the hazard mitigation plan include the following:

- Emergency response plans
- Capital improvement programs
- Tribal codes
- Community design guidelines
- Restoration plans
- Water-efficient landscape design guidelines
- Stormwater management programs
- Water system vulnerability assessments
- Community Wildfire Protection Plans
- Vegetation Studies
- Transportation Plans
- Climate Adaptation Plans
- Master fire protection plans.

Some action items do not need to be implemented through regulation. Instead, these items can be implemented through the creation of new educational programs, continued interagency coordination, or improved public participation. As information becomes available from other planning mechanisms that can enhance this plan, that information will be incorporated via the update process.

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APPENDIX A.
ACRONYMS AND DEFINITIONS

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ACRONYMS AND DEFINITIONS

ACRONYMS

CFR—Code of Federal Regulations

cfs—cubic feet per second

CIP—Capital Improvement Plan

CRS—Community Rating System

DFIRM—Digital Flood Insurance Rate Maps

DHS—Department of Homeland Security

DMA —Disaster Mitigation Act

EAP—Emergency Action Plan

EPA—U.S. Environmental Protection Agency

ESA—Endangered Species Act

FEMA—Federal Emergency Management Agency

FERC—Federal Energy Regulatory Commission

FIRM—Flood Insurance Rate Map

FIS—Flood Insurance Study

GIS—Geographic Information System

HAZUS-MH—Hazards, United States-Multi Hazard

HMGP—Hazard Mitigation Grant Program

IBC—International Building Code

IRC—International Residential Code

MM—Modified Mercalli Scale

NEHRP—National Earthquake Hazards Reduction Program

NFIP—National Flood Insurance Program

NOAA—National Oceanic and Atmospheric Administration

NWS—National Weather Service

PDM—Pre-Disaster Mitigation Grant Program

PDI—Palmer Drought Index

PGA—Peak Ground Acceleration

PHDI—Palmer Hydrological Drought Index

SFHA—Special Flood Hazard Area

SHELDUS—Special Hazard Events and Losses Database for the US

SPI—Standardized Precipitation Index

USGS—U.S. Geological Survey

DEFINITIONS

100-Year Flood: The term “100-year flood” can be misleading. The 100-year flood does not necessarily occur once every 100 years. Rather, it is the flood that has a 1 percent chance of being equaled or exceeded in any given year. Thus, the 100-year flood could occur more than once in a relatively short period of time. The Federal Emergency Management Agency (FEMA) defines it as the 1 percent annual chance flood, which is now the standard definition used by most agencies and by the National Flood Insurance Program (NFIP).

Acre-Foot: An acre-foot is the amount of water it takes to cover 1 acre to a depth of 1 foot. This measure is used to describe the quantity of storage in a water reservoir. An acre-foot is a unit of volume. One acre foot equals 7,758 barrels; 325,829 gallons; or 43,560 cubic feet. An average household of four will use approximately 1 acre-foot of water per year.

Asset: An asset is any man-made or natural feature that has value, including, but not limited to, people; buildings; infrastructure, such as bridges, roads, sewers, and water systems; lifelines, such as electricity and communication resources; and environmental, cultural, or recreational features such as parks, wetlands, and landmarks.

Base Flood: The flood having a 1% chance of being equaled or exceeded in any given year, also known as the “100-year” or “1% chance” flood. The base flood is a statistical concept used to ensure that all properties subject to the National Flood Insurance Program (NFIP) are protected to the same degree against flooding.

Basin: A basin is the area within which all surface water—whether from rainfall, snowmelt, springs, or other sources—flows to a single water body or watercourse. The boundary of a river basin is defined by natural topography, such as hills, mountains, and ridges. Basins are also referred to as “watersheds” and “drainage basins.”

Benefit: A benefit is a net project outcome and is usually defined in monetary terms. Benefits may include direct and indirect effects. For the purposes of benefit-cost analysis of proposed mitigation measures, benefits are limited to specific, measurable, risk reduction factors, including reduction in expected property losses (buildings, contents, and functions) and protection of human life.

Benefit/Cost Analysis: A benefit/cost analysis is a systematic, quantitative method of comparing projected benefits to projected costs of a project or policy. It is used as a measure of cost effectiveness.

Building: A building is defined as a structure that is walled and roofed, principally aboveground, and permanently fixed to a site. The term includes manufactured homes on permanent foundations on which the wheels and axles carry no weight.

Capability Assessment: A capability assessment provides a description and analysis of a community’s current capacity to address threats associated with hazards. The assessment includes two components: an inventory of an agency’s mission, programs, and policies, and an analysis of its capacity to carry them out. A capability assessment is an integral part of the planning process in which a community’s actions to reduce losses are identified, reviewed, and analyzed, and the framework for implementation is identified. The following capabilities were reviewed under this assessment:

- Legal and regulatory capability
- Administrative and technical capability
- Fiscal capability

Community Rating System (CRS): The CRS is a voluntary program under the NFIP that rewards participating communities (provides incentives) for exceeding the minimum requirements of the NFIP and completing activities that reduce flood hazard risk by providing flood insurance premium discounts.

Critical Area: An area defined by state or local regulations as deserving special protection because of unique natural features or its value as habitat for a wide range of species of flora and fauna. A sensitive/critical area is usually subject to more restrictive development regulations.

Critical Facility: Facilities and infrastructure that are critical 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:

- 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 contain occupants 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, and
- Public and private utilities, facilities and infrastructure that are vital to maintaining or restoring normal services to areas damaged by hazard events.
- Government facilities.

For the purposes of this planning effort, the Planning Team elected to define all structures on the reservation, including culturally significant areas, as critical facilities due to the impact the loss of one structure would have on the Tribe.

Cubic Feet per Second (cfs): Discharge or river flow is commonly measured in cfs. One cubic foot is about 7.5 gallons of liquid.

Dam: Any artificial barrier or controlling mechanism that can or does impound 10 acre-feet or more of water.

Dam Failure: Dam failure refers to a partial or complete breach in a dam (or levee) that impacts its integrity. Dam failures occur for a number of reasons, such as flash flooding, inadequate spillway size, mechanical failure of valves or other equipment, freezing and thawing cycles, earthquakes, and intentional destruction.

Debris Avalanche: Volcanoes are prone to debris and mountain rock avalanches that can approach speeds of 100 mph.

Debris Flow: Dense mixtures of water-saturated debris that move down-valley; looking and behaving much like flowing concrete. They form when loose masses of unconsolidated material are saturated, become unstable, and move down slope. The source of water varies but includes rainfall, melting snow or ice, and glacial outburst floods.

Debris Slide: Debris slides consist of unconsolidated rock or soil that has moved rapidly down slope. They occur on slopes greater than 65 percent.

Disaster Mitigation Act of 2000 (DMA); The DMA is Public Law 106-390 and is the latest federal legislation enacted to encourage and promote proactive, pre-disaster planning as a condition of receiving financial assistance under the Robert T. Stafford Act. The DMA emphasizes planning for disasters before they occur. Under the DMA, a pre-disaster hazard mitigation program and new requirements for the national post-disaster hazard mitigation grant program (HMGP) were established.

Drainage Basin: A basin is the area within which all surface water- whether from rainfall, snowmelt, springs or other sources- flows to a single water body or watercourse. The boundary of a river basin is defined by natural topography, such as hills, mountains and ridges. Drainage basins are also referred to as **watersheds** or **basins**.

Drought: Drought is a period of time without substantial rainfall or snowfall from one year to the next. Drought can also be defined as the cumulative impacts of several dry years or a deficiency of precipitation over an extended period of time, which in turn results in water shortages for some activity, group, or environmental function. A hydrological drought is caused by deficiencies in surface and subsurface water supplies. A socioeconomic drought impacts the health, well-being, and quality of life or starts to have an adverse impact on a region. Drought is a normal, recurrent feature of climate and occurs almost everywhere.

Earthquake: An earthquake is defined as a sudden slip on a fault, volcanic or magmatic activity, and sudden stress changes in the earth that result in ground shaking and radiated seismic energy. Earthquakes can last from a few seconds to over 5 minutes, and have been known to occur as a series of tremors over a period of several days. The actual movement of the ground in an earthquake is seldom the direct cause of injury or death. Casualties may result from falling objects and debris as shocks shake, damage, or demolish buildings and other structures.

Exposure: Exposure is defined as the number and dollar value of assets considered to be at risk during the occurrence of a specific hazard.

Extent: The extent is the size of an area affected by a hazard.

Fire Behavior: Fire behavior refers to the physical characteristics of a fire and is a function of the interaction between the fuel characteristics (such as type of vegetation and structures that could burn), topography, and weather. Variables that affect fire behavior include the rate of spread, intensity, fuel consumption, and fire type (such as underbrush versus crown fire).

Fire Frequency: Fire frequency is the broad measure of the rate of fire occurrence in a particular area. An estimate of the areas most likely to burn is based on past fire history or fire rotation in the area, fuel conditions, weather, ignition sources (such as human or lightning), fire suppression response, and other factors.

Flash Flood: A flash flood occurs with little or no warning when water levels rise at an extremely fast rate

Flood Insurance Rate Map (FIRM): FIRMs are the official maps on which the Federal Emergency Management Agency (FEMA) has delineated the Special Flood Hazard Area (SFHA).

Flood Insurance Study: A report published by the Federal Insurance and Mitigation Administration for a community in conjunction with the community’s Flood Insurance rate Map. The study contains such background data as the base flood discharges and water surface elevations that were used to prepare the FIRM. In most cases, a community FIRM with detailed mapping will have a corresponding flood insurance study.

Floodplain: Any land area susceptible to being inundated by flood waters from any source. A flood insurance rate map identifies most, but not necessarily all, of a community's floodplain as the Special Flood Hazard Area (SFHA).

Floodway: Floodways are areas within a floodplain that are reserved for the purpose of conveying flood discharge without increasing the base flood elevation more than 1 foot. Generally speaking, no development is allowed in floodways, as any structures located there would block the flow of floodwaters.

Floodway Fringe: Floodway fringe areas are located in the floodplain but outside of the floodway. Some development is generally allowed in these areas, with a variety of restrictions. On maps that have identified and delineated a floodway, this would be the area beyond the floodway boundary that can be subject to different regulations.

Fog: Fog refers to a cloud (or condensed water droplets) near the ground. Fog forms when air close to the ground can no longer hold all the moisture it contains. Fog occurs either when air is cooled to its dew point or the amount of moisture in the air increases. Heavy fog is particularly hazardous because it can restrict surface visibility. Severe fog incidents can close roads, cause vehicle accidents, cause airport delays, and impair the effectiveness of emergency response. Financial losses associated with transportation delays caused by fog have not been calculated in the United States but are known to be substantial.

Freeboard: Freeboard is the margin of safety added to the base flood elevation.

Frequency: For the purposes of this plan, frequency refers to how often a hazard of specific magnitude, duration, and/or extent is expected to occur on average. Statistically, a hazard with a 100-year frequency is expected to occur about once every 100 years on average and has a 1 percent chance of occurring any given year. Frequency reliability varies depending on the type of hazard considered.

Fujita Scale of Tornado Intensity: Tornado wind speeds are sometimes estimated on the basis of wind speed and damage sustained using the Fujita Scale. The scale rates the intensity or severity of tornado events using numeric values from F0 to F5 based on tornado wind speed and damage. An F0 tornado (wind speed less than 73 miles per hour (mph)) indicates minimal damage (such as broken tree limbs), and an F5 tornado (wind speeds of 261 to 318 mph) indicates severe damage.

Goal: A goal is a general guideline that explains what is to be achieved. Goals are usually broad-based, long-term, policy-type statements and represent global visions. Goals help define the benefits that a plan is trying to achieve. The success of a hazard mitigation plan is measured by the degree to which its goals have been met (that is, by the actual benefits in terms of actual hazard mitigation).

Geographic Information System (GIS): GIS is a computer software application that relates data regarding physical and other features on the earth to a database for mapping and analysis.

Hazard: A hazard is a source of potential danger or adverse condition that could harm people and/or cause property damage.

Hazard Mitigation Grant Program (HMGP): Authorized under Section 202 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, the HMGP is administered by FEMA and provides grants to states, tribes, and local governments to implement hazard mitigation actions after a major disaster declaration. The purpose of the program is to reduce the loss of life and property due to disasters and to enable mitigation activities to be implemented as a community recovers from a disaster

Hazards U.S. Multi-Hazard (HAZUS-MH) Loss Estimation Program: HAZUS-MH is a GIS-based program used to support the development of risk assessments as required under the DMA. The HAZUS-MH software program assesses risk in a quantitative manner to estimate damages and losses associated with natural hazards. HAZUS-MH is FEMA's nationally applicable, standardized methodology and software program and contains modules for estimating potential losses from earthquakes, floods, and wind hazards. HAZUS-MH has also been used to assess vulnerability (exposure) for other hazards.

Hydraulics: Hydraulics is the branch of science or engineering that addresses fluids (especially water) in motion in rivers or canals, works and machinery for conducting or raising water, the use of water as a prime mover, and other fluid-related areas.

Hydrology: Hydrology is the analysis of waters of the earth. For example, a flood discharge estimate is developed by conducting a hydrologic study.

Intensity: For the purposes of this plan, intensity refers to the measure of the effects of a hazard.

Inventory: The assets identified in a study region comprise an inventory. Inventories include assets that could be lost when a disaster occurs and community resources are at risk. Assets include people, buildings, transportation, and other valued community resources.

Landslide: Landslides can be described as the sliding movement of masses of loosened rock and soil down a hillside or slope. Fundamentally, slope failures occur when the strength of the soils forming the slope exceeds the pressure, such as weight or saturation, acting upon them.

Lightning: Lightning is an electrical discharge resulting from the buildup of positive and negative charges within a thunderstorm. When the buildup becomes strong enough, lightning appears as a "bolt," usually within or between clouds and the ground. A bolt of lightning instantaneously reaches temperatures approaching 50,000ºF. The rapid heating and cooling of air near lightning causes thunder. Lightning is a major threat during thunderstorms. In the United States, 75 to 100 Americans are struck and killed by lightning each year (see http://www.fema.gov/hazard/thunderstorms/thunder.shtm).

Liquefaction: Liquefaction is the complete failure of soils, occurring when soils lose shear strength and flow horizontally. It is most likely to occur in fine grain sands and silts, which behave like viscous fluids when liquefaction occurs. This situation is extremely hazardous to development on the soils that liquefy, and generally results in extreme property damage and threats to life and safety.

Local Government: Any county, municipality, city, town, township, public authority, school district, special district, intrastate district, council of governments (regardless of whether the council of governments is incorporated as a nonprofit corporation under State law), regional or interstate government entity, or agency or instrumentality of a local government; any Indian tribe or authorized tribal organization, or Alaska Native village or organization; and any rural community, unincorporated town or village, or other public entity.

Magnitude: Magnitude is the measure of the strength of an earthquake, and is typically measured by the Richter scale. As an estimate of energy, each whole number step in the magnitude scale corresponds to the release of about 31 times more energy than the amount associated with the preceding whole number value.

Mass movement: A collective term for landslides, mudflows, debris flows, sinkholes and lahars.

Mitigation: A preventive action that can be taken in advance of an event that will reduce or eliminate the risk to life or property.

Mitigation Actions: Mitigation actions are specific actions to achieve goals and objectives that minimize the effects from a disaster and reduce the loss of life and property.

Objective: For the purposes of this plan, an objective is defined as a short-term aim that, when combined with other objectives, forms a strategy or course of action to meet a goal. Unlike goals, objectives are specific and measurable.

Peak Ground Acceleration: Peak Ground Acceleration (PGA) is a measure of the highest amplitude of ground shaking that accompanies an earthquake, based on a percentage of the force of gravity.

Preparedness: Preparedness refers to actions that strengthen the capability of government, citizens, and communities to respond to disasters.

Presidential Disaster Declaration: These declarations are typically made for events that cause more damage than state and local governments and resources can handle without federal government assistance. Generally, no specific dollar loss threshold has been established for such declarations. A Presidential Disaster Declaration puts into motion long-term federal recovery programs, some of which are matched by state programs, designed to help disaster victims, businesses, and public entities.

Probability of Occurrence: The probability of occurrence is a statistical measure or estimate of the likelihood that a hazard will occur. This probability is generally based on past hazard events in the area and a forecast of events that could occur in the future. A probability factor based on yearly values of occurrence is used to estimate probability of occurrence.

Repetitive Loss Property: Any NFIP-insured property that, since 1978 and regardless of any changes of ownership during that period, has experienced:

- Four or more paid flood losses in excess of $1000.00; or
- Two paid flood losses in excess of $1000.00 within any 10-year period since 1978 or
- Three or more paid losses that equal or exceed the current value of the insured property.

Return Period (or Mean Return Period): This term refers to the average period of time in years between occurrences of a particular hazard (equal to the inverse of the annual frequency of occurrence).

Riverine: Of or produced by a river. Riverine floodplains have readily identifiable channels. Floodway maps can only be prepared for riverine floodplains.

Risk: Risk is the estimated impact that a hazard would have on people, services, facilities, and structures in a community. Risk measures the likelihood of a hazard occurring and resulting in an adverse condition that causes injury or damage. Risk is often expressed in relative terms such as a high, moderate, or low likelihood of sustaining damage above a particular threshold due to occurrence of a specific type of hazard. Risk also can be expressed in terms of potential monetary losses associated with the intensity of the hazard.

Risk Assessment: Risk assessment is the process of measuring potential loss of life, personal injury, economic injury, and property damage resulting from hazards. This process assesses the vulnerability of people, buildings, and infrastructure to hazards and focuses on (1) hazard identification; (2) impacts of hazards on physical, social, and economic assets; (3) vulnerability identification; and (4) estimates of the cost of damage or costs that could be avoided through mitigation.

Risk Ranking: This ranking serves two purposes, first to describe the probability that a hazard will occur, and second to describe the impact a hazard will have on people, property, and the economy. Risk estimates are based on the methodology for each hazard as identified within this plan.

Robert T. Stafford Act: The Robert T. Stafford Disaster Relief and Emergency Assistance Act, Public Law 100-107, was signed into law on November 23, 1988. This law amended the Disaster Relief Act of 1974, Public Law 93-288. The Stafford Act is the statutory authority for most federal disaster response activities, especially as they pertain to FEMA and its programs.

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

Special Flood Hazard Area: The base floodplain delineated on a Flood Insurance Rate Map. The SFHA is mapped as a Zone A in riverine situations and zone V in coastal situations. The SFHA may or may not encompass all of a community's flood problems

Stakeholder: Business leaders, civic groups, academia, non-profit organizations, major employers, managers of critical facilities, farmers, developers, special purpose districts, and others whose actions could impact hazard mitigation.

Stream Bank Erosion: Stream bank erosion is common along rivers, streams and drains where banks have been eroded, sloughed or undercut. However, it is important to remember that a stream is a dynamic and constantly changing system. It is natural for a stream to want to meander, so not all eroding banks are "bad" and in need of repair. Generally, stream bank erosion becomes a problem where development has limited the meandering nature of streams, where streams have been channelized, or where stream bank structures (like bridges, culverts, etc.) are located in places where they can actually cause damage to downstream areas. Stabilizing these areas can help protect watercourses from continued sedimentation, damage to adjacent land uses, control unwanted meander, and improvement of habitat for fish and wildlife.

Steep Slope: Different communities and agencies define it differently, depending on what it is being applied to, but generally a steep slope is a slope in which the percent slope equals or exceeds 25%. For this study, steep slope is defined as slopes greater than 33%.

Sustainable Hazard Mitigation: This concept 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.

Thunderstorm: A thunderstorm is a storm with lightning and thunder produced by cumulonimbus clouds. Thunderstorms usually produce gusty winds, heavy rains, and sometimes hail. Thunderstorms are usually short in duration (seldom more than 2 hours). Heavy rains associated with thunderstorms can lead to flash flooding during the wet or dry seasons.

Tornado: A tornado is a violently rotating column of air extending between and in contact with a cloud and the surface of the earth. Tornadoes are often (but not always) visible as funnel clouds. On a local scale, tornadoes are the most intense of all atmospheric circulations, and winds can reach destructive speeds of more than 300 mph. A tornado's vortex is typically a few hundred meters in diameter, and damage paths can be up to 1 mile wide and 50 miles long.

Vulnerability: Vulnerability describes how exposed or susceptible an asset is to damage. Vulnerability depends on an asset's construction, contents, and the economic value of its functions. Like indirect damages, the vulnerability of one element of the community is often related to the vulnerability of another.

For example, many businesses depend on uninterrupted electrical power. Flooding of an electric substation would affect not only the substation itself but businesses as well. Often, indirect effects can be much more widespread and damaging than direct effects.

Watershed: A watershed is an area that drains downgradient from areas of higher land to areas of lower land to the lowest point, a common drainage basin.

Wildfire: These terms refer to any uncontrolled fire occurring on undeveloped land that requires fire suppression. The potential for wildfire is influenced by three factors: the presence of fuel, topography, and air mass. Fuel can include living and dead vegetation on the ground, along the surface as brush and small trees, and in the air such as tree canopies. Topography includes both slope and elevation. Air mass includes temperature, relative humidity, wind speed and direction, cloud cover, precipitation amount, duration, and the stability of the atmosphere at the time of the fire. Wildfires can be ignited by lightning and, most frequently, by human activity including smoking, campfires, equipment use, and arson.

Windstorm: Windstorms are generally short-duration events involving straight-line winds or gusts exceeding 50 mph. These gusts can produce winds of sufficient strength to cause property damage. Windstorms are especially dangerous in areas with significant tree stands, exposed property, poorly constructed buildings, mobile homes (manufactured housing units), major infrastructure, and aboveground utility lines. A windstorm can topple trees and power lines; cause damage to residential, commercial, critical facilities; and leave tons of debris in its wake.

Zoning Ordinance: The zoning ordinance designates allowable land use and intensities for a local jurisdiction. Zoning ordinances consist of two components: a zoning text and a zoning map.

APPENDIX B.
EXAMPLE PROGRESS REPORT

APPENDIX B.
EXAMPLE PROGRESS REPORT

The Stillaguamish Tribe of Indians
Hazard Mitigation Plan
Annual Progress Report

Reporting Period: *(Insert reporting period)*

Background: The Stillaguamish Tribe of Indians developed a hazard mitigation plan to reduce risk from all hazards by identifying resources, information, and strategies for risk reduction. The federal Disaster Mitigation Act of 2000 requires state and local governments to develop hazard mitigation plans as a condition for federal disaster grant assistance. To prepare the plan, the Tribe organized resources, assessed risks from natural hazards, developed planning goals and objectives, reviewed mitigation alternatives, and developed an action plan to address probable impacts from natural hazards. By completing this process, the Tribe maintained compliance with the Disaster Mitigation Act, achieving eligibility for mitigation grant funding opportunities afforded under the Robert T. Stafford Act. The plan can be viewed on-line at:

INSERT LINK

Summary Overview of the Plan's Progress: The performance period for the Hazard Mitigation Plan became effective on ____, 2020, with the final approval of the plan by FEMA. The initial performance period for this plan will be 5 years, with an anticipated update to the plan to occur before ______, 20__. As of this reporting period, the performance period for this plan is considered to be __% complete. The Hazard Mitigation Plan has targeted __ hazard mitigation initiatives to be pursued during the 5-year performance period. As of the reporting period, the following overall progress can be reported:

- __ out of __ initiatives (__%) reported ongoing action toward completion.
- __ out of __ initiatives (__%) were reported as being complete.
- __ out of __ initiatives (___%) reported no action taken.

Purpose: The purpose of this report is to provide an annual update on the implementation of the action plan identified in the Tribe's Hazard Mitigation Plan. The objective is to ensure that there is a continuing and responsive planning process that will keep the Hazard Mitigation Plan dynamic and responsive to the needs and capabilities of the Stillaguamish Tribe of Indians. This report discusses the following:

- Natural hazard events that have occurred within the last year
- Changes in risk exposure within the planning area
- Mitigation success stories
- Review of the action plan
- Changes in capabilities that could impact plan implementation
- Recommendations for changes/enhancement.

The Hazard Mitigation Plan Planning Team: The Hazard Mitigation Plan Planning Team, made up of stakeholders within the planning area, reviewed and approved this progress report at its annual meeting held on _____, 20___. It was determined through the plan's development process that a Planning Team would remain in service to oversee maintenance of the plan. At a minimum, the Planning Team will provide technical review and oversight on the development of the annual progress report. It is anticipated that there will be turnover in the membership annually, which will be documented in the progress reports. For this reporting period, the Planning Team membership is as indicated in Table 1.

TABLE 1.
PLANNING TEAM MEMBERS

Name	Title	Jurisdiction/Agency

Natural Hazard Events within the Planning Area: During the reporting period, there were __ natural hazard events in the planning area that had a measurable impact on people or property. A summary of these events is as follows:

- ____________________________
- ____________________________

Changes in Risk Exposure in the Planning Area: *(Insert brief overview of any natural hazard event in the planning area that changed the probability of occurrence or ranking of risk for the hazards addressed in the hazard mitigation plan)*

Mitigation Success Stories: *(Insert brief overview of mitigation accomplishments during the reporting period)*

Review of the Action Plan: Table 2 reviews the action plan, reporting the status of each initiative. Reviewers of this report should refer to the Hazard Mitigation Plan for more detailed descriptions of each initiative and the prioritization process.

Address the following in the "status" column of the following table:

- *Was any element of the initiative carried out during the reporting period?*
- *If no action was completed, why?*
- *Is the timeline for implementation for the initiative still appropriate?*
- *If the initiative was completed, does it need to be changed or removed from the action plan?*

TABLE 2.
ACTION PLAN MATRIX

Action Taken? (Yes or No)	Time Line	Priority	Status	Status (X, O,✓)
Initiative #__—____________________[description]				
Initiative #__—____________________[description]				
Initiative #__—____________________[description]				
Initiative #__—____________________[description]				
Initiative #__—____________________[description]				
Initiative #__—____________________[description]				
Initiative #__—____________________[description]				
Initiative #__—____________________[description]				
Initiative #__—____________________[description]				

Completion status legend:
✓= Project Completed
O = Action ongoing toward completion
X = No progress at this time

Changes That May Impact Implementation of the Plan: *(Insert brief overview of any significant changes in the planning area that would have a profound impact on the implementation of the plan. Specify any changes in technical, regulatory and financial capabilities identified during the plan's development)*

Recommendations for Changes or Enhancements: Based on the review of this report by the Hazard Mitigation Plan Planning Team, the following recommendations will be noted for future updates or revisions to the plan:

- ______________________________
- ______________________________
- ______________________________
- ______________________________
- ______________________________
- ______________________________

Public review notice: *The contents of this report are considered to be public knowledge and have been prepared for total public disclosure. Copies of the report have been provided to the Tribe's governing board and to local media outlets and the report is posted on the Tribe's Hazard Mitigation Plan website. Any questions or comments regarding the contents of this report should be directed to:*

Insert Contact Info Here