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2024 CHELAN COUNTY MULTI-JURISDICTION NATURAL HAZARD MITIGATION PLAN

Volume 1 – Area-Wide Elements

PREPARED FOR

COUNTY OF CHELAN

DECEMBER 2, 2024

PERTEET

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EXECUTIVE SUMMARY

HAZARD MITIGATION OVERVIEW

Hazard mitigation is the use of long-term and short-term policies, programs, projects, and other activities to alleviate the death, injury, and property damage that can result from a disaster. Chelan County and a partnership of local governments, community-based organizations, and other stakeholders within the county have developed a hazard mitigation plan to reduce risks from natural disasters anywhere within the Chelan County boundaries. The plan complies with federal and state hazard mitigation planning requirements to establish eligibility for funding under Federal Emergency Management Agency (FEMA) grant programs for all planning partners.

UPDATING THE CHELAN COUNTY PLAN

This plan is a comprehensive update of the 2019 *Chelan County Hazard Mitigation Plan*, which covered the cities of Cashmere, Chelan, Entiat, Leavenworth, and Wenatchee, the unincorporated areas of Chelan County, and nine special purpose districts. These districts included the Chelan County Flood Control Zone District, Cascadia Conservation District, Lake Chelan Reclamation District and six fire districts. FEMA approved the 2019 plan on December 10, 2019, and it expired on December 9, 2024. This update reestablishes FEMA hazard mitigation grant assistance eligibility for participating planning partners.

Table ES-1. Planning Partners

Jurisdiction	Point of Contact	Title
Chelan County	Mike Kaputa	Natural Resources Department Director
City of Wenatchee	Jessica Shaw	Utilities Manager
City of Leavenworth	Maggie Boles	Development Services Manager
City of Chelan	Wade Ferris	Planning Director
City of Entiat	Mark Botello	Public Works Director
City of Cashmere	Steve Croci	Director of Operations
Fire District #1	Brian Brett	Fire Chief
Fire District #3	Mike Smith	Fire Captain
Fire District #5	Arnold Baker	Fire Chief

Fire District #6	Steven Spies	Fire Chief
Fire District #7	Brandon Asher	Fire Chief
Fire District #8	Adam Jones	Fire Chief
Fire District #9 (Lake Wenatchee Fire and Rescue)	Kris King	Wildfire Risk Reduction Coordinator
Chelan County Flood Control Zone District	Jason Detamore	Environmental Director
Cascadia Conservation District	Ryan Williams	Executive Director

PLAN DEVELOPMENT APPROACH

Organization

A core planning team consisting of contract consultants, Chelan County Department of Natural Resources staff, and Cascadia Conservation District staff was assembled to facilitate this plan update. A planning partnership was formed by engaging eligible local governments and making sure they understood their expectations for compliance under the updated plan. An 18-member steering committee was assembled to oversee the plan update, consisting of both governmental (50%) and non-governmental (50%) stakeholders within the planning area. In addition to the 18 primary members, there were 10 alternates. Coordination with other county, state, and federal agencies involved in hazard mitigation occurred throughout the plan update process. Organization efforts included a review of the 2019 Chelan County Hazard Mitigation Plan, the Washington State Hazard Mitigation Plan, and existing programs that may support hazard mitigation actions.

Public Outreach

The planning team implemented a multi-media public involvement strategy utilizing the outreach capabilities of the planning partnership that was approved by the Steering Committee. The strategy included public meetings, a hazard mitigation survey, a project website, an ArcGIS Story Map, and the use of social media and multiple media releases.

Plan Document Development

The planning team and Steering Committee assembled a document to meet federal hazard mitigation planning requirements for all partners. The updated plan contains two volumes. Volume 1 contains components that apply to all partners and the broader planning area. Volume 2 contains all components that are jurisdiction-specific. Each planning partner has a dedicated annex in Volume 2.

Adoption

Once pre-adoption approval has been granted by the Washington Emergency Management Division and FEMA Region X, the final adoption phase will begin. Each planning partner will individually adopt the updated plan.

RISK ASSESSMENT

Risk assessment is the process of measuring the potential loss of life resulting from natural hazards, as well as personal injury, economic injury and property damage, in order to determine the vulnerability of people, buildings, and infrastructure to natural hazards. For this update, risk assessment models were enhanced with new data and technologies that have become available since 2019. The Steering Committee used the risk assessment to rank risk and to gauge the potential impacts of each hazard of concern in the county. The risk assessment included the following:

- Hazard identification and profiling
- Assessment of the impact of hazards on physical, social, and economic assets
- Identification of particular areas of vulnerability
- Estimates of the cost of potential damage.

Based on the risk assessment, hazards were ranked for the risk they pose to the overall planning area, as shown in Table ES-2. Each planning partner also ranked hazards for its own area. Table ES-3 summarizes the categories of high, medium, and low (relative to other rankings) based on the numerical ratings that each jurisdiction assigned each hazard.

Table ES-2. Hazard Risk Ranking

Hazard Ranking	Hazard Event	Category
1	Wildfire	High
2	Severe Weather	High
3	Earthquake	Medium
4	Flooding	Medium
5	Landslide	Medium
6	Avalanche	Low
7	Drought	Low
8	Dam Failure	Low

Table ES-3. Summary of Hazard Ranking Results

	Number of Jurisdictions Assigning Ranking to Hazard			
	High	Medium	Low	Not Ranked
Dam Failure	0	0	5	1
Drought	0	6	0	0
Earthquake	2	4	0	0
Flooding	0	4	1	0
Landslide	0	2	0	4
Severe Weather	6	0	0	0
Avalanche	0	0	1	5
Wildfire	5	1	0	0

MITIGATION GOALS AND OBJECTIVES

The Steering Committee reviewed and made minor updates to the mission statement, goals, and objectives from the 2019 Chelan County Hazard Mitigation Plan. The following mission statement guided the Steering Committee and planning partners in selecting actions contained in this plan update:

> *To promote sound public policy designed to protect the whole community, critical facilities, infrastructure, private property and the environment from natural hazards by increasing public awareness, documenting the resources for risk reduction and loss-prevention from current and future hazard impacts, and identifying activities to guide Chelan County toward building a safer, more sustainable community.*

Goals

The Steering Committee and planning partners established the following goals for the plan update:

1. **To Protect People and Property** by making Chelan County homes, businesses, infrastructure, critical facilities, dams and their related infrastructure, and other property more resilient and resistant to losses from current and future natural hazard conditions
2. **To Protect the Economy** by developing mechanisms that ensure commerce, trade, and essential business activities remain viable in the event of a natural disaster
3. **To Protect the Environment** by preserving, rehabilitating, and enhancing natural systems to serve natural hazard mitigation functions
4. **To Strengthen Emergency Services** by increasing collaboration, coordination, and capabilities among public agencies, non-profit organizations, business, and industry
5. **To Increase Public Awareness and Education** of the whole community by providing the public information, tools, and funding resources for implementing mitigation activities to prevent future losses from natural hazards
6. **To Establish and Strengthen Partnerships for Implementation** through coordination and collaboration of the whole community, including public agencies, citizens, non-profit organizations, businesses, tribes, and industries whose authorities and capabilities will support implementation of planning for a disaster-resistant Chelan County

Objectives

The steering committee's defined hazard mitigation plan objectives are shown in Table ES-4. Each objective meets multiple goals, serving as a stand-alone measurement of the effectiveness of a mitigation action, rather than as a subset of a goal. The objectives also are used to help establish priorities.

Table ES-4. Objectives for the Hazard Mitigation Plan

Objective Number	Objective Statement	Goals for Which It Can Be Applied
O-1	Improve and protect early warning emergency response systems and plans.	1, 2, 3, 4
O-2	Sustain continuity of local emergency and government operations, including the operation of identified critical facilities, during and after a disaster.	1, 2, 4
O-3	Provide/improve fire protection thru proactive fuels management and structural ignition resistance programs.	1, 2, 3

O-4	Seek mitigation projects that provide the highest degree of hazard protection in a cost-effective manner and that will provide protection to the natural and built environments.	1, 2, 3, 4, 6
O-5	Encourage and incentivize mitigation of private property through programs such as the Community Rating System, Firewise USA and Storm Ready programs.	1, 2, 5, 6
O-6	Reduce natural hazard-related risks and vulnerability to populations, critical facilities and infrastructure within the planning area.	1, 4, 5, 6
O-7	Collect, use and share the best available data, science and technologies to improve understanding of the location and potential impacts of natural hazards, the vulnerability of building types, and community development patterns and the measures needed to protect life safety and natural and built environments.	1, 5
O-8	Enhance emergency response partnership capabilities.	1, 2, 4, 6
O-9	Create and enhance partnerships among all levels of government, community-based organizations, and the business community to coordinate mutually beneficial mitigation strategies.	1, 2, 6
O-10	Strengthen codes so that new construction can withstand the impacts of identified natural hazards and lessen the impact of that development on the environment's ability to absorb the impact of natural hazards.	1, 2, 3
O-11	Educate the whole community on their risk exposure to hazards and ways to increase their capability to prepare, respond, recover, and mitigate the impacts of these events.	1, 2, 4, 5, 6

MITIGATION ACTION PLAN

The planning partnership selected mitigation actions to help achieve the plan goals and objectives. Mitigation actions are activities designed to reduce or eliminate losses resulting from natural hazards. The update process resulted in the identification of 165 mitigation actions for implementation by individual planning partners, as presented in Volume 2 of this plan. In addition, the Steering Committee and planning partners identified countywide actions benefiting the whole partnership, as listed in Table ES-5.

Table ES-5. County-Wide Hazard Mitigation Actions

<table>
<tr><th>Hazards Addressed</th><th>Funding Options</th><th>Timeframe</th><th>Goals Met</th><th>In Previous Plan?</th></tr>
<tr><td colspan="5">CW-1—To the extent possible based on available resources, provide coordination and technical assistance in the application for grant funding that includes assistance in cost vs. benefit analysis for grant eligible projects.
Responsible Agency: County Natural Resource Department</td></tr>
<tr><td>All</td><td>Existing County programs; grant funding</td><td>Short-term</td><td>6</td><td>Yes</td></tr>
<tr><td colspan="5">CW-2—Encourage the development and implementation of a county-wide hazard mitigation public-information strategy that meets the needs of all planning partners. Leverage public outreach partnering capabilities to inform and educate the public about hazard mitigation and preparedness. Seek opportunities to promote the mitigation of natural hazards within the planning area, utilizing information contained within this plan. Sponsor and maintain a natural hazards informational website to include information such as:
• Hazard-specific information such as GIS layers, private property mitigation alternatives, important facts on risk and vulnerability
• Pre- and post-disaster information such as notices of grant funding availability
• Links to Planning Partners’ pages, FEMA, Red Cross, NOAA, USGS and the National Weather Service.
• Information such as progress reports, mitigation success stories, update strategies, Steering Committee meetings.
Responsible Agency: County Emergency Management with participation of all planning partners</td></tr>
<tr><td>All</td><td>Cost sharing from the Partnership, General Fund Allocations, Cost sharing with Stakeholders</td><td>Short-term</td><td>5, 6</td><td>Yes</td></tr>
<tr><td colspan="5">CW-3—Coordinate updates to land use and building regulations as they pertain to reducing the impacts of natural hazards, to seek a regulatory cohesiveness within the planning area. This can be accomplished via a commitment from all planning partners to involve each other in their adoption processes, by seeking input and comment during the course of regulatory updates or comprehensive planning.
Responsible Agency: Governing body of each eligible planning partner.</td></tr>
<tr><td>All</td><td>General funds</td><td>Short-term</td><td>1, 2, 3</td><td>Yes</td></tr>
<tr><td colspan="5">CW-4— Enhance emergency preparedness, response, and recovery efforts to mitigate risks and impacts associated with extreme weather, wildfire, and other hazards worsened by climate change.
Responsible Agency: County Emergency Management</td></tr>
<tr><td>All</td><td>County general fund through existing programs, grant funding</td><td>Short-term</td><td>1, 2, 4</td><td>No</td></tr>
<tr><td colspan="5">CW-5— Support actions that mitigate wildfire smoke, such as promoting HVAC updates for facilities that serve high-risk and vulnerable populations, such as hospitals, libraries, schools, and other community facilities.
Responsible Agency: County Emergency Management with participation of all planning partners</td></tr>
<tr><td>Wildfire Smoke</td><td>County general fund through existing programs, grant funding</td><td>Short-term</td><td>1, 2</td><td>No</td></tr>
<tr><td colspan="5">CW-6— Encourage and support the local agricultural community to become more resilient to the impacts of natural hazards, such as drought, severe weather, wildfire, and the effects of climate change.
Responsible Agency: County with participation of all planning partners</td></tr>
<tr><td>All</td><td>Ongoing programs, grant funding depending on the mandate</td><td>Short-term</td><td>1, 2, 3, 6</td><td>No</td></tr>
<tr><td colspan="5">CW-7— Support the collection of improved data (hydrologic, geologic, topographic, volcanic, historical, etc.) to better assess risks and vulnerabilities.
Responsible Agency: All planning partners</td></tr>
<tr><td>All</td><td>Ongoing programs grant funding</td><td>Short-term</td><td>1, 2, 3, 4, 5</td><td>Yes</td></tr>
</table>

CW-8— Utilize information within this plan to support updates to other emergency management plans in effect within the planning area. **Responsible Agency:** All planning partners				
All	Can be funded under existing programs	Short-term	1, 2, 4, 6	Yes
CW-9— Implement the wildfire mitigation actions identified within the updated 2025 CWPP, **Responsible Agency:** All planning partners				
Wildfire	Ongoing programs and grant funding	Short-term	1, 2, 3, 4, 5, 6	No

IMPLEMENTATION

The Steering Committee developed a plan implementation and maintenance strategy that includes grant monitoring and coordination, a strategy for continued public involvement, a commitment to plan integration with other relevant plans and programs, and a recommitment from the planning partnership to actively monitoring and evaluating the plan biannually over the five-year performance period.

Full implementation of the recommendations of this plan will require time and resources. The measure of the plan's success will be its ability to adapt to changing conditions. Chelan County and its planning partners will assume responsibility for adopting the recommendations of this plan and committing resources toward implementation. The framework established by this plan commits all planning partners to pursue actions when the benefits of a project exceed its costs. The planning partnership developed this plan with extensive public input, and public support of the actions identified in this plan will help ensure the plan's success.

Part 1. Background and Methods

1. INTRODUCTION TO HAZARD MITIGATION PLANNING

1.1 ABOUT HAZARD MITIGATION

1.1.1 What Is It?

As the cost of disasters continues to rise, communities must find ways to reduce hazard risks. The term "hazard mitigation" refers to actions that reduce or eliminate long-term risks caused by hazards such as earthquakes, floods, storms, and wildfires. It involves strategies such as planning, policy changes, programs, projects, and other activities that can mitigate the impacts of hazards. Without an investment in hazard mitigation, repeated disasters result in repeated damage and rebuilding. This recurrent reconstruction becomes more expensive as the years go by. Hazard mitigation breaks this costly cycle of damage and reconstruction by taking a long-term view of rebuilding and recovering from disasters.

1.1.2 When Does It Apply?

The federal Disaster Mitigation Act (DMA) of 2000 requires state and local governments to develop hazard mitigation plans as a condition for federal disaster grant assistance. The DMA emphasizes planning for disasters before they occur. However, hazard mitigation is also essential to post-disaster recovery. After disasters, repairs and reconstruction often just restore damaged property to pre-disaster conditions. The implementation of additional hazard mitigation actions leads to building smarter, safer, and more resilient communities that are better able to reduce future injuries and damage.

1.1.3 Who Is Responsible?

The responsibility for hazard mitigation lies with private property owners; business and industry; and local, state, and federal governments. The Federal Emergency Management Agency (FEMA) encourages multi-jurisdictional planning under its guidance for the DMA, urging state and local authorities to work together on pre-disaster planning. 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. One of the benefits of multi-jurisdictional planning is the ability to pool resources and eliminate redundant activities within a planning area that has uniform risk exposure and vulnerabilities.

1.1.4 How Is It Developed and Implemented?

The DMA promotes sustainability for disaster resistance. "Sustainable hazard mitigation" includes the sound management of natural resources and the recognition that hazards, and mitigation must be understood in the largest possible social and economic context. Efforts to reduce risks should be compatible with other community goals, which may be related to economic development, sustainability, public and environmental health, or other issues. As communities plan for new development and improvements to existing infrastructure, mitigation should be an important consideration.

1.2 WHO WILL BENEFIT FROM THIS PLAN?

Effective hazard mitigation can provide the following benefits:

- Reduce the loss of life, property, essential services, critical facilities, and economic hardship
- Reduce short-term and long-term recovery and reconstruction costs
- Increase cooperation and communication within the community through the planning process
- Increase potential for state and federal funding for pre- and post-disaster projects.

This plan update benefits the whole community within Chelan County. FEMA defines whole community as (FEMA n.d.):

- Individuals with families, including those with access and functional needs
- Businesses
- Faith-based and community organizations
- Nonprofit groups
- Schools and academia
- Media outlets
- All levels of government, including state, local, tribal, territorial, and federal partners

The plan identifies strategies and actions that will reduce risk for those who live in, work in, and visit the county. It provides a viable planning framework for all foreseeable natural hazards that may impact the county. Participation in the development of the plan by key stakeholders in the county, including agencies that represent socially vulnerable populations, helped ensure that outcomes will be mutually beneficial. The resources and background information in the plan are applicable countywide, and the plan's goals and recommendations can lay groundwork for the development and implementation of local mitigation activities and partnerships.

1.3 HAZARD MITIGATION FOR CHELAN COUNTY

1.3.1 2004 Initial Hazard Mitigation Plan and 2011 Update

The Chelan County Emergency Management Council (EMC) led the development of the initial Chelan County Natural Hazard Mitigation Plan in 2004 and again led the development of an update in 2011. The EMC consists of the Chelan County Commissioners, Chelan County Sheriff, and mayors from incorporated cities in the county. The Chelan County Natural Hazards Mitigation Plan is multi-jurisdictional and satisfies the DMA's natural hazard mitigation planning requirements for Chelan County its partner cities. The natural hazard mitigation strategies contained within the initial plan and previous update are the result of a planning process involving local jurisdictions, special purpose districts, and a cross-section of the business community and citizens.

1.3.2 2019 Hazard Mitigation Plan Update

The 2019 update to the *Chelan County Multi-Jurisdiction Natural Hazard Mitigation Plan* updated the identification of resources and strategies for reducing risk from natural hazards. Strategies were selected because they met a program requirement and the needs of the planning partners and their residents. The plan helped guide and coordinate mitigation activities throughout the planning area. The main purpose of the plan was to identify risks posed by hazards and to present strategies to reduce the impact of hazard events. The plan also met the following objectives:

- Meet or exceed requirements of the DMA.
- Enable all planning partners to use federal grant funding to reduce risk through mitigation.
- Meet the needs of each planning partner.
- Create a risk assessment that focuses on Chelan County hazards of concern.
- Create a single planning document that integrates all planning partners into a framework that supports partnerships within the county and puts all partners on the same planning cycle for future updates.
- Coordinate existing plans and programs so that high-priority actions and projects to mitigate possible disaster impacts are funded and implemented.

1.3.3 2022 Hazard Mitigation Plan Update

The Steering Committee and planning partners met on January 5, 2022, to review the biennial progress report and discuss required revisions to the plan. The plan required revisions to be compliant with FEMA's High Hazard Potential Dam (HHPD) Grant program. FEMA released required plan elements for grant eligibility after the 2019 *Chelan County Multi-Jurisdiction Natural Hazard Mitigation Plan* was completed.

The 2022 updates included revisions to goals, the risk assessment, and mitigation actions and priorities.

1.3.4 2024 Hazard Mitigation Plan Update

The 2024 updates include revisions to the mission statement, goals, objectives, action plan and priorities. In addition, the 2024 update process integrated the Community Wildfire Protection Plan (CWPP) process, uses new data for the flood risk assessment, and updated the risk assessments. The risk assessment chapter for dams was revised to meet the updated requirements in the 2022 FEMA planning guidance.

1.4 HOW TO USE THIS PLAN

To fulfill the requirements of the DMA and be eligible for federal disaster funding grant programs, a local hazard mitigation plan must contain a set of information as outlined in the Code of Federal Regulations (CFR). The *Chelan County Multi-Jurisdiction Natural Hazard Mitigation Plan* has been organized to provide all the required information. Throughout this plan, blue boxes highlight the 44 CFR 201.6(c) requirements in the respective sections where the requirements are met.

This plan has been set up in two volumes so that elements that are jurisdiction-specific can easily be distinguished from those that apply to the whole planning area:

- Volume 1—Volume 1 includes all federally required elements of a disaster mitigation plan that apply to the entire planning area. This includes the description of the planning process, public involvement strategy, goals and objectives, countywide hazard risk assessment, countywide mitigation actions, and a plan maintenance strategy. The following appendices at the end of Volume 1 include supporting information:
    - Appendix A—Public involvement materials
    - Appendix B—Summary of federal and state programs and laws
    - Appendix C—Detailed risk assessment results

    - Appendix D—Plan adoption resolutions from Planning Partners

- Volume 2—Volume 2 includes all federally required jurisdiction-specific elements, in annexes for each participating jurisdiction. It includes a description of the participation requirements that each jurisdiction agreed to, as well as instructions and templates that the partners used to complete their annexes.

All planning partners will adopt Volume 1 in its entirety and at least the following parts of Volume 2: Part 1; each partner's jurisdiction-specific annex; and the appendices.

2. PLAN UPDATE—WHAT HAS CHANGED

2.1 THE 2004 AND 2011 PLAN

In order to integrate various hazard planning activities, the Chelan County EMC chose to lead the development of the initial *Chelan County Multi-Jurisdiction Natural Hazard Mitigation Plan* in 2004 and the update in 2011. The update followed guidelines provided by *FEMA 386-8: Multijurisdictional Mitigation Planning* (August 2006), FEMA's *Local Multi-Hazard Mitigation Planning Guidance* (July 2008), and other FEMA guidance.

The 2011 update was written using the best available information obtained from a wide variety of sources, including the Chelan County Comprehensive Plan, the Chelan County Hazard Inventory and Vulnerability Assessment, the City of Wenatchee Hazard Inventory and Vulnerability Assessment, the Washington State Hazard Risk Assessment (Draft), professional judgment from a wide array of qualified contributors, and local officials and their representatives. Throughout the update process, a concerted effort was made by the planning committee to gather information from participating agencies, stakeholders, business and industry, and the citizens of Chelan County, especially those with specific knowledge of natural hazards and past historical events, as well as planning and zoning codes and ordinances and recent planning decisions.

The mission statement of the 2004 and 2011 plans was as follows:

> To promote sound public policy designed to protect citizens, critical facilities, infrastructure, private property and the environment from natural hazards by increasing public awareness, documenting the resources for risk reduction and loss-prevention, and identifying activities to guide Chelan County toward building a safer, more sustainable community.

The 2011 plan found that communities in Chelan County are subject to flooding, earthquake, severe storms, landslide, drought, wildfire, volcanic hazards, and avalanche. The mitigation strategy outlined actions to address natural hazard disasters. From developing disaster response plans to encouraging landowners through incentive programs to avoid disaster areas, the plan covers a breadth of activities that would mitigate the effects of natural disasters. The 2011 plan made minor adjustments to the initial plan's mitigation strategy to more accurately reflect current approaches to address natural hazard disasters.

Updated jurisdiction-specific sub-plans provided a focused and strategic approach to addressing natural hazard risks in the cities of Cashmere, Chelan, Entiat, Leavenworth, and Wenatchee and the unincorporated areas of Chelan County. These sub-plans provide a close look at the demographics, critical facilities, development trends, and vulnerabilities of the cities in Chelan County. The unincorporated areas sub-plan documents extensively the community assets in rural Chelan County and relies on the larger mitigation strategy for mitigation actions.

2.2 THE 2019 PLAN

The 2019 plan was written using the best available information and science. The 2019 update brought special purpose districts into the planning partnership. The hazards of concern were expanded to include drought, seiche, dam failure, and climate change. A Level-2 Hazus analysis formed the basis of risk assessment for the flood, earthquake, and dam failure hazards. In addition, a critical facilities and infrastructure database was developed and used in the risk assessment. The goals were reviewed and updated from the 2011 previous plan.

Each participating jurisdiction developed an annex to the plan with jurisdiction-specific information including hazard risk ranking and mitigation actions.

2.3 WHY UPDATE?

2.3.1 Federal Eligibility

Under 44 CFR, hazard mitigation plans must present a schedule for monitoring, evaluating, and updating the plan. This provides an opportunity to reevaluate recommendations, monitor the impacts of actions that have been accomplished, and determine if there is a need to change the focus of mitigation strategies. A jurisdiction covered by a plan that has expired is not able to pursue elements of federal funding for which a current hazard mitigation plan is a prerequisite.

2.3.2 Changes in Development

Local Plan Requirement E1—44 CFR Part 201.6(d)(3)

A local jurisdiction must review and revise its plan to reflect changes in development.

The planning area experienced a 10.4% increase in population between 2010 and 2023, an average annual growth rate of 0.80% per year during that time frame. The County and cities within Chelan County have comprehensive plans that govern land-use decisions and policy-making, as well as building codes and specialty ordinances based on state and federal mandates. This plan update assumes that some new development triggered by increased population occurred in hazard areas. Because all such new development would have been regulated pursuant to local programs and codes, it is assumed that vulnerability did not increase even if exposure did. More detailed information on the types and location of new construction over the last five years is available in the County and city annexes in Volume 2 of this plan.

2.3.3 New Analysis Capabilities

The risk assessment for the 2019 plan provided detailed information on exposed population and building counts for each hazard of concern. The update expanded the level of detail in multiple-scenario loss estimation modeling for earthquake, flood, landslide, and wildfire. Exposure and vulnerability estimates were presented at the jurisdictional level. The enhanced risk assessment allowed for a more detailed understanding of the ways risk in the planning area is changing over time.

2.4 THE UPDATED PLAN—WHAT IS DIFFERENT?

The updated plan improves upon the 2019 plan in a variety of ways:

- The planning partnership was expanded to include community-based organizations and other stakeholders.
- Improved flood risk assessment data was available for the Level-2 Hazus analysis, which increased confidence in the risk assessment results.
- The mission statement, goals, and objectives were reviewed and updated.

- Critical facilities were redefined to align with FEMA's definition of Community Lifelines.
- The planning process was integrated with the CWPP planning process.

Table 2-1 indicates the major changes between the two plans as they relate to 44 CFR planning requirements.

Table 2-1. Plan Changes Crosswalk

44 CFR Requirement	Previous Plan	Updated Plan
§201.6(b): In order to develop a more comprehensive approach to reducing the effects of natural disasters, the planning process shall include: ***(1) An opportunity for the public to comment on the plan during the drafting stage and prior to plan approval;*** ***(2) An opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, and agencies that have the authority to regulate development, as well as businesses, academia and other private and non-profit interests to be involved in the planning process; and*** ***(3) Review and incorporation, if appropriate, of existing plans, studies, reports, and technical information.***	The plan development process deployed for the 2019 plan included a public engagement strategy that was identified by the Steering Committee that included the following outreach efforts: • Press releases on the planning process, public meetings and final public comment period • A hazard mitigation survey • Two rounds of public meeting. The 1st round was early in the process to gauge the public's perception of risks and the 2nd round was to present the draft plan.	The plan development process deployed for the 2024 plan included a public engagement strategy that was identified by the Steering Committee that included the following outreach efforts: • Press releases on the planning process • A hazard mitigation survey • Hazard mitigation StoryMap • Hazard mapper • Open houses • Draft plan public comment period
§201.6(c)(2): The plan shall include a risk assessment that provides the factual basis for activities proposed in the strategy to reduce losses from identified hazards. Local risk assessments must provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards.	The 2019 plan included a comprehensive risk assessment for eight hazards of concern. Risk was defined as probability x impact, where impact is the impact on people, property and economy of the planning area. All planning partners ranked risk as it pertains to their jurisdiction. The potential impacts of climate change are discussed for each hazard in a climate change chapter.	The 2024 plan also included a comprehensive risk assessment for eight hazards of concern. Risk was defined as probability x impact, where impact is the impact on people, property and economy of the planning area. All planning partners ranked risk as it pertains to their jurisdiction. The potential impacts of climate change are discussed in each risk assessment chapter.

44 CFR Requirement	Previous Plan	Updated Plan
§201.6(c)(2)(i): [The risk assessment shall include a] description of the … location and extent of all natural hazards that can affect the jurisdiction. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.	Volume 1 Part 2 presents a risk assessment of each hazard of concern. Each hazard chapter includes the following components: • Hazard profile, including maps of extent and location, historical occurrences, frequency, severity, and warning time • Secondary hazards • Exposure of people, property, critical facilities and environment • Vulnerability of people, property, critical facilities and environment • Future trends in development • Scenarios • Issues	Volume 1 Part 2 presents a risk assessment of each hazard of concern. Each hazard chapter includes the following components: • Hazard profile, including maps of extent and location, historical occurrences, frequency, severity, and warning time • Future trends in development • Climate change impacts • Secondary hazards • Vulnerability of people, structures, systems, natural, historic, and cultural resources, activities of value, and agriculture • Impacts to people, structures, systems, natural, historic, and cultural resources, activities of value, and agriculture • Scenarios • Issues • Mitigation alternatives
§201.6(c)(2)(ii): [The risk assessment shall include a] description of the jurisdiction's vulnerability to the hazards described in paragraph (c)(2)(i). This description shall include an overall summary of each hazard and its impact on the community	Vulnerability was assessed for all hazards of concern. The Hazus computer model was used for the dam failure, earthquake, and flood hazards, incorporating local data sets. Site-specific data on Steering Committee-identified critical facilities were entered into the Hazus model. Vulnerability was assessed for other hazards by applying varying damage percentages to an asset inventory extracted from Hazus.	Vulnerability and impacts were assessed for all hazards of concern. The Hazus computer model was used for earthquake and flood hazards, incorporating local data sets. Site-specific data on Steering Committee-identified critical facilities were entered into the Hazus model. Vulnerability and impacts were assessed for other hazards by applying varying damage percentages to an asset inventory extracted from Hazus.
§201.6(c)(2)(ii): [The risk assessment] must also address National Flood Insurance Program insured structures that have been repetitively damaged floods	A qualifying repetitive loss section has been added to the 2019 plan update as the planning area has six repetitive loss properties.	The repetitive loss section was reviewed against current data. There were no changes to the repetitive loss list. The planning area has six repetitive loss properties.

44 CFR Requirement	Previous Plan	Updated Plan
§201.6(c)(2)(ii)(A): The plan should describe vulnerability in terms of the types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard area.	A complete inventory of the numbers and types of buildings exposed was generated for each hazard of concern. The Steering Committee defined and identified “critical facilities” for the planning area, and these facilities were inventoried by exposure. Each hazard chapter provides a discussion on future development trends.	A complete inventory of the numbers and types of buildings exposed was generated for each hazard of concern. The Steering Committee defined and identified “critical facilities” for the planning area, and these facilities were inventoried by exposure. Each hazard chapter provides a discussion on future development trends.
§201.6(c)(2)(ii)(B): [The plan should describe vulnerability in terms of an] estimate of the potential dollar losses to vulnerable structures identified in paragraph (c)(2)(i)(A) and a description of the methodology used to prepare the estimate.	Loss estimates were generated for all hazards of concern. These were generated by Hazus for the dam failure, earthquake, and flood hazards. For the other hazards, loss estimates were generated by applying a regionally relevant damage function to the exposed inventory. In all cases, a damage function was applied to an asset inventory. The asset inventory was the same for all hazards and was generated in Hazus.	Loss estimates were generated for all hazards of concern. These were generated by Hazus for the earthquake and flood hazards. For the other hazards, loss estimates were generated by applying a regionally relevant damage function to the exposed inventory. In all cases, a damage function was applied to an asset inventory. The asset inventory was the same for all hazards and was generated in Hazus.
§201.6(c)(2)(ii)(C): [The plan should describe vulnerability in terms of] providing a general description of land uses and development trends within the community so that mitigation options can be considered in future land use decisions.	There is a discussion on future development trends as they pertain to each hazard of concern. This discussion looks predominantly at the existing land use and the current regulatory environment that dictates this land use.	There is a discussion on future development trends and future conditions as they pertain to each hazard of concern. This discussion looks predominantly at growth patterns.
§201.6(c)(3): The plan shall include a mitigation strategy that provides the jurisdiction’s blueprint for reducing the potential losses identified in the risk assessment, based on existing authorities, policies, programs and resources, and its ability to expand on and improve these existing tools.	The plan contains a guiding principle, goals, objectives, and actions. The guiding principle, goals, and objectives are regional and cover all planning partners. Each planning partner identified actions that can be implemented within their capabilities. The actions are jurisdiction-specific and strive to meet multiple objectives. All objectives meet multiple goals and stand alone as components of the plan. Each planning partner completed an assessment of its regulatory, technical, and financial capabilities.	The plan contains a mission statement, goals, objectives, and actions that are regional and cover all planning partners. Each planning partner also identified actions that can be implemented within their capabilities. The actions are jurisdiction-specific and strive to meet multiple objectives. All objectives meet multiple goals and stand alone as components of the plan. Each planning partner completed an assessment of its regulatory, technical, and financial capabilities.

44 CFR Requirement	Previous Plan	Updated Plan
§201.6(c)(3)(i): [The hazard mitigation strategy shall include a] description of mitigation goals to reduce or avoid long-term vulnerabilities to the identified hazards.	The Steering Committee developed a new overall guiding principle for the plan and developed six (6) goals and eleven (11) objectives, as described in Chapter 20. The goals and objectives were specifically for the 2019 hazard mitigation plan and are completely new. They were identified based upon the capabilities of the Planning Partnership.	The Steering Committee updated the mission statement, goals, and objectives for the plan. The updates focused on inclusion of future conditions and vulnerable populations.
§201.6(c)(3)(ii): [The mitigation strategy shall include a] section that identifies and analyzes a comprehensive range of specific mitigation actions and projects being considered to reduce the effects of each hazard, with particular emphasis on new and existing buildings and infrastructure.	Volume I, Part 3 included a hazard mitigation catalog that was developed through a facilitated process. This catalog identifies actions that manipulate the hazard, reduce exposure to the hazard, reduce vulnerability, and increase mitigation capability. The catalog further segregates actions by scale of implementation. A table in the action plan chapter analyzes each action by mitigation type to illustrate the range of actions selected.	Each risk assessment chapter contains a hazard mitigation catalog that was updated through a facilitated process. This catalog identifies actions that manipulate the hazard, reduce exposure to the hazard, reduce vulnerability, and increase mitigation capability. The catalog further segregates actions by scale of implementation. A table in the action plan chapter and annexes analyzes each action by mitigation type to illustrate the range of actions selected.
§201.6(c)(3)(ii): [The mitigation strategy] must also address the jurisdiction's participation in the National Flood Insurance Program, and continued compliance with the program's requirements, as appropriate.	All municipal planning partners that participate in the National Flood Insurance Program identified an action stating their commitment to maintain compliance and good standing under the program.	All municipal planning partners updated a table in their annex addressing the current and continued compliance with the National Flood Insurance Program.

44 CFR Requirement	Previous Plan	Updated Plan
§201.6(c)(3)(iii): [The mitigation strategy shall describe] how the actions identified in Section (c)(3)(ii) will be prioritized, implemented, and administered by the local jurisdiction. Prioritization shall include a special emphasis on the extent to which benefits are maximized according to a cost benefit review of the proposed projects and their associated costs.	Each of the recommended actions was prioritized using a qualitative methodology that looked at the objectives the project will meet, the timeline for completion, how the project will be funded, the impact of the project, the benefits of the project and the costs of the project. This prioritization scheme is detailed in Chapter 21. The prioritization concept is entirely different from what was applied in the 2011 planning effort. Since each planning partner was asked to review all risks and prior actions, any action that was carried over to this plan from the prior plan had the opportunity to have its priority reviewed and if necessary, changed. Therefore, every risk and action in this plan, whether new or carried over from the prior plan, was prioritized as described in the introduction section of Volume 2.	A different prioritization method was used for this plan update to comply with current guidance requirements. The prioritization process evaluated different aspects and benefits of each mitigation action, including whether the hazard will mitigate impacts from climate change, benefit vulnerable communities, and be cost beneficial. Each answer was given a score, which was added to determine high, medium, or low priority.
§201.6(c)(4)(i): [The plan maintenance process shall include a] section describing the method and schedule of monitoring, evaluating, and updating the mitigation plan within a five-year cycle.	The plan maintenance strategy was revised for the 2019 plan. The planning partnership will be preparing bi-annual progress in years 2 and 4.	The plan maintenance strategy was updated for the 2024 plan. The planning partnership will continue to prepare bi-annual progress in years 2 and 4, to support the 5-year cycle.
§201.6(c)(4)(ii): [The plan shall include a] process by which local governments incorporate the requirements of the mitigation plan into other planning mechanisms such as comprehensive or capital improvement plans, when appropriate.	Volume I, Part 3 details recommendations for incorporating the plan into other planning mechanisms, such as: • General plans • Emergency response plans • Capital improvement programs • Municipal codes Specific current and future, plan and program integration activities are detailed in each participating jurisdiction's annex in Volume 2.	Volume 1, Chapter 19 details opportunities for implementation into other planning mechanisms, such as: • Capital improvement programs • Climate adaptation plans • Municipal codes • Debris management plans Each planning partner detailed opportunities for future integration in their annex in Volume 2.

44 CFR Requirement	Previous Plan	Updated Plan
§201.6(c)(4)(iii): [The plan maintenance process shall include a] discussion on how the community will continue public participation in the plan maintenance process.	Volume I, Part 3 detailed a comprehensive strategy for continuing public involvement.	Volume I, Part 3 details a comprehensive strategy for continuing public involvement.
§201.6(c)(5): [The local hazard mitigation plan shall include] documentation that the plan has been formally adopted by the governing body of the jurisdiction requesting approval of the plan (e.g., City Council, County Commission, Tribal Council).	All planning partners that fully met their “participation” requirements as defined by the planning process formally adopted the plan. Appendix E included the resolutions of all planning partners that adopted this plan.	All planning partners that fully met their “participation” requirements as defined by the planning process formally adopted the plan. Appendix D presents the resolutions of all planning partners that adopted this plan.

3. Plan Update Approach

Local Plan Requirement A1 – 44 CFR Part 201.6(c)(1)

The plan shall document the planning process used to develop the plan, including how it was prepared, who was involved in the process, and how the public was involved.

The approach to developing the *Chelan County Multi-Jurisdictional Hazard Mitigation Plan* encouraged broad participation from many stakeholders. This chapter describes the activities carried out during the plan update process.

Plan preparation was largely funded by grants from FEMA's Pre-Disaster Mitigation (PDM) program and Hazard Mitigation Grant Program (HMGP). Chelan County Natural Resources Department applied for an HMGP grant in 2021. Funding was appropriated in 2023. The grants covered 75% of the cost for developing the plan; the rest was funded by Chelan County and its planning partners.

GROUPS INVOLVED IN DEVELOPING THE HAZARD MITIGATION PLAN

Core Planning Team—The Perteet Inc., Black & Veatch, and The Ember Alliance consultant team members, and Chelan County Natural Resources Department and Cascadia Conservation District staff responsible for the facilitation of the planning processes and the development of the plan documents.

Steering Committee—Representative members from the planning partnership that serve as the oversight body. They are responsible for many of the planning milestones and decisions prescribed for this process to help reduce the burden of time required by each planning partner.

Planning Partners—Municipalities or special purpose districts that are developing an annex to the multi-jurisdictional plan.

3.1 DEFINING THE PLANNING AREA

The planning area was defined to consist of the unincorporated county, incorporated cities, and special purpose districts within the geographical boundary of Chelan County. All partners to this plan have jurisdictional authority within this planning area. A map showing the geographic boundary of the defined planning area for this plan update is provided in Chapter 4, along with a description of planning area characteristics.

3.2 DEFINING STAKEHOLDERS

At the beginning of the planning process, the planning team identified a list of stakeholders to engage during the update of the Hazard Mitigation Plan. For this planning process, "stakeholder" was defined as any person or public or private entity that owns or operates facilities that would benefit from the mitigation actions of this plan, and/or has an authority or capability to support mitigation actions identified by this plan.

3.3 FORMATION OF THE CORE PLANNING TEAM

Chelan County Natural Resources Department hired Perteet, Inc., Black & Veatch, and The Ember Alliance to assist with development and implementation of the HMP and CWPP and to provide subject-matter expertise to the overall planning process. A core planning team formed to lead the planning effort which included the following Chelan County and consultant staff:

- Elle Robinson, Chelan County Natural Resources Department Project Manager
- Christina Wollman, Perteet, Project Manager
- Samantha Criner, Perteet, Planner
- Rob Flaner, Black & Veatch, Risk Assessment Lead
- Megan Brotherton, Black & Veatch, Planner
- Kenzie Hart, The Ember Alliance, CWPP Lead
- Aimeé Artigues, The Ember Alliance, CWPP Planner
- Ryan Williams, Cascadia Conservation District
- Patrick Haggerty, Cascadia Conservation District

The Core Planning Team coordinated regularly throughout the course of the planning process to track plan development milestones and to develop the content for Steering Committee meetings. The team was principally responsible for the writing and formatting of this 2024 plan update.

3.4 ESTABLISHMENT OF THE PLANNING PARTNERSHIP

Chelan County Natural Resources Department encouraged all eligible local governments to participate in this hazard mitigation planning process. The planning team invited local governments to a planning partner kickoff meeting on November 2, 2023. This meeting was held to introduce the planning team, provide an overview of the mitigation planning process, solicit commitment from planning partners, and volunteers for the steering committee members. Key objectives were as follows:

- Provide an overview of the Disaster Mitigation Act.
- Describe the reasons for a plan.
- Introduce the planning team.
- Outline the work plan.
- Outline planning partner expectations.
- Seek commitment to the planning partnership.
- Seek volunteers for the Steering Committee.
- Explain the role of Chelan County Natural Resources Department in maintaining the plan and the partnership.

Each jurisdiction wishing to join the planning partnership was asked to provide a “letter of intent to participate” that designated a primary and secondary point of contact for the jurisdiction and confirmed the jurisdiction’s commitment to the process and understanding of expectations. Linkage procedures have been established (see Volume 2 of this plan) for any jurisdiction wishing to link to the Chelan County plan in the future. The planning partners that participated in the planning process are shown in

Table 3-1. Not all planning partners that participated in the planning process were able to complete their annex due to wildfires and other obligations. These partners were provided direction on how to complete their planning process. Except for those noted, all planning partners in the table completed their annex.

Table 3-1. Hazard Mitigation Planning Partners

Jurisdiction	Point of Contact	Title
Chelan County	Elle Robinson	Project Manager, Natural Resources Department
City of Wenatchee	Jessica Shaw	Utilities Manager
City of Leavenworth	Maggie Boles	Development Services Manager
City of Chelan	John Ajax	Planning Director
City of Entiat	Mark Botello	Public Works Director
City of Cashmere	Steve Croci	Director of Operations
Fire District #1	Brian Brett	Fire Chief
Fire District #3	Mike Smith	Fire Captain
Fire District #5[a]	Arnold Baker	Fire Chief
Fire District #6[a]	Steven Spies	Fire Chief
Fire District #7	Brandon Asher	Fire Chief
Fire District #8[a]	Adam Jones	Fire Chief
Fire District #9 (Lake Wenatchee Fire and Rescue)	Kris King	Wildfire Risk Reduction Coordinator
Chelan County Flood Control Zone District	Jason Detamore	Environmental Manager
Cascadia Conservation District	Ryan Williams	Executive Director

a. Planning partners that were unable to complete their annex prior to the plan's public comment period.

3.5 THE STEERING COMMITTEE

Hazard mitigation planning enhances collaboration among diverse parties who can be affected by hazard losses. A key element of the public engagement strategy for this plan update was the formation of a stakeholder steering committee to oversee all phases of the update. Early in the planning process the Core Planning Team prepared a press release to notify community members that the process would begin soon and to invite interested community members to participate in the Steering Committee. Several members of the community responded to volunteer on the committee. The members of this committee included planning partner representatives, citizens, and other stakeholders from within the planning area. The Core Planning Team prioritized the involvement of community-based organizations (CBOs) in the steering committee such as Sustainable NCW and RC3. The planning team assembled a list of candidates representing interests within the planning area that could have recommendations for the plan or be impacted by its recommendations. The planning partners confirmed a committee of 22 members at the steering committee kickoff meeting on March 6, 2024, with 7 alternates. Table 3-2 lists the Steering Committee members and their designated alternates.

Table 3-2. HMP Steering Committee Members

Name	Jurisdiction/Agency/Organization
Kurt Blanchard[a]	Fire District 1 (WVFD)
Ed Martinez[b]	RC3
Elle Robinson	Chelan County Natural Resources Department
Sgt. Jason Reinfield	Chelan County Emergency Management

Stan Smoke (A)	Chelan County Emergency Management
Jason Detamore	Chelan County PW/FCZD
Jessica Shaw	City of Wenatchee
Stephen Neuenschwand (A)	City of Wenatchee
John Ajax	City of Chelan
Maggie Boles	City of Leavenworth
Steve Croci	City of Cashmere
Mark Botello	City of Entiat
Hillary Heard (A)	Fire District 1 (WVFD)
Brandon Asher	Chelan Fire and Rescue (FD7)
Shawn Sherman (A)	Chelan Fire and Rescue (FD7)
Ryan Williams	Cascadia Conservation District
Patrick Haggerty (A)	Cascadia Conservation District
Kris King	Lake Wenatchee Fire and Rescue (FD 9)
Jake Hardt	Washington Department of Natural Resources
Amy Ramsey (A)	Washington Department of Natural Resources
Jana Fischback	Sustainable NCW
Mandy Maxwell (A)	EK Consulting
Jan Yalowitz (A)	RC3
Jean-Michael Dapena	Confluence Health
Stephen Maher	Our Valley Our Future
Bob Keller	Chumstick Community Wildfire Coalition
Richard Hyatt	Chelan PUD
Laura Cross	Citizen
Russ Truman	USDA Forest Service, Retired

a. Chairperson
b. Vice-Chairperson. The Vice-Chairman took over role of Chairperson for the second half of the planning process.

The Steering Committee establish leadership roles and ground rules during the Steering Committee's first meeting, on March 6, 2024. The Steering Committee then met on the third Thursday of every month as needed throughout the course of the plan's development. The planning team facilitated each Steering Committee meeting, which addressed a set of objectives based on an established work plan. The Steering Committee met seven times from March 2024 through September 2024. Meeting summaries and attendance logs are provided in Appendix A to this volume. All Steering Committee meetings were open to the public and were advertised as such on the hazard mitigation plan website. Agendas were posted to the website prior to each scheduled Steering Committee meeting, and meeting summaries were posted to the hazard mitigation plan website following their approval by the Steering Committee.

3.5.1 Community Wildfire Protection Plan

The Community Wildfire Protection Plan (CWPP) was a separate but integrated process that was led by a wildfire sub-committee. The Ember Alliance led the planning process and managed the sub-committee which met separately to discuss wildfire specific plan updates, plan objectives, and data. The wildfire sub-committee also met the third Thursday of every month, as needed throughout the course of the plan's development, directly following the HMP steering committee meeting. Table 3-3 lists the primary committee members; alternates are not shown. More information on the CWPP planning process is within the updated CWPP.

Table 3-3. Community Wildfire Protection Plan Sub-Committee Members

Name	Jurisdiction/Agency
Patrick Haggerty[a]	Cascadia Conservation District
Bob Keller[b]	Chumstick Wildfire Stewardship Coalition
Brandon Asher	Fire District 7
Brian Brett	Fire District 1
Alma Chacon	CAFÉ
Andy Day	RC3
Ben Eddings	USFS
Elle Robinson	Chelan County Natural Resources Department
Jana Fischback	Sustainable NCW
Rachel Hansen	Chelan PUD
Jake Hardt	DNR Community Resilience Coordinator
Adam Jones	Fire District 8
Kris King	Fire District 9
Lexi Lieurance	Chelan-Douglas Health District
Lauren Loebsack	WSDOT
Whitney Machado	BLM
Mike Smith	Fire District 3
Nolan Brewer	DNR Southeast Region Forest Health and Resilience Program
Joel Perez	DNR Southeast Region State Lands Program
Walter Escobar	DNR Southeast Region Wildfire Program
Jeff Pierce	Holden Village
Richard Finger	WDFW

a. Chairperson
b. Vice-Chairperson

3.6 COORDINATION WITH STAKEHOLDERS

Local Plan Requirement A2 – 44 CFR Part 201.6(b)(2)

The planning process shall include an opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, and agencies that have the authority to regulate development, as well as businesses, academia and other non-profit interests to be involved in the planning process.

Robust coordination with stakeholders occurred throughout the update process and was accomplished by the planning team as follows:

- **Planning Partnership Formation**—In addition to the County, fourteen eligible local agencies in the planning area were invited to participate in the planning partnership. All agencies submitted letters of intent to participate in the planning partnership but only eleven were able to complete the planning process. Participants included:
    - County
    - Cities
    - Fire Districts
    - Flood Control Zone District
    - Conservation District
- **Steering Committee and Wildfire Sub-Committee Involvement**—Agency representatives were invited to participate in the committees. Agencies that participated in the process include:
    - Washington Department of Natural Resources
    - US Forest Service
    - Bureau of Land Management
    - Chelan County PUD
    - Washington Department of Fish and Wildlife
    - Washington State Department of Transportation
    - Chelan-Douglas Health District
- **Other Interests—**Many other entities, including private businesses (P), academia/education (E), non-profits (NP), and community-based organizations (CBO) were invited to participate in the process. Many of these other interests have a specific focus on vulnerable communities (V). The following entities participated:
    - Confluence Health (P, V)
    - Community for the Advancement of Family Education (CAFÉ) Wenatchee (NP, CBO, E, V)
    - Residents Coalition of Chelan County (CBO)
    - Our Valley Our Future (NP, CBO, E, V)
    - Sustainable NCW (NP, CBO, E)
    - Chumstick Wildfire Stewardship Coalition (CBO, E)
- **Data Provision**—The following agencies were contacted during the planning process to provide data or technical input:
    - Washington Department of Natural Resources
    - Washington Department of Ecology
    - Chelan County GIS

- Chelan County Assessor
- FEMA
- USGS
- National Weather Service

3.7 REVIEW OF EXISTING PROGRAMS

Local Plan Requirement A4 – 44 CFR Part 201.6(b)(3)

Review and incorporation, if appropriate, of existing plans, studies, reports, and technical information.

Chapter 5 of this plan provides a review of laws and ordinances in effect within the planning area that can affect hazard mitigation actions. In addition, the following programs can affect mitigation within the planning area, and were reviewed and incorporated where appropriate:

- 2023, Washington State Hazard Mitigation Plan
- 2017, Chelan County Comprehensive Flood Hazard Management Plan
- Local capital improvement programs
- Local emergency operations plans
- Local comprehensive plans
- Housing elements of comprehensive plans
- Local zoning ordinances

Assessments of all planning partners' regulatory, technical and financial capabilities to implement hazard mitigation actions are presented in the individual jurisdiction-specific annexes in Volume 2. Many of these relevant plans, studies and regulations are cited in the capability assessments.

Many technical documents, reports, studies, and other resources were incorporated into this plan and supported the risk assessment update. For example, resources such as Drought.gov, DNR Geology Portal, FEMA flood insurance studies, research studies, and Avalanche.org were used to update the plan. When used, these sources are referenced in the text. A complete list of references is provided at the end of the document.

3.8 PUBLIC INVOLVEMENT

Local Plan Requirement A3 – 44 CFR Part 201.6(b)(1)

The planning process shall include an opportunity for the public to comment on the plan during the drafting stage and prior to plan approval.

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

- Include members of the public on the Steering Committee.
- Open steering committee meetings to the public.

- Use a questionnaire to determine if the public's perception of risk and support of hazard mitigation has changed since the initial planning process.
- Utilize/leverage existing public outreach efforts implemented by Chelan County
- Attempt to reach as many planning area citizens as possible using multiple media, including social media.
- Identify and involve planning area stakeholders including community-based organizations (CBOs) and groups that serve the whole community.

3.8.1 Stakeholders and the Steering Committee

Stakeholders are the individuals, agencies and jurisdictions that have a vested interest in the recommendations of the hazard mitigation plan, including planning partners. All planning partners are stakeholders in the process. The diversity brought to the table by special purpose districts and private non-profit entities creates an opportunity to leverage partnerships between entities that typically do not work together in the field of hazard mitigation.

The effort to include stakeholders in this process began early in the planning process. The first press release for this project occurred early in the process to notify the public that the planning process would begin soon and invited interested community members to participate in the Steering Committee or the Wildfire Sub-Committee. Several community organizations and members of the public responded to the press release and requested to participate in the Steering Committee. Three members represented Chelan County, four members represented cities, three members represented fire districts, and the balance represented state or local agencies or community-based organizations. The Steering Committee met throughout the course of the plan's development, and all meetings were open to the public. Protocols for handling public comments were established in the ground rules developed by the Steering Committee.

3.8.2 Community Based Organizations

The Core Planning Team emphasized the involvement of community-based organizations (CBO) in the planning process. Many CBOs participated in the planning process, including CBOs that focus on or provide support to vulnerable communities. CBOs were contacted by the planning team and provided different methods of participation, with most choosing to participate on either the Steering Committee or the Wildfire Sub-Committee. CBOs that chose to participate include:

- CAFÉ Wenatchee
- Residents Coalition of Chelan County
- Our Valley Our Future
- Sustainable NCW
- Chumstick Wildfire Stewardship Coalition

In addition to these organizations, the Chelan-Douglas Health District and Confluence Health, the primary medical care provider in Chelan County and surrounding region, also participated in the committees.

3.9 PUBLIC OUTREACH

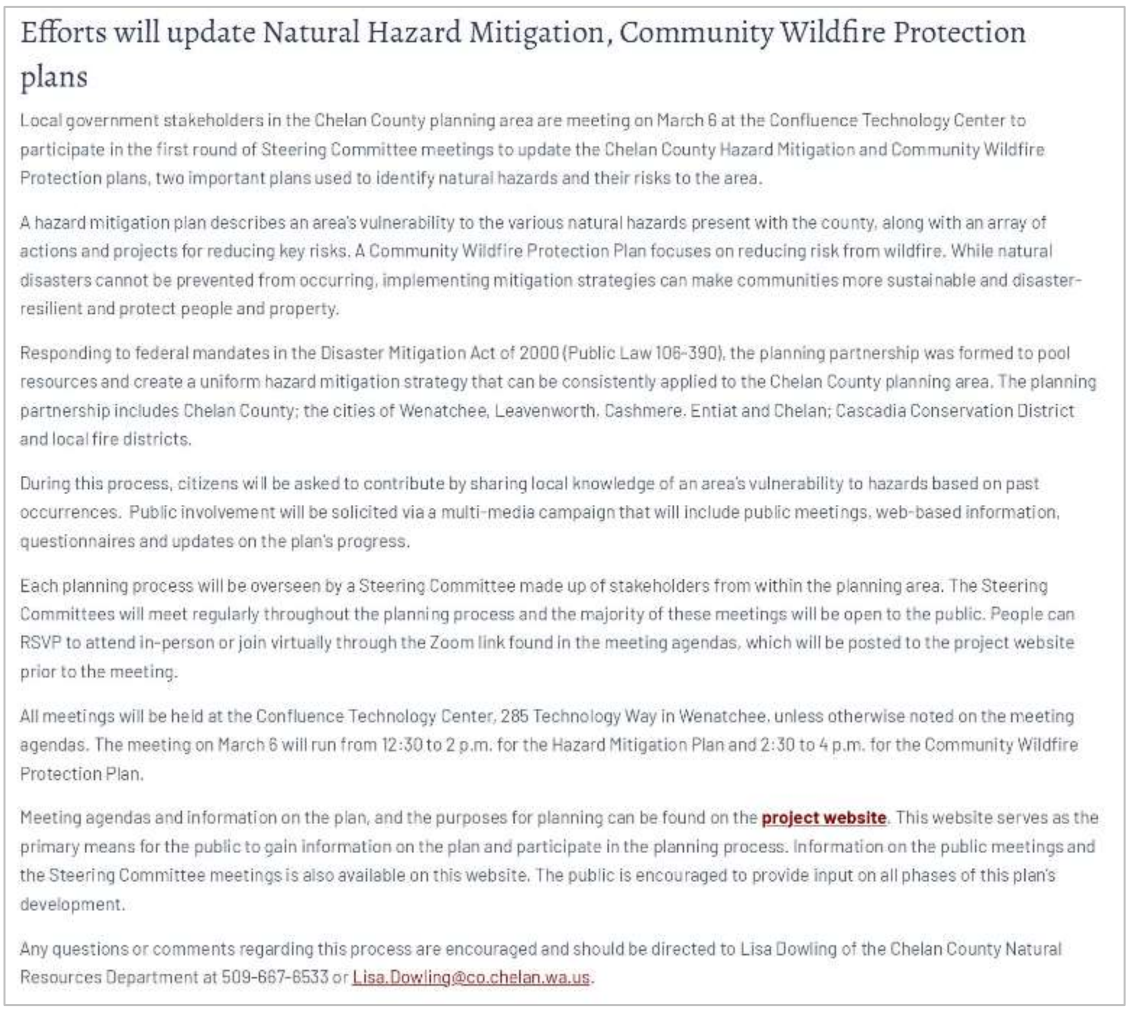
The public outreach process for this plan update consisted of multiple methods and opportunities to participate.

3.9.1 Phase 1 Public Outreach

The Phase 1 public outreach occurred near the beginning of the planning process and included website updates and a press releases. The outreach was to notify the public that the planning process was starting, where to find more information, and how to participate. The following sections describe activities that took place during Phase 1.

Press Release

Two press releases were sent out at the beginning of the planning process. The first press release, on October 31, 2023, was to notify the public of the upcoming planning process and to seek community volunteers for the steering committee. Several steering committee members joined the process by responding to the press release. The second press release provided more information to the public about the planning process and noted the times and locations of the Steering Committee meetings. The public was encouraged to attend Steering Committee meetings. See Figure 3-1 to read the press release.



Efforts will update Natural Hazard Mitigation, Community Wildfire Protection plans

Local government stakeholders in the Chelan County planning area are meeting on March 6 at the Confluence Technology Center to participate in the first round of Steering Committee meetings to update the Chelan County Hazard Mitigation and Community Wildfire Protection plans, two important plans used to identify natural hazards and their risks to the area.

A hazard mitigation plan describes an area's vulnerability to the various natural hazards present with the county, along with an array of actions and projects for reducing key risks. A Community Wildfire Protection Plan focuses on reducing risk from wildfire. While natural disasters cannot be prevented from occurring, implementing mitigation strategies can make communities more sustainable and disaster-resilient and protect people and property.

Responding to federal mandates in the Disaster Mitigation Act of 2000 (Public Law 106-390), the planning partnership was formed to pool resources and create a uniform hazard mitigation strategy that can be consistently applied to the Chelan County planning area. The planning partnership includes Chelan County; the cities of Wenatchee, Leavenworth, Cashmere, Entiat and Chelan; Cascadia Conservation District and local fire districts.

During this process, citizens will be asked to contribute by sharing local knowledge of an area's vulnerability to hazards based on past occurrences. Public involvement will be solicited via a multi-media campaign that will include public meetings, web-based information, questionnaires and updates on the plan's progress.

Each planning process will be overseen by a Steering Committee made up of stakeholders from within the planning area. The Steering Committees will meet regularly throughout the planning process and the majority of these meetings will be open to the public. People can RSVP to attend in-person or join virtually through the Zoom link found in the meeting agendas, which will be posted to the project website prior to the meeting.

All meetings will be held at the Confluence Technology Center, 285 Technology Way in Wenatchee, unless otherwise noted on the meeting agendas. The meeting on March 6 will run from 12:30 to 2 p.m. for the Hazard Mitigation Plan and 2:30 to 4 p.m. for the Community Wildfire Protection Plan.

Meeting agendas and information on the plan, and the purposes for planning can be found on the **project website**. This website serves as the primary means for the public to gain information on the plan and participate in the planning process. Information on the public meetings and the Steering Committee meetings is also available on this website. The public is encouraged to provide input on all phases of this plan's development.

Any questions or comments regarding this process are encouraged and should be directed to Lisa Dowling of the Chelan County Natural Resources Department at 509-667-6533 or Lisa.Dowling@co.chelan.wa.us.

Figure 3-1. Press Release – February 29, 2023

<u>Hazard Mitigation Plan Website</u>

The existing hazard mitigation plan website was updated to keep the public posted on plan development milestones and to solicit relevant input (see Figure 3-2). The site's address (https://www.co.chelan.wa.us/natural-resources/pages/natural-hazard-mitigation-plan) was publicized in all press releases, mailings, surveys and public meetings. Information on the plan development process, the Steering Committee, a plan survey, and drafts of the plan was made available to the public on the site throughout the process. Chelan County intends to keep a website active after the plan's completion to keep the public informed about successful mitigation projects and future plan updates.

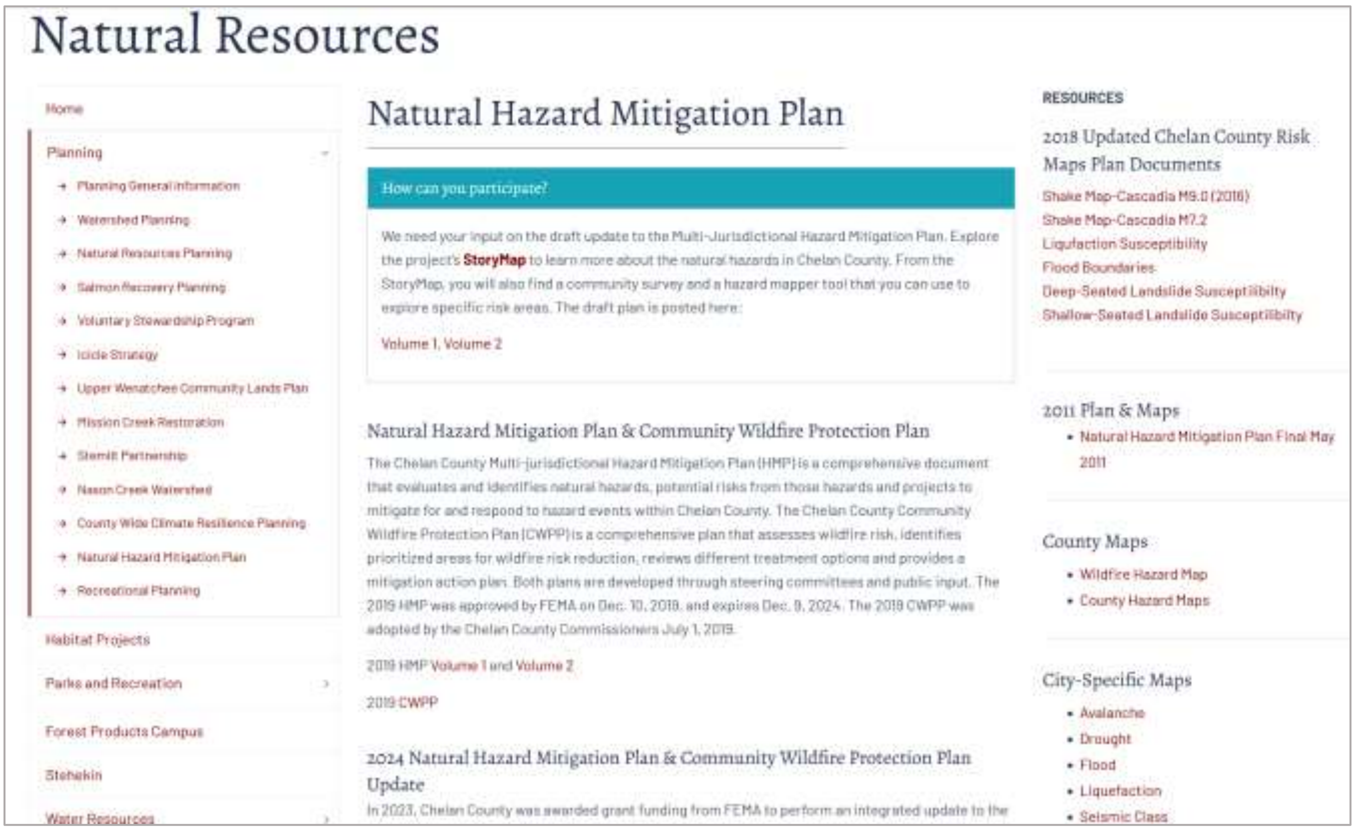


Figure 3-2. Hazard Mitigation Plan Website

3.9.2 Phase 2 Public Outreach

<u>Press Release</u>

A press release was sent out on September 25, 2024 to notify the public of the upcoming participation opportunities. See Figure 3-3 to read the press release. The press release was picked up by local news organizations, shared on social media (see Figure 3-4), and sent to distribution lists of local community organizations. The press release reached thousands of people using these methods.

Chelan County Natural Resources

www.co.chelan.wa.us

Contact: Elle Robinson
Senior natural resource specialist
Elle.Robinson@co.chelan.wa.us
509-667-6533

PRESS RELEASE (Sept. 25, 2024)

Chelan County Seeks public input on updated Hazard Mitigation Plan

Join Natural Resources for one of two upcoming open houses

WENATCHEE -- The planning team for the Chelan County Multijurisdictional Hazard Mitigation Plan (HMP) update invites the community to review the draft plan and provide feedback by attending upcoming open houses, exploring the project's online maps and participating in a public survey.

The HMP outlines the county's vulnerabilities to natural hazards and details various strategies and projects designed to reduce risks. While natural disasters cannot be stopped, proactive mitigation efforts can help communities become more resilient, protecting lives and property while promoting long-term sustainability.

Two open houses are scheduled for Thursday, Oct. 3, in Wenatchee and Leavenworth. The first session is 1 to 3:30 p.m. at Wenatchee City Hall, 129 S. Chelan Ave. A second session will be 6 to 7:30 p.m. at Leavenworth City Hall, 700 Highway 2. Both events will present the same information.

A 14-day public comment period for the draft plan will run from Oct. 3 to Oct. 17. The draft plan will be available for review starting Oct. 3 on the County's Hazard Mitigation Plan webpage.

The webpage also features a project storymap that provides in-depth and interactive maps and information on natural hazards within Chelan County, along with a hazard mapper tool that allows users to explore specific risk areas. More details can be found at: https://www.co.chelan.wa.us/natural-resources/pages/natural-hazard-mitigation-plan.

The public is also encouraged to take a survey to help guide updates to the County's Community Wildfire Protection Plan (CWPP). The draft CWPP is currently in development and will be ready for public comment in January 2025.

##

Figure 3-3. Press Release – September 25, 2024

Chelan County Emergency Management

3 days ago

Join Natural Resources for one of two upcoming open houses.
The planning team for the Chelan County Multi-jurisdictional Hazard Mitigation Plan (HMP) update invites the community to review the draft plan and provide feedback by attending upcoming open houses, exploring the project's online maps and participating in a public survey.

The HMP outlines the county's vulnerabilities to natural hazards and details various strategies and projects designed to reduce risks. While natural disasters cannot be stopped, proactive mitigation efforts can help communities become more resilient, protecting lives and property while promoting long-term sustainability.

Two open houses are scheduled for Thursday, Oct. 3, in Wenatchee and Leavenworth. The first session is 1 to 3:30 p.m. at Wenatchee City Hall, 129 S. Chelan Ave. A second session will be 6 to 7:30 p.m. at Leavenworth City Hall, 700 Highway 2. Both events will present the same information.

A 14-day public comment period for the draft plan will run from Oct. 3 to Oct. 17. The draft plan will be available for review starting Oct. 3 on the County's Hazard Mitigation Plan webpage.

The webpage also features a project StoryMap that provides in-depth and interactive maps and information on natural hazards within Chelan County, along with a hazard mapper tool that allows users to explore specific risk areas.

The public is also encouraged to take a survey to help guide updates to the County's Community Wildfire Protection Plan (CWPP). The draft CWPP is currently in development and will be ready for public comment in January 2025.
https://www.co.chelan.wa.us/.../county-seeks-public-input...

Story Map: https://storymaps.arcgis.com/.../428e2320e1614442806fce53...

County seeks public input on updated Hazard Mitigation Plan

(File Photo: Mission Creek flooding in February 2024)

Figure 3-4. Chelan County Emergency Management Facebook Post

Hazard Mitigation Survey

A hazard mitigation plan survey (see Figure 3-5) was developed by the planning team with guidance from the Steering Committee. The survey was used to gauge household preparedness for natural hazards and the level of knowledge of tools and techniques that assist in reducing risk and loss from natural hazards. The survey asked several questions related to wildfire mitigation, preparedness, and evacuation to support the CWPP planning process. Each planning partner was able to use the survey results to help identify actions as follows:

- Gauge the public's perception of risk and identify what citizens are concerned about.
- Identify the best ways to communicate with the public.
- Determine the level of public support for different mitigation strategies.
- Understand the public's willingness to invest in hazard mitigation.
- Enhanced focus on wildfire risk to support integration of the County's CWPP.
- During this planning process, 95 completed surveys were submitted. The complete survey and a summary of its findings can be found in Appendix A of this volume.

Chelan County Natural Hazards Survey

Natural Hazard Preparedness, Knowledge, and Concerns

3. How concerned are you about the following natural hazards in Chelan County?

	Not concerned	Only slightly concerned	Moderately concerned	Very concerned
Avalanche				
Dam Failure				
Earthquake				
Flood				
Landslide				
Drought				
Severe Weather				
Wildfire and Wildfire Smoke				

Figure 3-5. Sample Question from Survey Distributed to the Public

Hazard Mitigation Plan StoryMap

The StoryMap was a resource for people who wanted to learn more information or were unable to attend the open houses. The StoryMap was designed to be accessible and take advantage of in-browser translation. See Figure 3-6 for the StoryMap landing page.

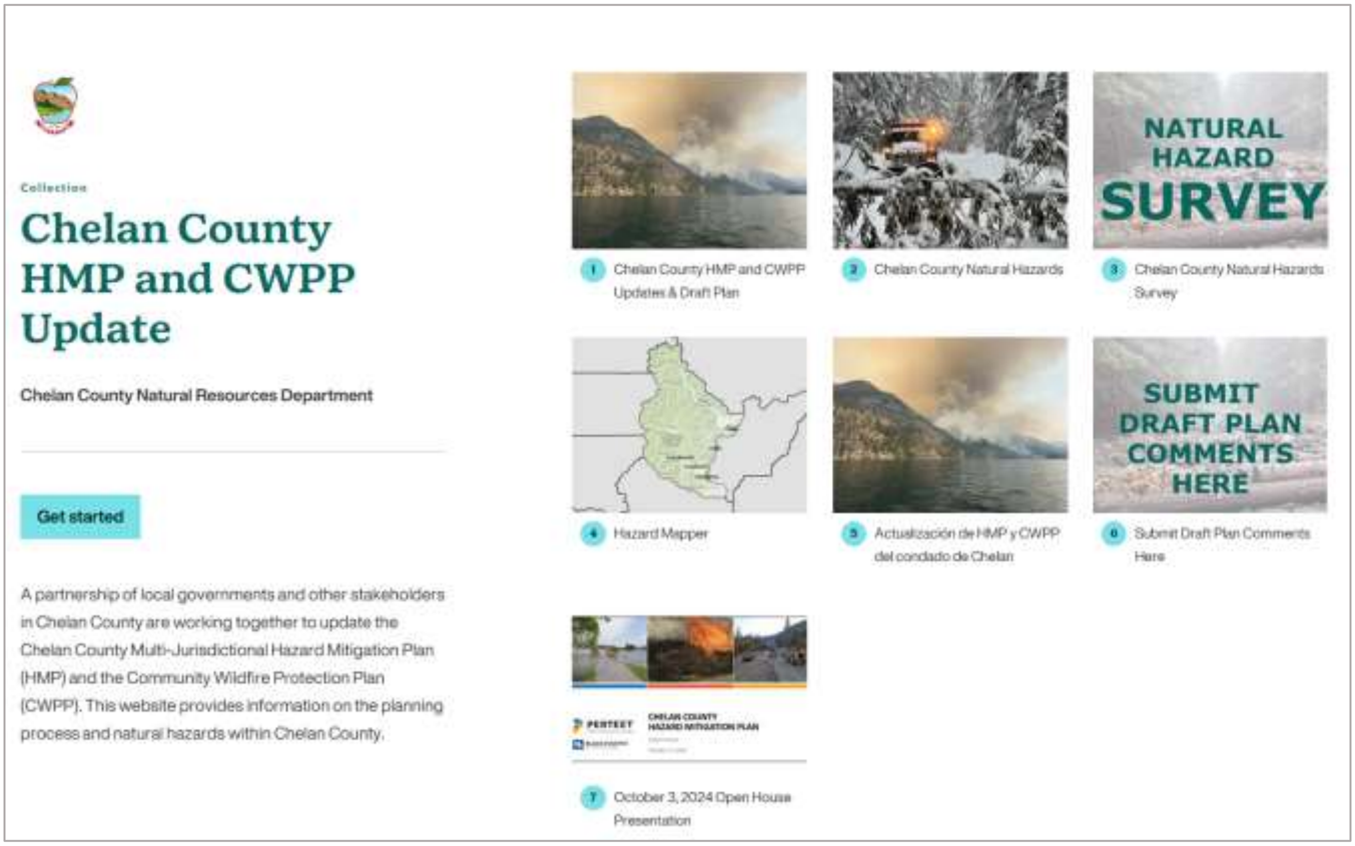


Figure 3-6. StoryMap Landing Page

Public Comment Period

The draft plan was provided to the public for a two-week public comment period, which began on October 3, 2024 and ended on October 17, 2024. The public comment period gave the public an opportunity to comment on the draft plan update prior to its submittal to Washington State Emergency Management Division and FEMA. The principal avenue for public comment on the draft plan was the website established for this plan update. Comments received on the draft plan are available upon request. All comments were reviewed by the planning team and incorporated into the draft plan as appropriate.

Open Houses

The open houses were advertised through the press release and a flyer which was sent out to mailing lists and posted on social media pages. See Figure 3-7 for a copy of the flyer.

The core planning team hosted two open houses on October 3, 2024, one in Wenatchee from 1:00 to 3:30 PM and the second in Leavenworth from 6:00 to 7:30 PM. See Figure 3-8 and Figure 3-9 for photos from each event.

The open houses presented the same information, which included an overview of the planning process and the draft plan, and a summary of the risk assessment and selected mitigation actions. The open houses also provided an opportunity for the public to comment and ask questions.

Figure 3-7. Open House Flyer

Figure 3-8. Phase 2 Public Meeting in Wenatchee

Figure 3-9. Phase 2 Public Meeting in Leavenworth

3.9.3 Public Involvement Results

Survey

95 community members completed surveys.

Public Comment Period

One comment was received during the public comment period.

Open House

A total of 33 community members participated in the open houses.

Table 3-4. Summary of Public Outreach Events

Date	Location	Number of Citizens in Attendance	Summary of Meeting
10/3/2024	Wenatchee	7	Attendees were interested in hazards specific to Wenatchee area. They reviewed maps and discussed their concerns.
10/3/2024	Leavenworth	26	Attendees included community members from Leavenworth and the surrounding areas. The community members came most interested to discuss wildfire risk, which is the most visible and pressing hazard in that area. The consultant gave a presentation to the group, which included all hazards. Community members were very engaged and asked questions about all hazards. Many said afterwards that they were not aware of how the other natural hazards could affect their region.

3.10 PLAN DEVELOPMENT CHRONOLOGY/MILESTONES

Table 3-5 summarizes important milestones in the plan update process.

Table 3-5. Plan Development Chronology/Milestones

Date	Event	Description	Attendance
		2023	
7/21	Organize Resources	The County releases request for proposals for a technical support contractor to facilitate the update to the hazard mitigation plan.	N/A
8/17	Organize Resources	County selects Perteet Inc. as its technical assistance contractor to facilitate the plan update process.	N/A
11/2	Project Kickoff Meeting	All potential planning partners were invited to learn about the plan and meet the consultant team.	19
		2024	
2/23	Community-Based Organization Meeting	• The County organized a meeting with CBOs to discuss how they can be involved in the planning process.	
3/6	Steering Committee Meeting #1	• Review work plan • Organize Steering Committee • Review previous 2019 HMP and 2023 Washington State Hazard Mitigation Plan • Discuss hazards of concern	24
4/18	Steering Committee Meeting #2	• Confirm hazards of concern • Discuss and define critical facility definition • Review, update, and confirm mission statement • Review, update, and confirm goals • Introduced social vulnerability maps • Initiate Phase 1 of jurisdiction annex process	17
5/16	Steering Committee Meeting #3	• Determined social vulnerability map • Review, update, and confirm plan objectives • Discuss public outreach strategy • Deploy Phase 2 of jurisdiction annex process	17
6/20	Steering Committee Meeting #4	• Reviewed and approved plan maintenance strategy • Risk assessment update • Discuss mitigation alternatives catalog • Update on Phase 3 workshops	15
7/18	Steering Committee Meeting #5	• Risk assessment update on earthquakes, dam failure, flood, and landslide • Review and update county-wide mitigation actions	18
7/31 and 8/1	Phase 3 Workshops	• Planning partners were invited to attend an in-person Phase 3 workshop to solidify mitigation actions and finish annexes. • There were two virtual office hours held after the workshop to answer questions.	
9/24	Steering Committee Meeting #6	• Reviewed and discussed draft plan	13
10/3	Begin Comment Period	• Two week public comment period began	N/A
10/3	Open House in Wenatchee	• The open house was held at Wenatchee City Hall.	7

10/3	Open House in Leavenworth	• The open house was held at Leavenworth City Hall.	26
10/17	End Comment Period	• Public comment period closed. One comment was received.	N/A
11/7	Plan submittal	• Pre-adoption review draft of the plan submitted to Washington State Emergency Management Division and FEMA Region X. Concurrent review requested.	N/A
11/25	BOCC Public Hearing	• The Chelan County Commissioners held a public hearing to consider adopting the draft plan.	8
12/2	BOCC Adoption	• The Chelan County Commissioners adopted the plan by resolution.	N/A
DATE	Plan Approval	• Final Plan approval issued by FEMA Region X	N/A

4. CHELAN COUNTY PROFILE

Chelan County is in Central Washington on the east side of the Cascade Mountains, west of the Columbia River (see Figure 4-1). With an area of 2,994 square miles, it is the third largest of Washington's 39 counties. There are five incorporated municipalities in the county: Cashmere, Chelan, Entiat, Leavenworth and Wenatchee. Wenatchee is the largest city in the County and the county seat. Large areas of the county are public lands managed by state agencies or the USDA Forest Service.

4.1 HISTORICAL OVERVIEW

Prior to European settlement of what is now Chelan County, the Wenatchee tribe lived along the Wenatchee River and the Chelan tribe lived along the south end of Lake Chelan. The culture and economy of the tribes centered on fishing, but members also gathered roots and berries and hunted game. In 1855, the Wenatchee and 13 other Native American tribes signed the Yakama Treaty, forfeiting title to 10.8 million acres of north central Washington in exchange for a smaller reservation, cash, and other incentives. Soon afterward, many tribes repudiated the agreements and war broke out. Eventually, only a few small allotments near Lake Chelan remained in Native American hands (Wilma 2006).

Trappers visited the Chelan and Wenatchee valleys from the 1810s through the 1840s in search of beaver pelts. Placer miners came from California in the 1860s and established a village on the Columbia opposite the mouth of the Chelan. Two traders set up a commercial operation in 1872 at the future site of Wenatchee. That same year, a missionary built a small log church, and the town that was established nearby eventually became Cashmere. For a short time in 1880, the U.S. Army maintained Camp Chelan at the south end of Lake Chelan. The town of Wenatchee was founded in 1888. In July 1889, the town of Chelan was laid out where the Chelan River left the lake. The Wenatchee Development Company platted a town site a mile south of the original town in May 1892, and residents of the original town moved to the new community. The residents of Wenatchee voted for incorporation in December 1892 (Wilma 2006).

After 1888, the Chelan Valley was part of Okanogan County to the north and the Wenatchee Valley was part of Kittitas County to the south. In 1899, the State Legislature created Chelan County out of the two other counties with Wenatchee as the county seat (Wilma 2006).

Starting in 1901, businessmen and landowners raised money for the Wenatchee Canal Company and the Highline Canal, running 14 miles from Dryden to Wenatchee. This later became the Wenatchee Reclamation District. The federal Reclamation Act of 1902 provided for the organization and funding of irrigation districts that had the authority of government in acquiring land and issuing bonds. This made possible the construction of reservoirs and canals and the dramatic growth of the fruit industry. In the 1930s, the U.S. government began constructing irrigation and flood control dams on the Columbia (Wilma 2006).

The Wenatchee Canal Company used the flow from the Highline Canal for power. Several small power companies later sprung up using the hydraulic potential of the area's rivers. These firms eventually combined under the Puget Sound Power & Light Co. Congress created the Bonneville Power Administration in 1937 to distribute the electricity from Columbia River dams to publicly owned utilities.

Figure 4-1. Planning Area

Voters approved the Chelan County Public Utility District in 1937, which acquired the properties of Puget Sound Power & Light in 1948, the assets of the Washington Water Power Co. in 1955, and Rock Island Dam on the Columbia in 1956. The Aluminum Company of America (Alcoa) built its plant at Malaga in 1952 to take advantage of the cheap and plentiful power (Wilma 2006).

Today, Chelan County's Board of County Commissioners is responsible for overall administration of Chelan County government. The Board consists of three officials elected from designated Commissioner districts. Its duties include adopting and enacting ordinances and resolutions, levying taxes, establishing County policies, and conducting general County administration. The Board is responsible for adoption of the annual budget, provision and maintenance of public facilities, construction and maintenance of County roads, development and implementation of planning and zoning policies, and appointments to advisory committees and boards.

4.2 MAJOR PAST HAZARD EVENTS

Presidential disaster declarations are typically issued for hazard events that cause more damage than state and local governments can handle without assistance from the federal government. A presidential disaster declaration puts federal recovery programs into motion to help disaster victims, businesses and public entities. Some of the programs are matched by state programs. Review of presidential disaster declarations helps establish the probability of reoccurrence for each hazard and identify targets for risk reduction. Table 4-1. shows the declared disasters that have affected Chelan County through 2024 (records date back to 1972). The County has experienced several significant events that do not qualify for a declaration, such as the Dinkleman Fire of 1988, Tyee and Hatchery/Rat fires of 1994, and the Lightening Fires of 1970. Many of these event are discussed in more detail in the risk assessment chapters.

Table 4-1. Historical Chelan County Natural Hazard Events

Event	State or Federal Disaster [1] #	Date
Severe Storms and Flooding	DR-334-WA	6/10/1972
Drought	EM-3037-WA	3/31/1977
Volcanic Eruption, Mt. St. Helens	DR-623-WA	5/21/1980
Severe Storms and Flooding	DR-883-WA	11/9/1990
Severe Storms, High Wind, and Flooding	DR-1079-WA	11/7/1995
Severe Winter Storms, Land and Mud Slides, Flooding	DR-1159-WA	12/26/1996
Earthquake	DR-1361-WA	2/28/2001
Union Valley Fire	FSA-2368-WA	7/28/2001
Icicle Fire Complex	FSA-2374-WA	8/14/2001
Rex Creek Fire Complex	FSA-2379-WA	8/13/2001
Deer Point Fire	FSA-2449-WA	7/20/2002
Severe Storms and Flooding	DR-1499-WA	10/15/2003
Deep Harbor Fire	FM-2537-WA	7/30/2004
Fischer Wildfire	FM-2543-WA	8/11/2004
Dirty Face Fire	FM-2572-WA	7/31/2005
Hurricane Katrina Evacuation	EM-3227-WA	8/29/2005
Flick Creek Fire	FM-2674-WA	9/9/2006

Severe Storms, Flooding, Landslides, and Mudslides	DR-1671-WA	11/2/2006
Severe Winter Storm, Landslides, and Mudslides	DR-1682-WA	12/14/2006
Easy Street Fire	FM-2711-WA	7/8/2007
Severe Winter Storm, Landslides, Mudslides, and Flooding	DR-1817-WA	1/6/2009
Severe Winter Storm and Record and Near Record Snow	DR-1825-WA	12/12/2008
Union Valley Fire	FM-2823-WA	7/28/2009
1st Canyon Fire	FM-5012-WA	9/9/2012
Byrd Canyon Fire	FM-5015-WA	9/10/2012
Poison Fire	FM-5017-WA	9/12/2012
Peavine Fire	FM-5018-WA	9/12/2012
Table Mountain Fire	FM-5020-WA	9/10/2012
Colockum Tarps Fire	FM-5038-WA	7/27/2013
Mile Post 10 Fire	FM-5042-WA	8/10/2013
Eagle Fire	FM-5048-WA	8/20/2013
Mills Canyon Fire	FM-5059-WA	7/10/2014
Chiwaukum Fire	FM-5061-WA	7/15/2014
Wildfires	EM-3371-WA	7/9/2014
Hansel Fire	FM-5072-WA	8/5/2014
Sleepy Hollow Fire	FM-5087-WA	6/28/2015
Chelan Fire Complex	FM-5100-WA	8/14/2015
Wildfires	EM-3372-WA	8/13/2015
Wildfires and Mudslides Severe Storms, Straight-Line	DR-4243-WA	8/9/2015
Winds, Flooding, Landslides, and Mudslides	DR-4249-WA	11/12/2015
Suncrest Fire	FM-5152-WA	8/27/2016
Spromberg Fire	FM-5182-WA	5/23/2017
Cougar Creek Fire	FM-5270-WA	8/10/2018
COVID-19	EM-3427-WA	1/20/2020
COVID-19 Pandemic	DR-4481-WA	1/20/2020
Apple Acres Fire	FM-5352-WA	9/72020
Red Apple Fire	FM-5398-WA	7/13/2021
Twentyfive Mile Fire	FM-5414-WA	8/17/2021
Severe Winter Storms, Snowstorms, Straight-line Winds, Flooding	DR-4650-WA	12/26/2021

[1] DR: Major Disaster Declaration
EM-Emergency Declaration
FSA- Federal Surplus Assistance
FM- Fire Management Assistance Declaration

4.3 PHYSICAL SETTING

4.3.1 Geology

Chelan County sits between the Cascade Mountains to the west and the Columbia Plateau to the east; a significant portion of the County is within the Cascade Mountain Range. The topography of the county ranges from mountainous, with cirques, moraines, spurs and other glacial features, to lower, milder terrain consisting of soils formed of alluvial deposits and glacial drift. The Cascade Mountains are primarily metamorphosed sedimentary, volcanic and granite rock in large outcropping with shallow soils. The Columbia Plateau is mainly thick layers of basaltic bedrock, with outwash deposits of silty sands to sandy gravel at tributary mouths. Elevations range from 700 feet above sea level at the Columbia River to more than 9,000 feet at the highest point of the Cascades.

The Chelan Mountains stretch south to the Columbia River between the Entiat River and the Chelan River. The northern end the Chelan Range merges with the northern end of the Entiat Mountains. Most of the range is within Wenatchee National Forest. The northern end is part of the Glacier Peak Wilderness.

Lake Chelan was formed by the confluence of two glaciers 18,000 years ago: the Chelan Glacier, which originated in the Cascades and advanced down toward the Columbia; and the Cordilleran ice sheet, advancing south from Canada across the Columbia Plateau. The Chelan Glacier extended to somewhere near The Narrows, carving the deep steep walled valley of Lake Chelan's upper Lucerne basin. The continental glacier extended or overrode the basin to at least Wapato Point, creating a small lake between the two ice masses. As the glaciers retreated, the outlet of the valley remained filled by the vast quantities of the material deposited by the glaciers, impounding the present-day Lake Chelan. As a result of this history, the lake above The Narrows is quite deep.

4.3.2 Watersheds

The Washington Department of Ecology has divided Washington into Water Resource Inventory Areas (WRIAs) to delineate the state's major watersheds. The following WRIAs make up Chelan County:

- **WRIA 45, Wenatchee River Watershed**—The Wenatchee Watershed (WRIA 45) is approximately 1,370 square miles, including some areas that drain directly into the Columbia River. This area includes 230 miles of major streams and rivers. The headwaters are the Little Wenatchee and White Rivers in the Cascade Mountain range. These rivers flow into Lake Wenatchee, the source of the Wenatchee River. The Wenatchee River discharges into the Columbia River in the City of Wenatchee.
- **WRIA 46, Entiat River Watershed**—The Entiat River is the major surface water source in this 418-square-mile watershed. Dozens of small creeks and streams are tributary to the river.
- **WRIA 47, Lake Chelan Watershed**—The main surface water feature of this 1,047-square-mile watershed is Lake Chelan, the largest and deepest lake in Washington.
- **WRIA 40, Alkali-Squilchuck (Malaga-Stemilt-Squilchuck Area)**—A small portion of WRIA 40 (Alkali-Squilchuck) extends into the southeastern corner of Chelan County around Malaga. The portion of WRIA 40 in Chelan County includes the Squilchuck Creek, Stemilt Creek, and Cummings Canyon Creek watersheds. The rest of the watershed extends into Kittitas, Yakima, and Benton Counties, and includes other small creeks primarily draining directly to the Columbia River.

4.3.3 Climate

The climate of Chelan County possesses both continental and marine characteristics, with the Cascades serving as a topographic and climatic barrier. Air warms and dries as it descends the eastern slopes of the Cascades, resulting in shrub-steppe conditions in the lower elevations of Chelan County. Table 4-2 summarizes annual temperature and precipitation data for three weather stations around Chelan County: Wenatchee, Plain, and Stehekin. Monthly averages are shown on Figure 4-2 and Figure 4-3.

Table 4-2. Annual Average Chelan County Climate Data

	Wenatchee	Plain	Stehekin
Annual Average Daily High Temperature (ºF)	62.7	57.4	57.2
Annual Average Daily Low Temperature (ºF)	42.3	34.2	38.6
Annual Average Total Precipitation (inches)	9.00	27.24	36.9
Annual Average Total Snowfall (inches)	16.5	117.4	129.7

Source: (National Oceanic and Atmospheric Administration (NOAA) 2020)

Source: (National Oceanic and Atmospheric Administration (NOAA) 2020)

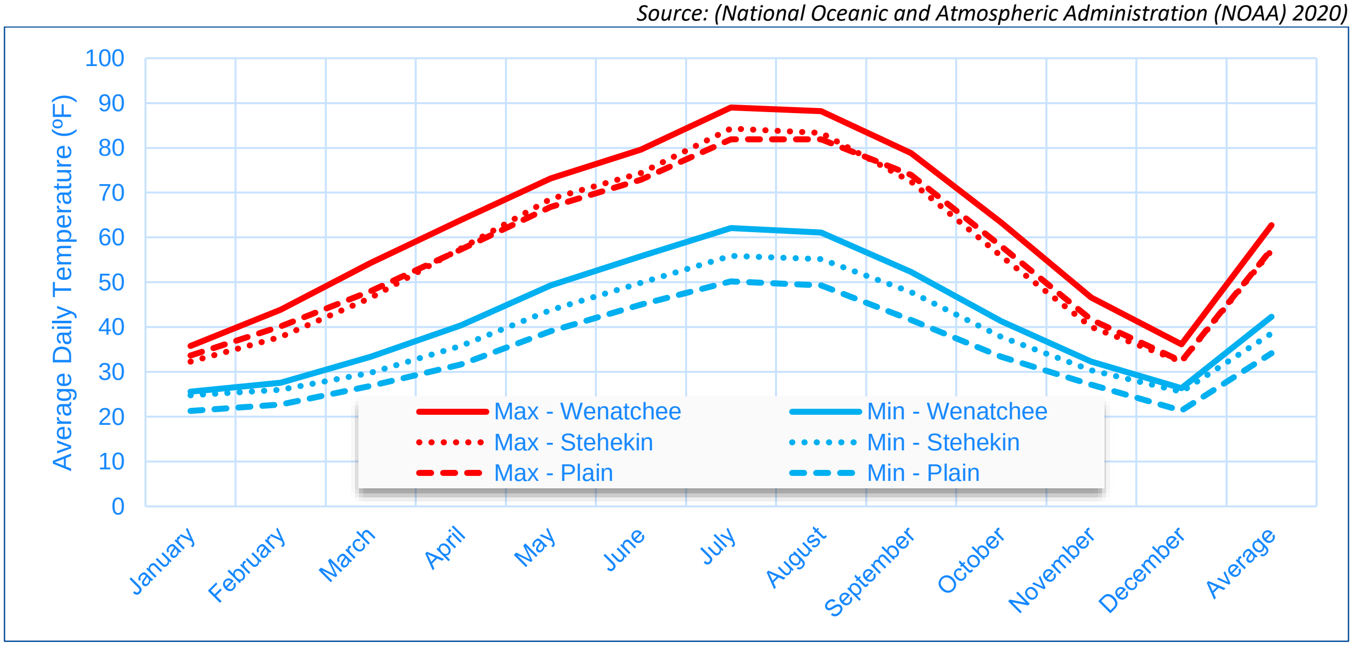


Figure 4-2. Average Daily Temperatures

Source: (National Oceanic and Atmospheric Administration (NOAA) 2020)

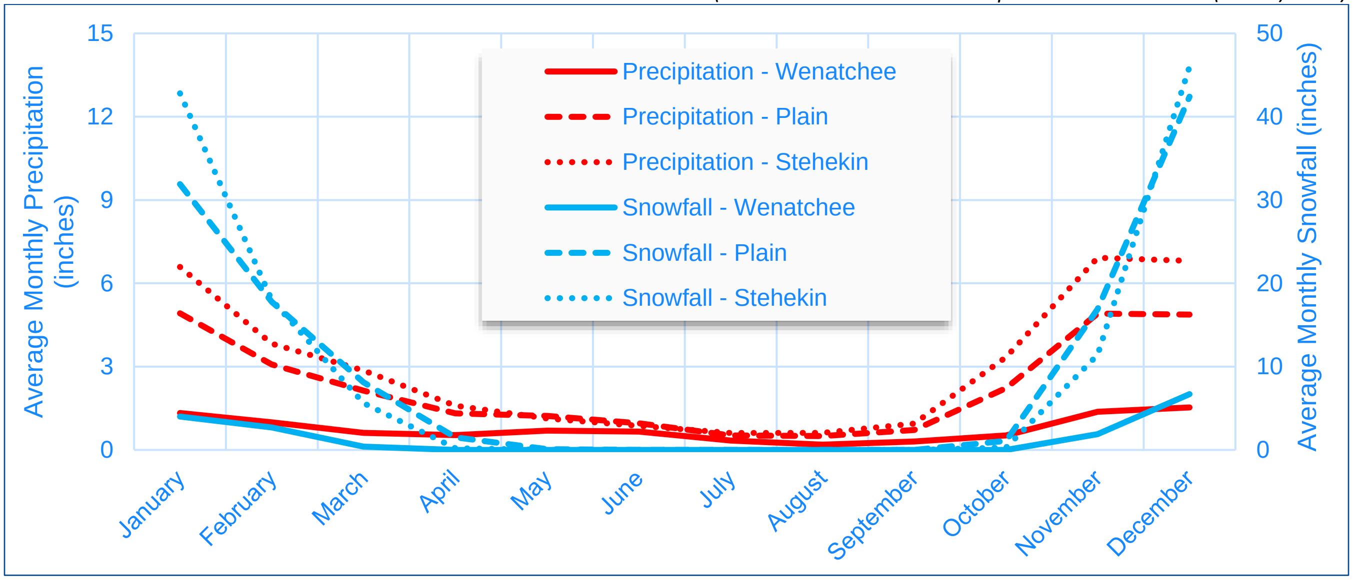


Figure 4-3. Monthly Average Precipitation and Snowfall

Rainfall occurs about 70 days each year in the lowland and about 120 days in the higher elevations. During July and August four to eight weeks can pass with only a few scattered showers. Thunderstorms, most as isolated cells, occur on one to three days each month from April through September. A few damaging hailstorms are reported each summer. Severe local storms occur when the interior of British Columbia is under the influence of high barometric pressure and a deep low-pressure center from over the Pacific approaches the Washington coast. Severe storms normally approach Chelan County from the south or southeast.

Extremes in summer and winter temperatures generally occur when air from the continent influences the inland basin. During the coldest months, freezing drizzle occasionally occurs, as does a Chinook wind that produces a rapid rise in temperature. During most of the year, the prevailing wind is from the southwest or west. The frequency of northeasterly winds is greatest in fall and winter. Wind velocities ranging from 4 to 12 mph can be expected 60 to 70% of the time; 13 to 24 mph, 15 to 24% of the time; and 25 mph or higher, 1 to 2% of the time. The highest wind velocities are from the southwest or west and are frequently associated with rapidly moving weather systems. Extreme wind velocities can be expected to reach 50 mph at least once in two years; 60 to 70 mph once in 50 years; and 80 mph once in 100 years.

4.4 DEVELOPMENT PROFILE

Local Plan Requirement B2— 44 CFR Part 201.6(c)(2)(ii)(C)	Local Plan Requirement E1— 44 CFR Part 201.6(d)(3)
The plan should describe vulnerability in terms of providing a general description of land uses and development trends within the community so that mitigation options can be considered in future land use decisions.	*A local jurisdiction must review and revise its plan to reflect changes in development.*

4.4.1 Land Use

Wenatchee River Watershed

The Wenatchee River watershed includes the cities of Wenatchee, Cashmere and Leavenworth and communities of Monitor, Sunnyslope, Plain, Peshastin, and Dryden. The primary land uses are forestry, wilderness areas, agriculture, range, residential, and recreation. Much of the area is mountainous forest land that are part of the Okanogan-Wenatchee National Forest. The largest land administrator in the watershed is the U.S. Forest Service, with approximately 395,000 acres of forest land covering about 45% of the total watershed area. Most of the private land in the area is concentrated along the major water bodies and transportation routes. Irrigated farmland acreage within the Wenatchee River valley and its tributaries is estimated to be about 12,500 acres. In the upper watershed, much of the area is not suitable for development due to steep unstable slopes, floodways, wetlands and other critical areas. Development is also constrained by designated resource lands. Current development has occurred on limited areas around the river edges, Lake Wenatchee, and Fish Lake (Washington Department of Ecology 1995).

The rural environment of the lower watershed is characterized by orchards in the valley and on the lower elevations of the rolling hills. Orchards are located throughout much of the valley between Dryden and Sunnyslope. Major crops include apples, pears, and cherries. Service industries are found primarily in the incorporated City of Cashmere and the unincorporated community of Sunnyslope. In 2008, a portion of Sunnyslope was included in the City of Wenatchee Urban Growth Area. Several communities along the Wenatchee River and the highway provide small town residential and work opportunities. These areas also contain agricultural processing facilities.

Most of the Upper Wenatchee River Valley contains evergreen mountains with residential development along the rivers and lakes. The development areas are pockets of higher densities surrounded by natural lands. Land to the west of Leavenworth is extremely limited by mountains and steep slopes. Small parcel sizes are common due to the building area and ownership patterns.

Most of the Plain-Lake Wenatchee area contains residential homes among the evergreen mountains, with denser populations along the lakes and rivers. This is consistent with the rural recreation opportunities of the area. Plain provides a community area with commercial services and a public post office and school. Development is limited by ownership and parks.

Entiat River Watershed

The Entiat watershed is 87% forested, and timber is the largest land use. Agricultural uses are the second biggest land uses. Most of the irrigated agricultural use is along the Entiat River and downstream from the town of Ardenvoir. There are also 9,000 acres of range land, mostly in the lower part of the watershed near Entiat.

Residences and businesses are mostly in the southeastern portion of the watershed near Ardenvoir and Entiat. Development is limited by public access up the valley. The City of Entiat and its urban growth area are at the base of the Entiat River along the Columbia. The area provides for pockets of residential development and rural businesses. Virtually all existing structural and orchard development has occurred on lands below 2,000 feet in elevation and on less than a 20% slope (Washington Department of Ecology 1995).

Lake Chelan Watershed

Over 3% of the Chelan watershed is in agricultural use, primarily orchards, and less than 1% is developed into roads, houses, and commercial areas. Approximately 6% of the watershed consists of Lake Chelan and other water bodies, and about 90% of the watershed is forest land managed by the U.S. Forest Service, the National Park Service, and private owners. Virtually all existing structural and orchard development has occurred on lands below 2,000 feet in elevation and on less than a 20% slope. Most development is concentrated around the lower end of Lake Chelan, where private land dominates. The upper portion of the basin lies within the North Cascades National Park and the Lake Chelan National Recreation Area, while the area between is in the Wenatchee National Forest, a portion of which is in the Glacier Peak Wilderness Area (Washington Department of Ecology 1995).

The Chelan and Manson communities provide urban services. The rest of the region is characterized by a variety of parcel sizes and a mix of orchards, vineyards, wineries, estate homes, golf courses, ranchettes, open space, and pasture land. To the west, access roads are primitive, private or forest service, which greatly reduces the number and types of land uses. Higher levels of development, primarily residential uses, are common along the lakes.

Most of the Stehekin area is undeveloped federal land. The area is influenced by the National Park Service 1995 General Management Plan for the Lake Chelan National Recreation Area. The Park Service manages the majority of federal property in the area. There are about 820 acres of private land, classified as single-family, intermingled with federal land administered by the National Park Service and commercial forest lands. A small community along the northern shore of Lake Chelan continues to develop and grow as a recreation tourist service center. The area is spotted with remote cabins and is not expected to develop.

Malaga-Stemilt-Squilchuck Area

The town site of Malaga was platted in 1903. Chelan County’s first irrigation ditch was built in Malaga to serve orchards and vineyards. Development of the Alcoa plant in the early 1950s stimulated residential development in the area. Most recent development has been southwest of the original town site, especially around Cortez Lake, which is part of the Three Lakes residential area. The Wenatchee Heights area is a large plateau overlooking the Wenatchee Valley that contains several large orchard tracts. Residences are scattered throughout the area. The Stemilt Hill is another large agricultural area, with residential development scattered throughout the orchards. South of Malaga, the rural character is defined by industrial uses, primarily the Alcoa plant. Colockum Creek, Jumpoff Ridge, Stemilt Basin, and Mission Ridge are mainly undeveloped open spaces varying from grassland to forest. Primary land uses in those areas include rangeland, timber production and recreation. Recreation, industrial development, and agriculture are the most significant contributors to the economic base.

4.4.2 Critical Facilities and Infrastructure

A critical facility is any structure, facility, or other improvement that, because of its function, service area, or uniqueness, provides service that enables the continuous operation of critical business and government functions, and is critical to human health and safety or economic security. For the purposes of this hazard mitigation plan, all FEMA Community Lifelines are defined as critical facilities:

- **Safety and Security—**Law Enforcement/Security, Fire Service, Search and Rescue, Government Service, Community Facilities, Schools, Community Safety
- **Food, Hydration, Shelter—**Food, Hydration, Shelter, Agriculture, Irrigation Systems
- **Health and Medical—**Medical Care, Public Health, Patient Movement, Medical Supply Chain, Fatality Management
- **Energy—**Power Grid, Generation Systems, Dams, Fuel, Pipelines
- **Communications—**Infrastructure, Responder Communications, Alerts Warnings and Messages, Finance, 911 and Dispatch
- **Transportation—**Highway/Roadway/Motor Vehicle, Mass Transit, Railway, Aviation, Maritime
- **Hazardous Materials—**Facilities, HAZMAT, Pollutants and Contaminants
- **Water Systems–** Potable Water Infrastructure, Wastewater Management Infrastructure

An inventory of facilities that meet this definition was created and input to the Hazus model used to assess risk for this hazard mitigation plan. Two principle sources of information were used for this inventory:

- The Hazus default entries contained in the Comprehensive Data Management System (Hazus version 4.2)
- The inventory of critical facilities and infrastructure maintained by Chelan County Emergency Management to support the Critical Infrastructure/Key Resource initiative.

Figures 4-4 and 4-5 show the location of critical facilities in the planning area. Due to the sensitivity of this information, a detailed list of facilities is not provided. The list is on file with Chelan County. Table provides a summary of the general types of critical facilities and infrastructure in the planning area. All critical facilities and infrastructure were analyzed to help identify the natural hazard risk and mitigation actions. Each risk assessment chapter assesses facilities that are vulnerable and may be impacted by the hazard.

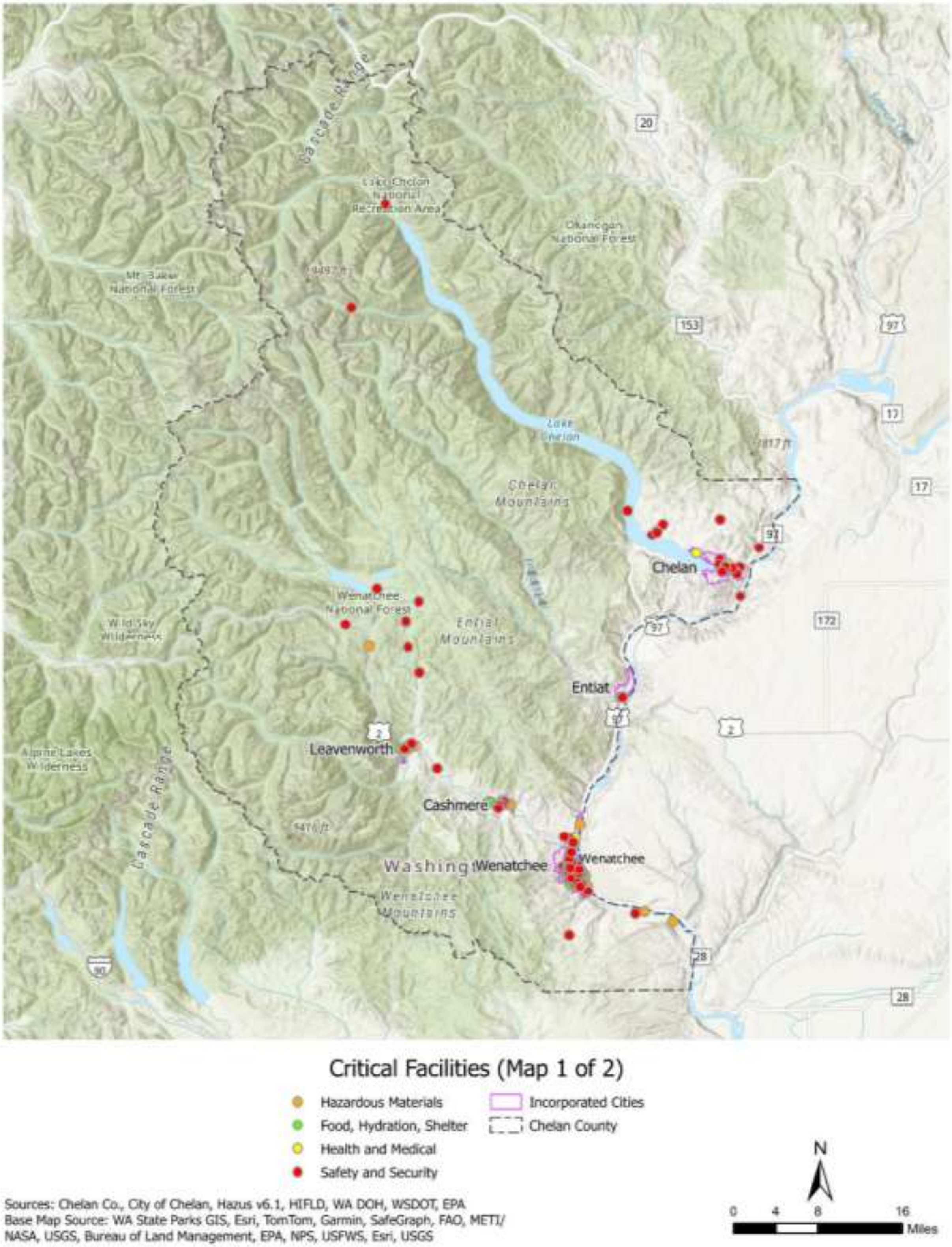


Figure 4-4. Critical Facilities (Map 1)

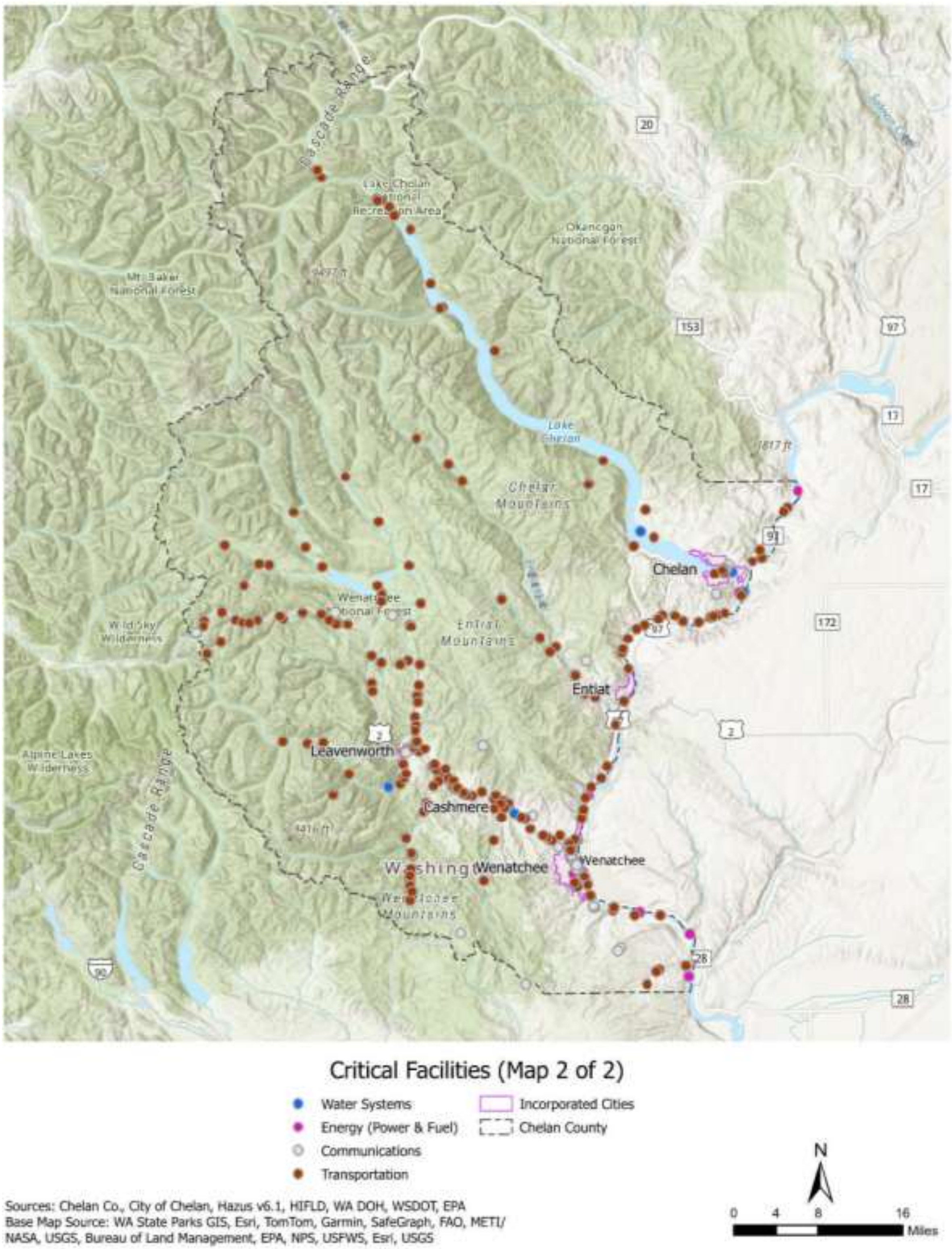


Figure 4-5. Critical Facilities (Map 2)

Table 4-3. Chelan County Critical Facilities

City	Communi cations	Energy	Food, Hydration, Shelter	Hazardous Materials	Health and Medical	Safety and Security	Transportation	Water Systems	Total
Cashmere	1	0	3	1	3	4	4	1	**16**
Chelan	7	0	2	0	8	17	4	1	**39**
Entiat	0	0	0	0	0	3	0	0	**3**
Leavenworth	3	0	1	0	3	6	1	0	**14**
Wenatchee	19	1	12	4	20	31	14	1	**102**
Unincorporated	23	8	9	3	1	25	202	11	**282**
Total	**53**	**9**	**26**	**8**	**35**	**86**	**225**	**14**	**456**

4.4.3 Future Trends in Development

While Chelan County appears to be a large county, with approximately 1.9 million acres or 2,920 square miles, most of the land, approximately 1.5 million acres, is in federal and state ownership. The major geographic features include: Cascade Mountains, Chiwaukum Mountains, Stuart Range, The Enchantments, Bonanza Peak, and the Chelan, Wenatchee, and Columbia Rivers. Most of the County is nationally protected lands: Lake Chelan National Recreation Area, North Cascades National Park (part) and the Wenatchee National Forest (part). This land is not expected to be developed at any point within the future.

The County and its cities have adopted comprehensive plans that govern land use decision and policy making their jurisdictions and well as building codes and specialty ordinances based on state and federal mandates. Decisions on land use area governed by these programs. This plan will work together with these programs to support wise land use in the future by providing vital information on the risk associated with natural hazards in Chelan County. Any large-scale development should occur concurrent with a Comprehensive Plan review or amendment to analysis potential Countywide impacts.

As noted in the 2017-2037 Chelan County Comprehensive Plan, there is enough land in the County to satisfy future housing needs; however, the overall number of residential building permits exceeds the creation of new lots (subdivisions). This may impact housing costs, affordability and availability as demand continues to grow. Land available for development, about 436 square miles, is generally found along the valleys and rolling hills associated with Chelan Lake, the Entiat River, the Wenatchee River and the Columbia River. The largest populated area is located at the southeast corner of the County, in the City of Wenatchee.

The County anticipates growth to occur in a manner consistent with the land use designations planned for by the zoning map and regulations. Growth is expected to occur in areas identified as vacant and underutilized by the County Assessor's primary land use classification code. However, there is less land available for development within the Rural Residential/Resource 2.5 and LAMIRD (limited area of more intense rural development) designations. Therefore, the percentage of growth in these areas may be less than other residentially designated lands. As noted in the 2017-2037 Comprehensive Plan, the County has adequate land to meet the projected population growth over the next 20 years.

All municipal planning partners will seek to incorporate this hazard mitigation plan by reference into their comprehensive plans. 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.

4.5 DEMOGRAPHICS

Some populations are at greater risk from hazard events because of decreased resources or physical abilities. Elderly people, for example, may be more likely to require additional assistance. Research has shown that people living near or below the poverty line, the elderly (especially older single men), the disabled, women, children, ethnic minorities, and renters all experience, to some degree, more severe effects from disasters than the general population (Rufat, et al. 2015). These vulnerable populations may vary from the general population in risk perception, living conditions, access to information before, during and after a hazard event, capabilities during an event, and access to resources for post-disaster recovery. Indicators of vulnerability—such as disability, age, poverty, and minority race and ethnicity—often overlap spatially and often in the geographically most vulnerable locations. Detailed spatial analysis to locate areas where there are higher concentrations of vulnerable community members would help to extend focused public outreach and education to these most vulnerable citizens.

4.5.1 Population Characteristics

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. The Washington State Office of Financial Management estimated Chelan County's population at 79,926 as of 2022, making it the 17th largest county by population in the state (Washington Office of Financial Management 2024).

Population changes are useful socio-economic indicators. A growing population generally indicates a growing economy, while a decreasing population signifies economic decline. Figure 4-6 shows the Chelan County population change from 1995 to 2022 compared to that of the State of Washington (Washington Employement Security Department 2023). The County grew faster than the statewide average through the early 1990s but has since had a growth rate somewhat below that of the state. Table 4-4 shows the county population from 2005 to 2018.

The Washington Office of Financial Management developed forecasts of future population as shown in Table 4-5. The projections estimate a population of 91,063 in Chelan County by 2040, a 12.2% increase from 2022.

Source: (Washington Employement Security Department 2023)

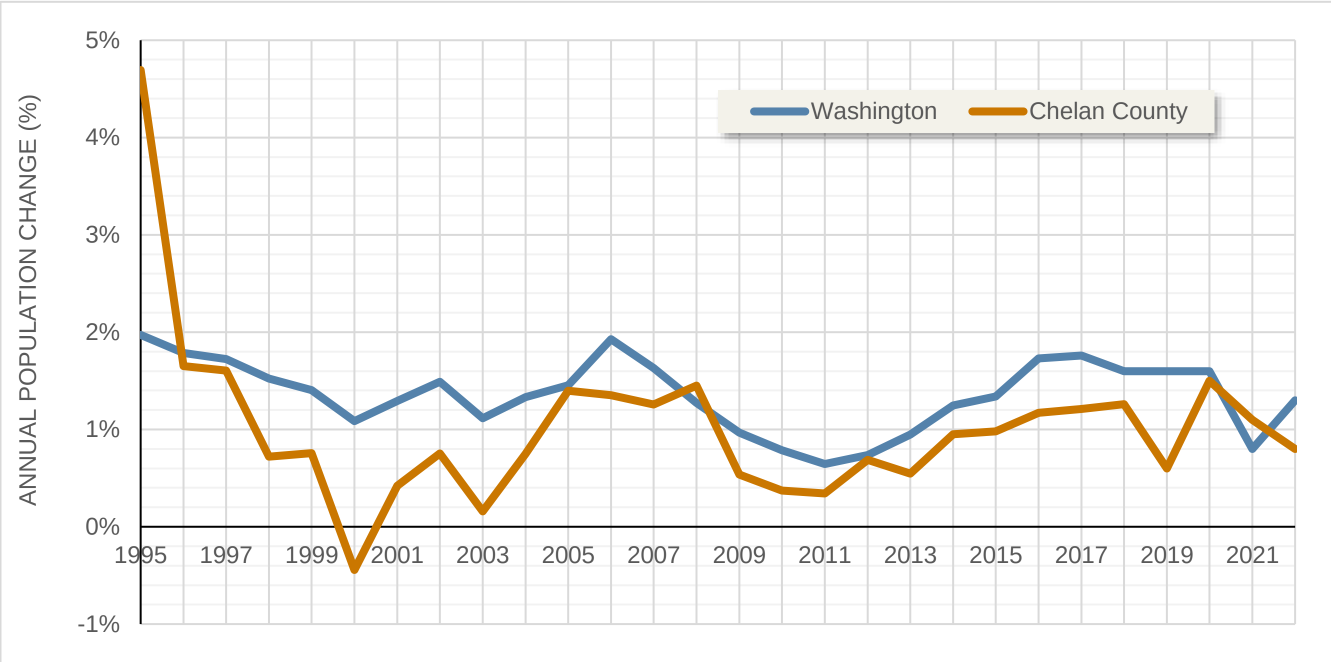


Figure 4-6. Washington and Chelan County Population Growth

Table 4-4. Recent County Population Growth

Year	Chelan County Population	Year	Chelan County Population	Year	Chelan County Population
2005	68,963	2013	73,600	2019	77,944
2006	69,895	2014	74,300	2020	79,141
2007	70,773	2015	75,030	2021	80,000
2008	71,799	2016	75,910	2022	80,650
2009	72,185	2015	75,030	2023	81,340
2010	72,453	2016	75,910	2024	82,001
2011	72,700	2017	76,830		
2012	73,200	2018	77,800		

Source: (Washington Employement Security Department 2023)

Table 4-5. Projected Future County Population

Year	Chelan County Population
2030	85,735
2035	88,516
2040	91,063

Source: (Washington Office of Financial Management 2024)

4.5.2 Socially Vulnerable Population

This plan identifies socially vulnerable populations to include those with heightened risks and limited capacities to cope with disasters, such as low-income individuals, the elderly, children, and people with disabilities. This also includes racial and ethnic minorities, immigrants, refugees, and indigenous populations who face language and other barriers that may impact their ability to prepare for and respond to disasters. Rural residents are also vulnerable due to limited access to emergency services and lack of effective response and recovery. Effective mitigation requires inclusive planning, accessible communication, and equitable resource distribution to enhance resilience.

This plan utilized the data from the Social Vulnerability Index (SVI) map. The results from the SVI are shown in Figure 4-7 and Figure 4-8. The SVI analyzes social vulnerability in four themes: socioeconomic status, household characteristics, racial and ethnic minority status, and housing type/transportation (Social Vulnerability Index (SVI) 2022).

4.5.3 Socioeconomic Status

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 disadvantaged when confronting hazards such as flooding, wildfires, and severe storms. Roughly 17.7% of the population in Chelan County are living below 150% poverty level (Social Vulnerability Index (SVI) 2022). Additionally, the poor typically occupy more poorly built and inadequately maintained housing, rent instead of own, and reside in less desirable areas that are prone to natural hazards, such as floodplains.

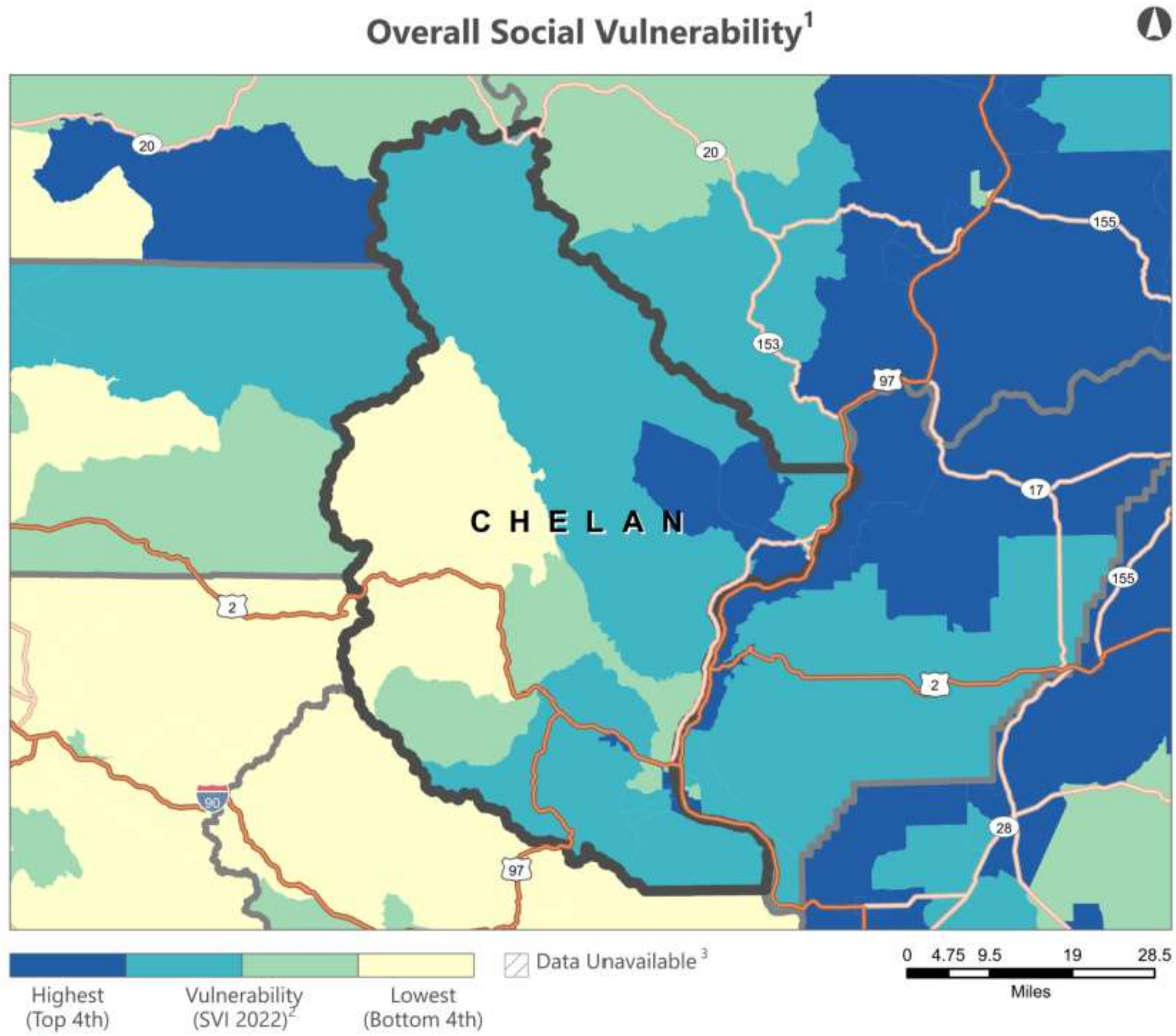
Furthermore, residents below the poverty level are less likely to have insurance to compensate for losses incurred from natural disasters. Based on the most recent three-year estimates (2018-2022) from the U.S. Census Bureau's American Community Survey, per capita income per person in Chelan County was $39,746 compared to the state average of $48,685. An estimated 10.9% of residents from 2016-2020 were uninsured in Chelan County (Social Vulnerability Index (SVI) 2022). 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.

4.5.4 Household Characteristics

As a group, the elderly 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. These facilities are typically identified as "critical facilities" by emergency managers because they require extra notice to implement evacuation. 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. The SVI identifies that 19.9% of the population in Chelan County is 65 or older, compared to the state average of 16.8%.

CDC/ATSDR Social Vulnerability Index 2022

CHELAN COUNTY, WASHINGTON



Social vulnerability refers to a community's capacity to prepare for and respond to the stress of hazardous events ranging from natural disasters, such as tornadoes or disease outbreaks, to human-caused threats, such as toxic chemical spills. The **CDC/ATSDR Social Vulnerability Index (CDC/ATSDR SVI 2022)**[4] **County Map** depicts the social vulnerability of communities, at census tract level, within a specified county. CDC/ATSDR SVI 2022 groups **sixteen census-derived factors** into **four themes** that summarize the extent to which the area is socially vulnerable to disaster. The factors include economic data as well as data regarding education, family characteristics, housing, language ability, ethnicity, and vehicle access. Overall Social Vulnerability combines all the variables to provide a comprehensive assessment.

ATSDR Agency for Toxic Substances and Disease Registry

GRASP Geospatial Research, Analysis, and Services Program

Figure 4-7. SVI Map for Chelan County

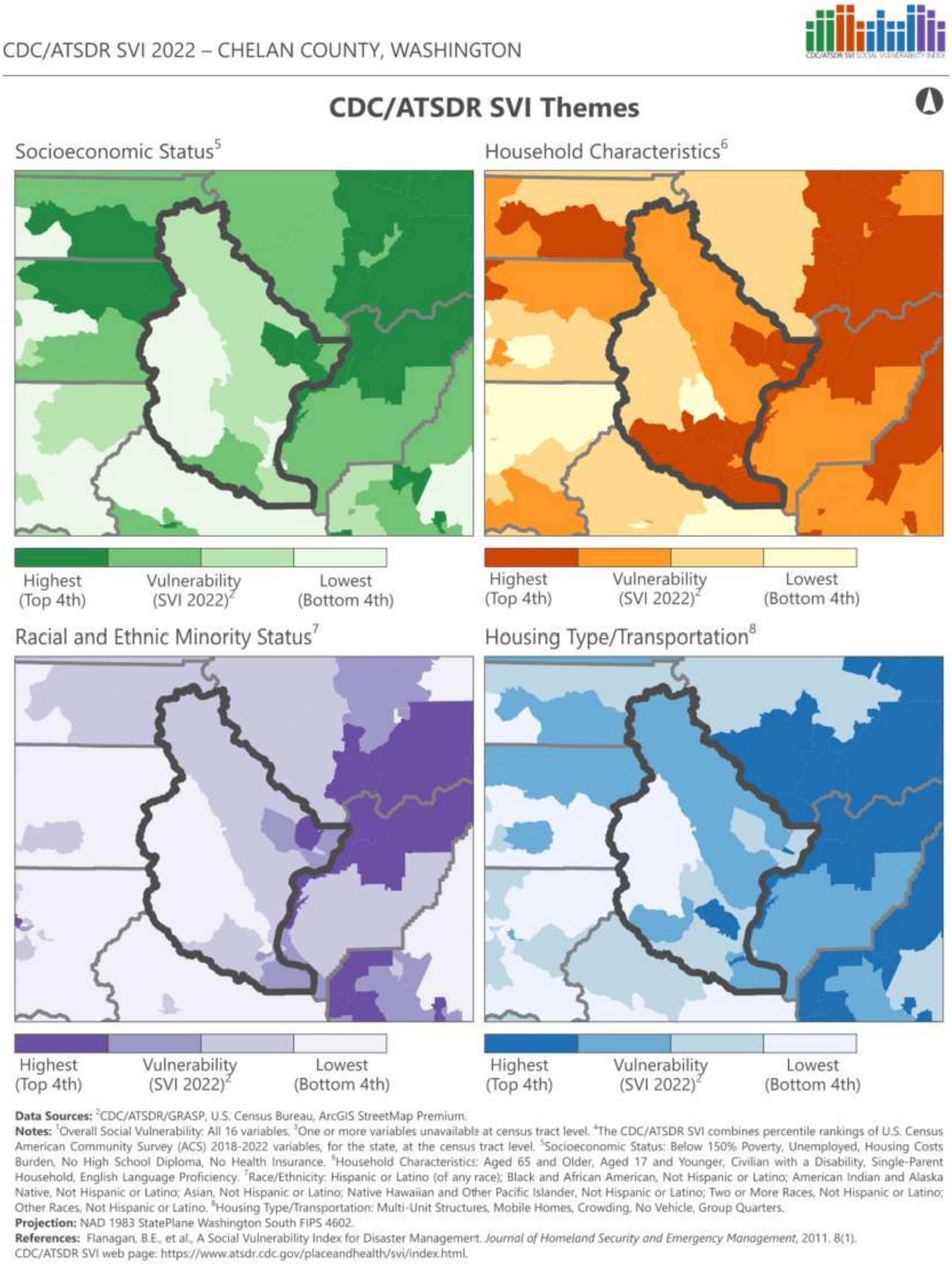


Figure 4-8. SVI Themes for Chelan County

Children under 17 are 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 the flood hazard. According to the SVI, 22.9% of individuals in Chelan County are under the age of 17. The overall age distribution for the planning area is illustrated in Figure 4-9.

Furthermore, people with disabilities are more likely to have difficulty responding to a hazard event than the general population. Local government is the first level of response to assist these individuals, and coordination of efforts to meet their access and functional needs is paramount to life safety efforts. It is important for emergency managers to distinguish between functional and medical needs in order to plan for incidents that require evacuation and sheltering. Knowing the percentage of population with a disability will allow emergency management personnel and first responders to have personnel available who can provide services needed by those with access and functional needs. The 2018-2022 three-year U.S. Census estimates that 9.1% of residents in Washington State and 12.3% of residents in Chelan County under the age of 65 have a disability (U.S. Census Bureau 2022). The SVI estimates that 17.9% of the population in Chelan County have a disability.

Source: (U.S. Census Bureau 2020)

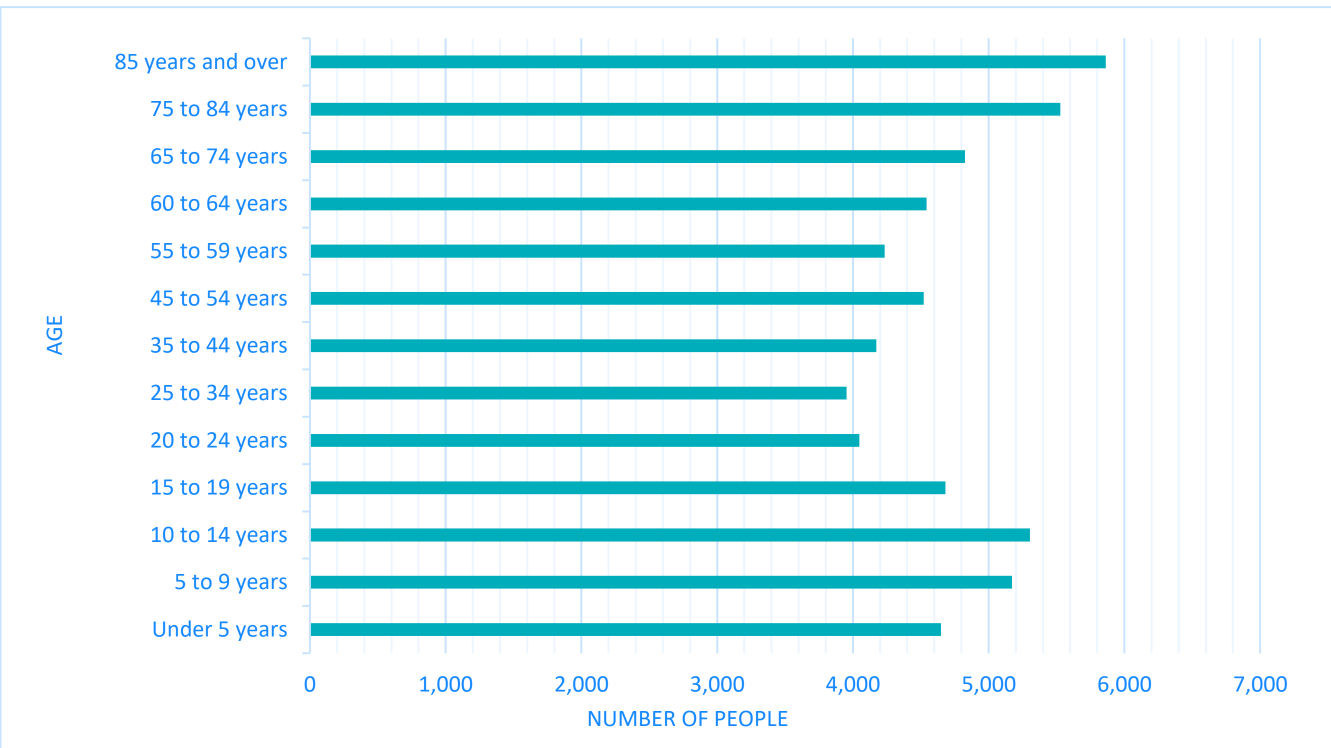


Figure 4-9. Planning Area Age Distribution

4.5.5 Racial and Ethnic Minority Status

Research shows that minorities are less likely to be involved in pre-disaster planning and experience higher mortality rates during a disaster event (Gibbs and Montagnino 2006). Post-disaster recovery can be ineffective and is often characterized by cultural insensitivity. Since higher proportions of ethnic minorities live below the poverty line than the majority white population, poverty can compound vulnerability. The SVI estimates that the minority population in Chelan County is 33.6% (Social Vulnerability Index (SVI) 2022).

According to the 2022 American Community Survey, 29% of the population identifies as Hispanic or Latino. The race and ethnicity composition of the planning area is white alone (non-Hispanic), at 64.8%. The largest non-Hispanic and non-white populations are those identifying as two or more races at 3.4% and those identifying as Black or American Indian at 0.9% each. Figure 4-10 shows the racial and ethnical distribution in the planning area (U.S. Census Bureau 2022).

The planning area has a 14% foreign-born population based on the U.S. Census Bureau American Survey from 2018-2022. 26.1% of individuals over the age of five speak a language other than English at home from the years 2018-2022 (U.S. Census Bureau 2022). In addition, 7.2% of individuals over the age of five speak English less than well (Social Vulnerability Index (SVI) 2022).

Source: (U.S. Census Bureau 2022)

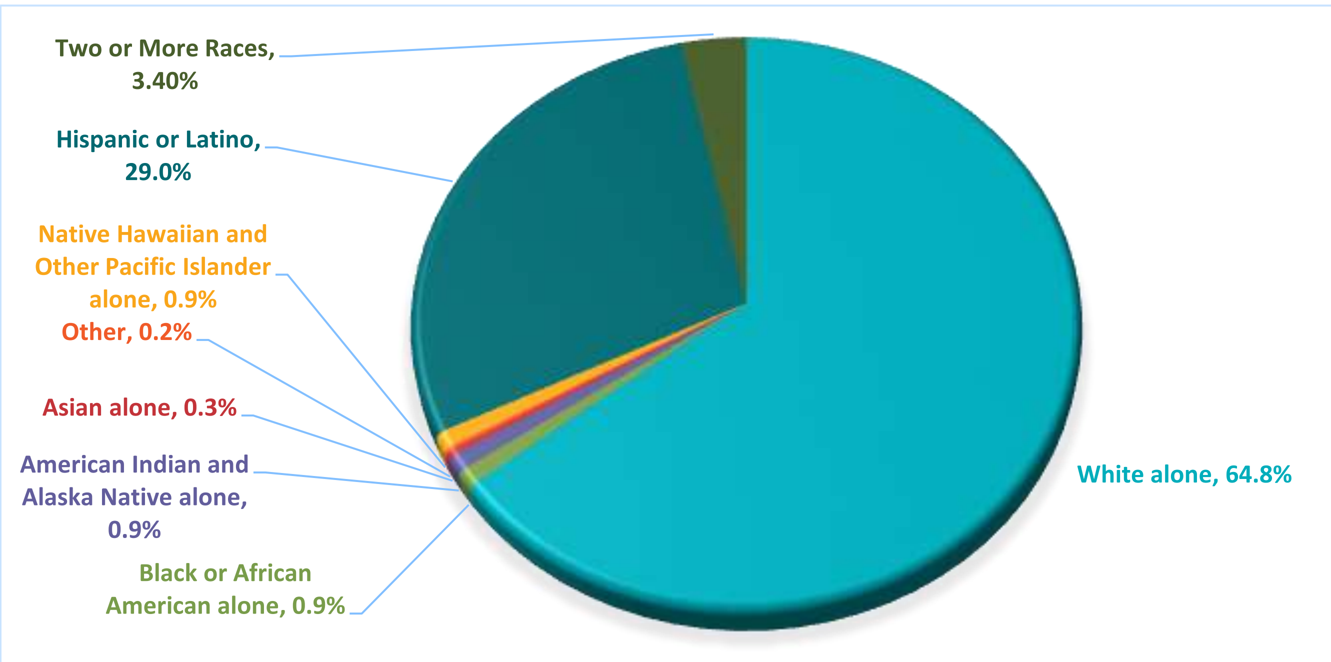


Figure 4-10. Planning Area Race and Ethnicity Distribution (Hispanic and non-Hispanic)

4.5.6 Housing Type and Transportation

Mobile homes are more susceptible to damage in floods, severe weather, and other natural disasters than other types of housing. The SVI estimates that 9.7% of residents are housed in mobile homes. In addition, 9.6% are housed in structures with 10 or more units, 3.1% in houses with more people than rooms, and 2.1% reside in group quarters (Social Vulnerability Index (SVI) 2022).

The events following Hurricane Katrina in 2005 illustrated that personal household economics significantly impact people’s decisions on evacuation. Individuals who cannot afford gas for their cars will likely decide not to evacuate. In addition, not having access to a vehicle will also greatly impact residents’ ability to respond to hazards. 5.3% of households in Chelan County do not have a vehicle (Social Vulnerability Index (SVI) 2022).

4.6 ECONOMY

4.6.1 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 disadvantaged when confronting hazards such as flooding. Additionally, the poor typically occupy more poorly built and inadequately maintained housing. Mobile or modular homes, for example, are more susceptible to damage in floods than other types of housing. 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. The events following Hurricane Katrina in 2005 illustrated that personal household economics significantly impact people's decisions on evacuation. Individuals who cannot afford gas for their cars will likely decide not to evacuate.

Based on the most recent three-year estimates (2018-2022) from the U.S. Census Bureau's American Community Survey, per capita income per person in Chelan County was $39,746, compared to $78,161 per capital income for Washington State. The median household income is $86,282, compared to $91,306 in Washington State. The Census Bureau estimates that 9.3% of the population in the planning area lives below the poverty level (U.S. Census Bureau 2022).

4.6.2 Industry, Businesses, and Institutions

The planning area's economy is strongly based in the education/health care/social service industry (23% of employment), followed by retail trade (11%) and agriculture/forestry/fishing/hunting/mining (10%). Finance, insurance, real estate, rental and leasing (6%), public administration (4%), and information (0.3%) make up the smallest source of the local economy. Figure 4-11 shows the breakdown of industry types in the planning area (U.S. Census Bureau 2022).

Source: (U.S. Census Bureau 2022)

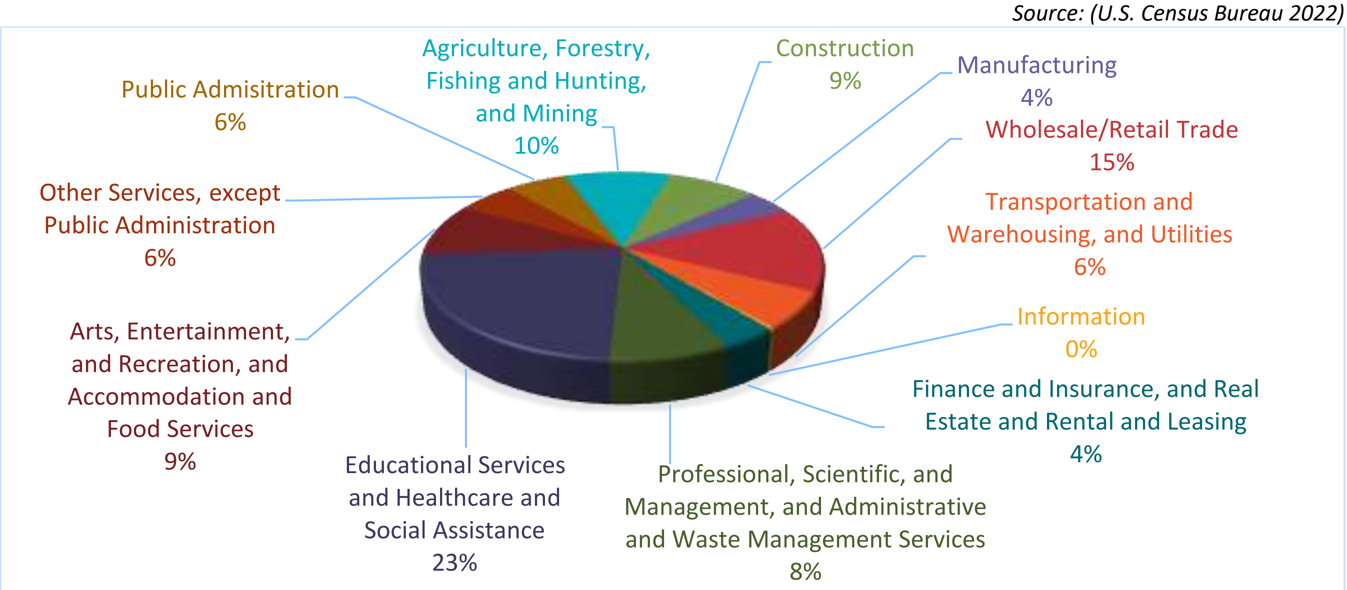


Figure 4-11. Industry in the Planning Area

4.6.3 Employment Trends and Occupations

According to the 2018-2022 3-Year American Community Survey, 61.4% of the planning area's population 16 years old or older is in the labor force, including 56.7% of women in that age range (U.S. Census Bureau 2022).

Figure 4-12 compares unemployment trends from 2002 through 2022 for the United States, Washington and Chelan County, based on data from the state Employment Security Department (Washington Employement Security Department 2023). In 2020, Chelan County (8.2%), Washington State (8.5%), and the United States (8.1%) saw a rise in unemployment. Since the end of the COVID-19 pandemic, unemployment rates have continued to steadily decline.

Source: (Washington Employement Security Department 2023)

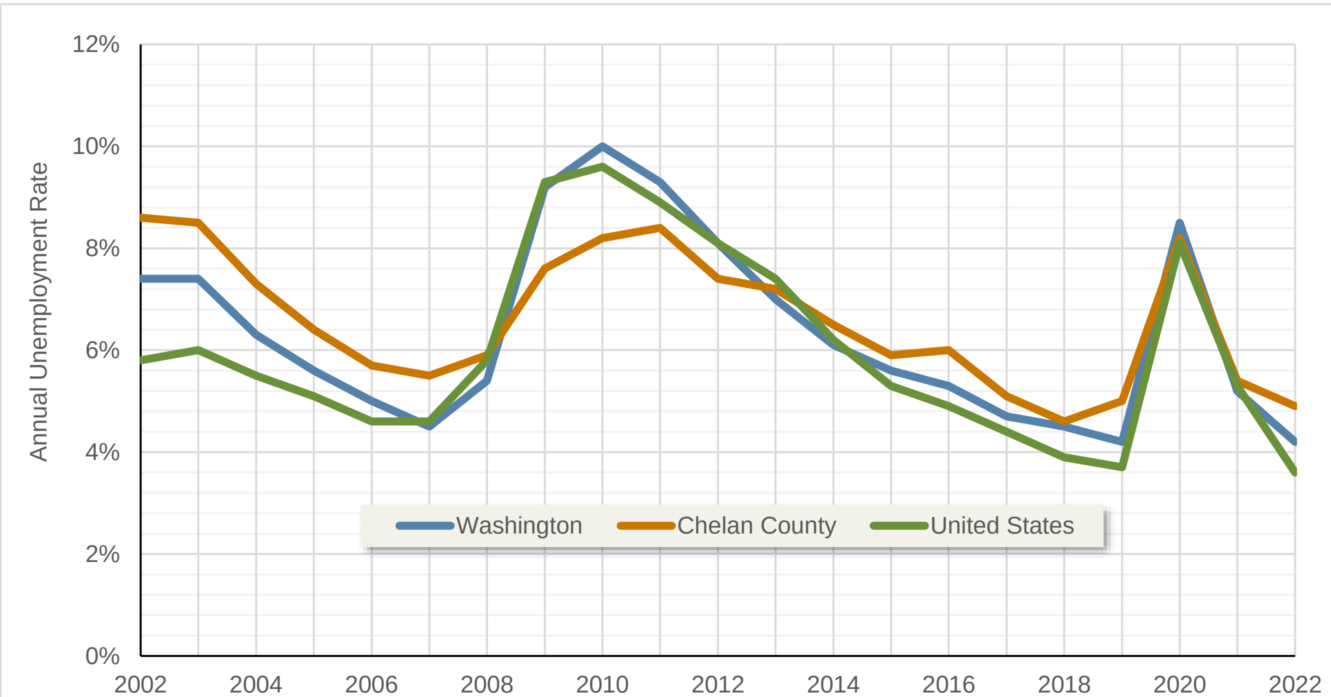


Figure 4-12. U.S., Washington and Chelan County Unemployment Rate

Figure 4-13 shows U.S. Census estimates of employment distribution by occupation category (U.S. Census, 2023). Management, business, science, and arts occupations make up 44% of the jobs in the planning area. Natural resources, construction, and maintenance occupations make up 16% of the jobs in Chelan County.

The 2022 American Community 1-Year Survey estimates that 69.9 % of workers in the planning area commute alone (by car, truck or van) to work, 12.6% carpool, and 10.5% work from home (U.S. Census Bureau 2022).

Source: : (U.S. Census Bureau 2022)

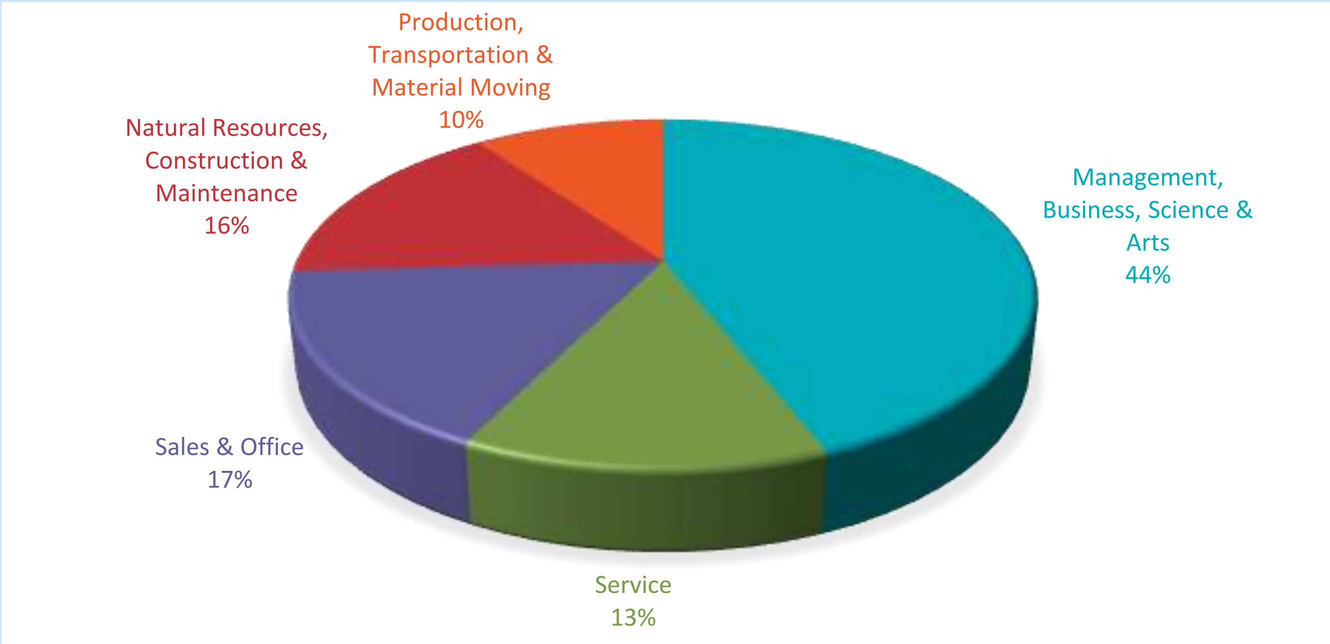


Figure 4-13. Occupations in the Planning Area

5. REGULATIONS AND PROGRAMS

Local Plan Requirement A4 – 44 CFR Part 201.6(b)(3)

Review and incorporation, if appropriate, of existing plans, studies, reports, and technical information.

Existing regulations, agencies and programs at the federal, state, and local level can support or impact hazard mitigation actions identified in this plan. Information presented in this section can be used to review local capabilities to implement the action plan this hazard mitigation plan presents. Individual review by each planning partner of existing local plans, studies, reports, and technical information is presented in the annexes in Volume 2.

5.1 RELEVANT FEDERAL AND STATE AGENCIES, PROGRAMS, AND REGULATIONS

State and federal regulations and programs that need to be considered in hazard mitigation are constantly evolving. For this plan, a review was performed to determine which regulations and programs are currently most relevant to hazard mitigation planning. The findings are summarized in Table 5-1 and Table 5-2. Short descriptions of each program are provided in Appendix B.

Table 5-1. Summary of Relevant Federal Agencies, Programs, and Regulations

Agency, Program, or Regulation	Hazard Mitigation Area Affected	Relevance
A Collaborative Approach for Reducing Wildfire Risks to Communities and the Environment	Wildfire Hazard	This strategy implementation plan prepared by federal and Western state agencies outlines measures to restore fire-adapted ecosystems and reduce hazardous fuels.
Americans with Disabilities Act	Action Plan Implementation	FEMA hazard mitigation project grant applications require full compliance with applicable federal acts.
Bureau of Indian Affairs	Wildfire Hazard	The Bureau's Fire and Aviation Management National Interagency Fire Center provides wildfire protection, fire use and hazardous fuels management, and emergency rehabilitation on Indian forest and rangelands.
Bureau of Land Management	Wildfire Hazard	The Bureau funds and coordinates wildfire management programs and structural fire management and prevention on BLM lands.
Civil Rights Act of 1964	Action Plan Implementation	FEMA hazard mitigation project grant applications require full compliance with applicable federal acts.
Clean Water Act	Action Plan Implementation	FEMA hazard mitigation project grant applications require full compliance with applicable federal acts.

Agency, Program, or Regulation	Hazard Mitigation Area Affected	Relevance
Community Development Block Grant Disaster Resilience Program	Action Plan Funding	This is a potential alternative source of funding for actions identified in this plan.
Community Rating System	Flood Hazard	This voluntary program encourages floodplain management activities that exceed the minimum National Flood Insurance Program requirements.
Disaster Mitigation Act	Hazard Mitigation Planning	This is the current federal legislation addressing hazard mitigation planning.
Emergency Relief for Federally Owned Roads Program	Action Plan Funding	This is a possible funding source for actions identified in this plan.
Emergency Watershed Program	Action Plan Funding	This is a possible funding source for actions identified in this plan.
Endangered Species Act	Action Plan Implementation	FEMA hazard mitigation project grant applications require full compliance with applicable federal acts.
Federal Energy Regulatory Commission Dam Safety Program	Dam Failure Hazard	This program cooperates with a large number of federal and state agencies to ensure and promote dam safety.
Federal Wildfire Management Policy and Healthy Forests Restoration Act	Wildfire Hazard	These documents mandate community-based collaboration to reduce risks from wildfire.
National Dam Safety Act	Dam Failure Hazard	This act requires a periodic engineering analysis of most dams in the country
National Environmental Policy Act	Action Plan Implementation	FEMA hazard mitigation project grant applications require full compliance with applicable federal acts.
National Fire Plan (2001)	Wildfire Hazard	This plan calls for joint risk reduction planning and implementation by federal, state and local agencies.
National Flood Insurance Program	Flood Hazard	This program makes federally backed flood insurance available to homeowners, renters, and business owners in exchange for communities enacting floodplain regulations
National Incident Management System	Action Plan Development	Adoption of this system for government, nongovernmental organizations, and the private sector to work together to manage incidents involving hazards is a prerequisite for federal preparedness grants and awards
Presidential Executive Order 11988 (Floodplain Management)	Flood Hazard	This order requires federal agencies to avoid long and short-term adverse impacts associated with modification of floodplains
Presidential Executive Order 11990 (Protection of Wetlands)	Action Plan Implementation	FEMA hazard mitigation project grant applications require full compliance with applicable presidential executive orders.

Agency, Program, or Regulation	Hazard Mitigation Area Affected	Relevance
U.S. Army Corps of Engineers Dam Safety Program	Dam Failure Hazard	This program is responsible for safety inspections of dams that meet size and storage limitations specified in the National Dam Safety Act.
U.S. Army Corps of Engineers Flood Hazard Management	Flood Hazard, Action Plan Implementation, Action Plan Funding	The Corps of Engineers offers multiple funding and technical assistance programs available for flood hazard mitigation actions
U.S. Fire Administration	Wildfire Hazard	This agency provides leadership, advocacy, coordination, and support for fire agencies and organizations.
U.S. Fish and Wildlife Service	Wildfire Hazard	This service's fire management strategy employs prescribed fire throughout the National Wildlife Refuge System to maintain ecological communities.

Table 5-2. Summary of Relevant State Agencies, Programs, and Regulations

Agency, Program, or Regulation	Hazard Mitigation Area Affected	Relevance
Building Code	Action Plan Implementation	The adoption and enforcement of appropriate building codes is a significant component for hazard mitigation loss avoidance. Using the most up to date and relevant codes reduces risk and increases capability.
Comprehensive Emergency Management Planning	Hazard Mitigation Planning	Emergency management functions of the state and its political subdivisions must be coordinated with comparable functions of the federal government, agencies of other states and localities, and private agencies.
Dam Safety Program	Dam Failure	This program requires regular inspection of state-regulated dams.
Department of Ecology Grants	Action Plan Implementation; Flood Hazard	Flood Control Maintenance Program provides grant funding to local governments for flood hazard management planning and implementation
Enhanced Mitigation Plan	Hazard Mitigation Planning	Local hazard mitigation plans must be consistent with their state's hazard mitigation plan. The Chelan County plan must, at a minimum, address those hazards identified in the state plan as impacting Chelan County.
Environmental Policy Act	Action Plan Implementation	This act establishes a protocol of analysis and public disclosure of the potential environmental impacts of development projects. Any project action identified in this plan will seek full Environmental Policy Act compliance upon implementation.
Floodplain Management Law	Flood Hazard	Identifies prevention of flood damage as a matter of statewide public concern and authorizes county governments to levy taxes, condemn properties and undertake flood control activities

Agency, Program, or Regulation	Hazard Mitigation Area Affected	Relevance
Growth Management Act	Hazard Mitigation Planning	Regulates development in critical areas, and therefore has the potential to affect hazard vulnerability and exposure at the local level
Hydraulic Code	Action Plan Implementation	Will require state permit for mitigation projects that will use, divert, obstruct, or change the natural flow or bed of any salt or freshwaters of the state.
Land and Water Conservation Fund	Action Plan Implementation	May provide funding for mitigation projects that include land acquisition and development or renovation, such as natural areas and open space.
Salmon Recovery Fund	Action Plan Implementation	May provide funding for mitigation projects that protect existing, high quality habitat for salmon or that restore degraded habitat to increase overall habitat health and biological productivity
Shoreline Management Act	Hazard Mitigation Planning	Shoreline management programs are local capabilities relevant to mitigation activities.
Silver Jackets	Flood Hazard	The team's projects address state needs and improve flood risk management throughout the full flood life cycle.
Washington Administrative Code 118-30-060(1)	Hazard Mitigation Planning	Requires each political subdivision to base its comprehensive emergency management plan on a hazard analysis and provides a standardized definition of "hazard."
Watershed Management Act	Hazard Mitigation Planning	Encourages local communities to develop plans for protecting local water resources and habitat.

5.2 LOCAL AGENCIES, PLANS, AND CODES

Plans, reports and other technical information were identified and provided directly by participating jurisdictions and stakeholders or were identified through independent research by the planning consultant. These documents were reviewed to identify the following:

- Existing jurisdictional capabilities.
- Needs and opportunities to develop or enhance capabilities, which may be identified within the local mitigation strategies.
- Mitigation-related goals or objectives considered during the development of the overall goals and objectives.
- Proposed, in-progress, or potential mitigation projects, actions, and initiatives to be incorporated into the updated jurisdictional mitigation strategies.

Local regulations, codes, ordinances and plans were reviewed in order to develop complementary and mutually supportive goals, objectives, and mitigation strategies that are consistent across local and regional planning and regulatory mechanisms:

- Comprehensive plans (housing elements, safety elements)
- Building codes

- Zoning and subdivision ordinances
- NFIP flood damage prevention ordinances
- Stormwater management plans
- Emergency management and response plans
- Land use and open space plans
- Climate action plans.
- Community wildfire protection plans.

The following sections describe countywide agencies, plans and codes relevant to the hazard mitigation planning process. Additional local information is provided in the partner annexes in Volume 2 of this plan.

5.2.1 Flood Control Zone District

The Chelan County Flood Control Zone District was initiated by the Board of Chelan County Commissioners in June 2014 (Resolution 2014-59). RCW 86.15 enables the creation of such districts for the purpose of undertaking, operating or maintaining flood control projects. Activities of the Flood Control Zone District may include the following:

- Flood warning and emergency response
- Flood-proofing and elevation of structures
- Property acquisition
- Implementation of consistent development regulations that recognize the impacts of flooding
- Basin-wide flood planning
- Flood facility maintenance
- Public education and outreach
- Mapping and technical studies
- Mechanisms for citizen inquiry and public assistance
- Identification, engineering and construction of capital projects to mitigate flood problems.

The Chelan County Flood Control Zone District was established in response to the growing frequency and severity of flash and stage flooding in greater Chelan County. The operating guidelines for the Flood Control Zone District identified the following primary purposes of the District, the spirit of which will continue to be implemented throughout the life of this Plan (Chelan County Flood Control Zone District 2014):

- To safeguard human life, health, and safety by protecting public infrastructure from flooding and channel migration
- To identify and implement flood hazard management activities in a cost-effective and environmentally sensitive manner
- To identify flood-prone and repetitive loss areas involving public infrastructure within Chelan County and identify solutions for flood control mitigation in those areas
- To prioritize capital projects to mitigate damage from flash and stage flooding in flood-prone and repetitive loss areas
- To lead and coordinate recovery efforts for significant flooding events within Chelan County with local, state, and federal agencies
- To increase awareness and provide education to the public and other local agencies on flood hazards and effective mitigation measures

- To update, manage, and administer flood zone mapping, local flood zone regulations, and flood hazard assessments within greater Chelan County for consistency with the NFIP.

The Chelan County Flood Control Zone District is funded by an annual property tax of $0.0408 per $1,000 assessed value (2023). Twenty counties in Washington have some type of flood control district, including several with county-wide flood control zone districts. Examples of 2023 levy rates in these districts include $0.03404 per $1,000 in King County, $0.1344 per $1,000 in Whatcom County, $0.070029 per $1,000 in Kittitas County, $0.10 per $1,000 in Pierce County and $0.06228 per $1,000 in Yakima County.

Completion of the 2017 Comprehensive Flood Hazard Management Plan was one of the principle goals identified under the interim operating guidelines. The adopted Flood Plan directs future operations of the Flood Control Zone District.

5.2.2 Comprehensive Plan

Chelan County's first Comprehensive Plan, adopted in 1958, provided guidance about what residents hoped to see in their community. Washington's 1990 Growth Management Act established specific goals and requirements for local comprehensive plans and development regulations. Chelan County adopted a Comprehensive Plan in 2000 to comply with the Washington Growth Management Act (GMA). The last mandated review and update to the Comprehensive Plan was completed in 2017 (Resolution 2017-119), with additional updates occurring annually. The next periodic update of the Comprehensive Plan is due in June 2026.

5.2.3 Emergency Management Plan

The 2023 Comprehensive Emergency Management Plan is Chelan County's framework for response to a disaster or emergency. Several emergency support function documents provided as functional annexes to the basic plan outline general guidelines by which County organizations will carry out the responsibilities assigned in the plan. These emergency support function documents are consistent with FEMA's 2008 *National Response Framework*.

The Comprehensive Emergency Management Plan details the authorities, functions, and responsibilities of local, state, and federal agencies in the event of emergency. It describes the processes of crisis and consequence management and how the integrated actions of local, state, and federal agencies establish a mutually cooperative environment for preparedness, prevention, response, and recovery activities.

5.2.4 Critical Areas Ordinance

Washington's GMA requires cities and counties to adopt policies and development regulations based on the best available science to protect critical areas. Chelan County updated its Critical Areas Ordinance to comply with the GMA in 2021. Title 11 of the Zoning Code describes, and defines setback requirements for, the following critical areas:

- Fish and wildlife habitat conservation areas
- Wetland areas
- Aquifer recharge areas
- Frequently flooded areas
- Geologically hazardous areas.

5.2.5 Shoreline Master Program

Chelan County's Shoreline Master Program is a planning and regulatory document that contains policies, goals and land-use regulations for shorelines. The current Shoreline Master Program was adopted by the Chelan County Regional Planning Council and the Washington Department of Ecology in 1975 and was revised in 1979. Primary responsibility for administering this regulatory program is assigned to the County's Community Development Department, which has jurisdiction for permitting development on the state's shoreline within the County.

The Chelan County Community Development Department updated the Shoreline Master Program in June 2021 (Resolution 2021-076). The Cities of Cashmere, Chelan, Entiat, Leavenworth and Wenatchee also participated in the Shoreline Master Program update. Each city and the county adopted Shoreline Master Programs in the mid-1970s and has performed periodic updates to comply with the state's Shoreline Management Act.

5.2.6 WRIA Planning

Although Washington's Watershed Management Act does not require planning, Chelan County and local governments have undertaken WRIA-related planning activities. The Washington Department of Ecology is providing technical and financial support for the effort. Chelan County has participated in watershed planning for four WRIAs (see descriptions in Section 4.3.2):

- Wenatchee Watershed (WRIA 45)
- Entiat Watershed (WRIA 46)
- Chelan Watershed (WRIA 47)
- Alkali-Squilchuck Watershed (WRIA 40).

5.2.7 Chelan County Natural Resources Department

The County's Natural Resource Department addresses federal, state, and local natural resource mandates and issues. Areas of focus include water resources and timber, fish, wildlife, and agricultural activities within Chelan County and north-central Washington. The Department addresses the impacts of local, state, federal, tribal, and other initiatives, both regulatory and non-regulatory, on natural resource and the economic base of Chelan County. It responds to the general policy direction of the Board of County Commissioners and integrates other County departments' activities into its work products.

5.2.8 Voluntary Stewardship Program

The Voluntary Stewardship Program is an optional, incentive-based approach to protecting critical areas while promoting agriculture. The program is allowed under the Growth Management Act as an alternative to traditional approaches to critical areas protection, such as "no touch" buffers. Chelan County is one of 28 counties that has opted in to the Voluntary Stewardship Program and completed a work plan in 2017.

5.3 LOCAL CAPABILITY ASSESSMENT

Local Plan Requirement C1a—44 CFR Part 201.6(c)(3)	Local Plan Requirement C1b—44 CFR Part 201.6(c)(3)
The plan must describe how the existing authorities, policies, programs, funding and resources of each participant are available to support the mitigation strategy. This must include a discussion of the existing building codes and land use and development ordinances or regulations.	***The plan must describe the ability of each participant to expand on and improve the capabilities described in the plan. If the participants do not have the ability or authority to expand and/or improve their capabilities, the plan must describe this lack of ability or authority.***

All participating jurisdictions compiled an inventory and analysis of existing authorities and capabilities called a "capability assessment." A capability assessment creates an inventory of a jurisdiction's mission, programs and policies, and evaluates its capacity to carry them out. This assessment identifies potential gaps in the jurisdiction's capabilities.

The planning partnership views all core jurisdictional capabilities as fully adaptable to meet a jurisdiction's needs. Every code can be amended, and every plan can be updated. Such adaptability is itself considered to be an overarching capability. If the capability assessment identified an opportunity to add a missing core capability or expand an existing one, then doing so has been selected as an action in the jurisdiction's action plan, which is included in the individual annexes presented in Volume 2 of this plan.

Capability assessments for each planning partner are presented in the jurisdictional annexes in Volume 2. Each planning partner described how their capabilities could be expanded or improved on. The sections below describe the specific capabilities evaluated under the assessment.

5.3.1 Legal and Regulatory Capabilities

Jurisdictions can develop policies and programs and to implement rules and regulations to protect and serve residents. Local policies are typically identified in a variety of community plans, implemented via a local ordinance, and enforced through a governmental body.

Jurisdictions regulate land use through the adoption and enforcement of zoning, subdivision and land development ordinances, building codes, building permit ordinances, floodplain, and stormwater management ordinances. When effectively prepared and administered, these regulations can lead to hazard mitigation.

5.3.2 Fiscal Capabilities

Assessing a jurisdiction's fiscal capability provides an understanding of the ability to fulfill the financial needs associated with hazard mitigation projects. This assessment identifies both outside resources, such as grant-funding eligibility, and local jurisdictional authority to generate internal financial capability, such as through impact fees.

5.3.3 Administrative and Technical Capabilities

Legal, regulatory, and fiscal capabilities provide the backbone for successfully developing a mitigation strategy; however, without appropriate personnel, the strategy may not be implemented. Administrative and technical capabilities focus on the availability of personnel resources responsible for implementing all the facets of hazard mitigation. These resources include technical experts, such as engineers and scientists, as well as personnel with capabilities that may be found in multiple departments, such as grant writers.

5.3.4 NFIP Compliance

Flooding is the costliest natural hazard in the United States and, with the promulgation of recent federal regulation, homeowners throughout the country are experiencing increasingly high flood insurance premiums. Community participation in the NFIP opens opportunity for additional grant funding associated specifically with flooding issues. Assessment of the jurisdiction's current NFIP status and compliance provides planners with a greater understanding of the local flood management program, opportunities for improvement, and available grant funding opportunities.

5.3.5 Public Outreach Capability

Regular engagement with the public on issues regarding hazard mitigation provides an opportunity to directly interface with community members. Assessing this outreach and education capability illustrates the connection between the government and community members, which opens a two-way dialogue that can result in a more resilient community based on education and public engagement.

5.3.6 Participation in Other Programs

Other programs, such as the Community Rating System, StormReady, and Firewise USA, enhance a jurisdiction's ability to mitigate, prepare for, and respond to natural hazards. These programs indicate a jurisdiction's desire to go beyond minimum requirements set forth by local, state and federal regulations in order to create a more resilient community. These programs complement each other by focusing on communication, mitigation, and community preparedness to save lives and minimize the impact of natural hazards on a community.

5.3.7 Development and Permitting Capability

Identifying previous and future development trends is achieved through a comprehensive review of permitting since completion of the previous plan and in anticipation of future development. Tracking previous and future growth in potential hazard areas provides an overview of increased exposure to a hazard within a community.

5.3.8 Adaptive Capacity

An adaptive capacity assessment evaluates a jurisdiction's ability to anticipate impacts from future conditions. By looking at public support, technical adaptive capacity, and other factors, jurisdictions identify their core capability for resilience against changing conditions. The adaptive capacity assessment provides jurisdictions with an opportunity to identify areas for improvement by ranking their capacity high, medium or low.

5.3.9 Integration Opportunity

The assessment looked for opportunities to integrate this mitigation plan with the legal/regulatory capabilities identified. Capabilities were identified as integration opportunities if they can support or enhance the actions identified in this plan or be supported or enhanced by components of this plan. Planning partners considered actions to implement this integration as described in their jurisdictional annexes.

6. Hazards of Concern for 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. The DMA requires hazard mitigation planning to include risk assessment (44 CFR, Section 201.6(c)(2)). The risk assessment for the *Chelan County Multi-Jurisdiction Natural Hazard Mitigation Plan* evaluates all natural hazards that are prevalent in the defined planning area. The first step in the process was to identify which hazards to include in the assessment. This chapter describes the process of identifying these hazards of concern.

6.1 FOCUS ON NATURAL HAZARDS

Natural hazards are naturally occurring severe events that have the potential to result in the loss of life and property. Technological or human-caused hazards also have the potential to result in the loss of life and property but originate from human activities. Federal hazard mitigation planning guidelines require risk assessment for all natural hazards of concern; risk assessment of non-natural hazards (technological and/or human-caused) is optional. The Steering Committee decided that this plan will focus on natural hazards of concern, based on several factors:

- The federal funding streams for which this plan creates eligibility are focused on natural hazards of concern.
- The expertise needed to identify and implement appropriate mitigation actions for non-natural hazards of concern differs from the expertise needed for assessing natural hazards. The Steering Committee was formed with an emphasis on knowledge of and experience with natural hazards.
- It is difficult to develop a relative ranking of the risk of natural and non-natural hazards because of differences between the two types of hazard in probabilities, consequences and spatial extent.

During the 2019 update, the Steering Committee discussed cyber-related threats, specifically crypto currency mining, but decided not to include this hazard in the plan at that time. The 2024 Steering Committee made the same decision. This hazard will be monitored and included in the next update if warranted.

6.2 IDENTIFIED HAZARDS OF CONCERN

The Steering Committee considered the full range of natural hazards that could impact the planning area and selected those that present the greatest concern for evaluation in this hazard mitigation plan. 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 the perceived vulnerability of planning area assets to natural hazards was used as appropriate. Table 6-1 summarizes the review of hazards and selection of hazards of concern for this plan.

The Steering Committee also recognized the importance in Chelan County of impacts from various hazards on agriculture. In 2024, agriculture was identified as an asset of community importance. Each individual hazard profile contains a discussion on the vulnerability and impacts to agriculture.

Table 6-1. Assessment of Hazards for this Hazard Mitigation Plan

Hazard	Included in 2019 Chelan County Plan	Noted as Local Hazard in State Plan	Consideration	Included in Current Update
Avalanche	Yes	Yes	Winter snow accumulations, temperature variations (freeze-thaw cycle), and steep slopes result in occasional avalanches in the area, although development is typically not located in these areas.	Yes
Climate change	Yes	N/A	Steering Committee identified this as a current local hazard. It was determined that climate change would be examined in each individual hazard's chapter.	Yes
Cyber threats	No	N/A	Not a natural hazard; may be included in future updates	No
Dam failure	Yes	N/A	Steering Committee identified this as a current local hazard	Yes
Drought	Yes	Yes	Extreme summer heat and markedly low precipitation in the lowlands, where most of the agricultural and residential development occur, result in occasional drought conditions and declarations.	Yes
Earthquake	Yes	Yes	The mountainous terrain and geologic instability of the region result in frequent minor earthquakes and occasional events that cause property damage.	Yes
Flood	Yes	Yes	Chelan County is distinguished by mountainous terrain and narrow river valley bottoms that contain much of the developable land base.	Yes
Landslide	Yes	Yes	A combination of severe storms, steep slopes and unstable geography results in occasional landslides.	Yes
Seiche	Yes	No	Steering Committee identified this as a current local hazard; discussed in earthquake hazard chapter	Yes
Severe weather	Yes	No	The area is marked by four traditional seasons, with summer and winter weather exhibiting sometimes extreme conditions. Long periods of cold weather and snow in the winter and extended periods of 100 degrees + in summer are not uncommon.	Yes
Wildfire	Yes	Yes	Extreme summer conditions combined with historic and present timber management practices have resulted in large-scale wildfires, including areas at the urban wildland interface. For the 2024 plan, the Steering Committee agreed to change the chapter name to Wildfire and Wildfire Smoke, due to the prevalence and nature of smoke during the summer.	Yes
Volcano	No	No	State plan does not recognize this as a hazard for Chelan County; risk is limited to ash fall.	No

7. RISK ASSESSMENT METHODOLOGY

7.1 OVERALL RISK ASSESSMENT APPROACH

Local Plan Requirement A4 – 44 CFR Part 201.6(b)(3)

Review and incorporation, if appropriate, of existing plans, studies, reports, and technical information.

The risk assessments in Chapter 8 though Chapter 15 describe the risks associated with each identified hazard of concern. Each chapter describes the hazard, the planning area's exposure and vulnerability, and probable event scenarios. The planning team reviewed existing studies, reports and technical information to determine the best available data to utilize in the risk assessment. Information from these sources was incorporated into the hazard profiles and forms the basis of the exposure and vulnerability assessment (see Section 7.7). The following steps were used to define the risk of each hazard:

- Profile each hazard—The following information is given for each hazard:
    - Summary of past events
    - Geographic area most affected by the hazard
    - Event frequency estimates
    - Severity estimates
    - Warning time likely to be available for response
    - Secondary hazards associated with or resulting from the hazard of concern
    - Future trends that may impact risk, including future development and climate trends
    - Worst-case event scenario
    - Key issues related to mitigation of the hazard in the planning area.
- Determine vulnerability to each hazard—vulnerability was determined by overlaying hazard maps with demographic information and an inventory of structures, facilities and systems to determine which of them would be vulnerable to each hazard. For each hazard of concern, the best available existing data was used to delineate the hazard area, based on scale, age and source. Data available in a GIS-compatible format with coverage of the full extent of the planning area was preferred when available.
- Assess the impact of vulnerable facilities—Impact of vulnerable structures and infrastructure was determined by interpreting the probability of occurrence of each event and assessing structures, facilities, and systems that are vulnerable to each hazard. FEMA's hazard-modeling program, Hazus was used to perform this assessment for some hazards; GIS-based spatial analysis or qualitative assessments were used for others.

7.2 NATIONAL RISK INDEX

FEMA's National Risk Index (NRI) was included as an additional layer of data to assess potential hazard-related losses. The NRI assigns numerical risk scores (based on percentiles) and descriptive risk ratings (very low to very high) at the Census tract and county levels. These scores and ratings are based on estimates of annual losses due to 18 types of hazard events, with adjustments to account for social vulnerability (which increases risk) and community resilience (which decreases risk).

The NRI multiplies the expected annual loss by a community risk factor derived from the social vulnerability and community resilience scores. Each community's resulting risk value is compared to all communities nationwide to assign its percentile-based score from zero (lowest risk value) to 100 (highest risk value).

The annual losses estimated in the NRI represent economic losses to buildings and agriculture and human fatalities and injuries. Building values and populations are derived from the Hazus model default inventory. Agriculture values are taken from the U.S. Department of Agriculture (USDA) Census of Agriculture.

Hazards included in the NRI analysis that align with this plan are:

- Avalanche
- Drought
- Earthquake
- Flood
- Landslide
- Severe Weather
  - Winter storms
  - High Winds
  - Extreme Temperatures
  - Thunderstorms
- Wildfire

7.3 MAPPING

National, state and county databases were reviewed to locate spatially based data relevant to this planning effort. Maps were produced using GIS software to show the spatial extent and location of identified hazards when such data was available. These maps are included in the hazard profile chapters of this document. Additionally, municipal planning partners have jurisdiction-scale maps included in their annexes in Volume 2 of this plan.

7.4 EARTHQUAKE AND FLOOD

7.4.1 Overview of FEMA's Hazus Software

FEMA developed the Hazards U.S., or Hazus, model in 1997 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. The use of Hazus for hazard mitigation planning offers numerous advantages:

- 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 local government and can be used to manage and update a hazard mitigation plan throughout its implementation.

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, community lifelines, transportation and utility lifeline, and multiple models to estimate potential losses from natural disasters. The program can be used to map hazard data and the results of damage and economic loss estimates for buildings and infrastructure.

7.4.2 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.

7.4.3 Application for This Plan

The Hazus model was used as follows for the hazards evaluated in this plan:

- **Flood**—A Level 2 user-defined analysis was performed for general building stock in flood zones and for critical facilities and infrastructure. Draft flood mapping for the planning area was used to delineate flood hazard areas and estimate potential losses from the 1%-annual-chance and 0.2%-annual-chance flood events. To estimate damage that would result from a flood, Hazus uses pre-defined relationships between flood depth at a structure and resulting damage, with damage given as a percent of total replacement value. Curves defining these relationships have been developed for damage to structures and for damage to typical contents within a structure. By inputting flood depth data and known property replacement cost values, dollar-value estimates of damage were generated.
- **Earthquake**—A Level 2 analysis was performed to assess earthquake exposure and vulnerability for two scenario events:
  - A Magnitude-7.2 event on the Chelan Fault with an epicenter approximately 5.6 miles east-southeast of the City of Chelan.

- A Magnitude-9.34 event on the Cascadia Fault with an epicenter approximately 250 miles southwest of Wenatchee.

7.5 DROUGHT

The risk assessment methodologies used for this plan focus on damage to structures. Because drought does not impact structures to the same degree as other hazards, the risk assessment for drought was more limited and qualitative than the assessment for the other hazards of concern.

7.6 WILDFIRE

The Ember Alliance used predictions of crown fire behavior and flame length from the 2022 Pacific Northwest Quantitative Wildfire Risk Assessment (PNW QWRA) to assess the risk that radiant heat and short-range and long-range ember cast can pose to structures. The production, transport, and ability of embers to ignite recipient fuels are guided by complex processes, so we utilized a simplified approach that assumes:

- The ability of direct flame exposure to ignite structures depends on flame length. We identified structures with >50% probability of loss from direct flame exposure following the methodology of Abo El Ezz et all (Abo El Ezz, et al. 2022).
- Radiant heat can ignite structures when extreme fire behavior occurs within 33 yards (30 meters) of structures. The distance cutoff for radiant heat comes from Beverly et al. (2010). Extreme fire behavior was defined as areas with >5% probability of ≥8 foot flame lengths (Beverly, et al. 2010).
- Short-range embers can ignite homes within about 110 yards (100 meters) of high-grade passive crown fire and active crown fire. The distance cutoff for short-range comes from Beverly et al. (2010). Caggiano et al., (2020) also found that a vast majority (95%) of home losses during WUI fires occurred within 100 m of wildland vegetation.
- Long-range embers can ignite homes within 0.5 mile (850 meters) of high-grade passive crown fire and active crown fire (Caggiano, et al. 2020).

The fire behavior model used by the 2022 PNW QWRA and the approach outlined above cannot account for defensible space, the fire resistance of materials used in structure construction, and other fine-scale variation in fuel loads that contribute to the ignition potential of individual structures.

7.7 SOURCES OF DATA USED IN RISK ASSESSMENT

7.7.1 Building Count and Replacement Cost Value

Parcel and building information from the Chelan County Assessor were used to compile a detailed, countywide structure inventory including replacement costs. When available, an updated inventory was used in place of the Hazus defaults for critical facilities and infrastructure.

Replacement cost is the cost to replace the entire structure with one of equal quality and utility. Replacement cost is based on industry-standard cost-estimation models published in RS Means Square Foot Costs (RS Means, 2024). It is calculated using the RS Means square foot cost for a structure, which is based on the Hazus occupancy class (i.e., multi-family residential or commercial retail trade), multiplied by the square footage of the structure from the tax assessor data. The construction class and number of stories for single-family residential structures also factor into determining the square foot costs.

7.7.2 Hazus Data Inputs

The following hazard datasets were used for the Hazus Level 2 analysis conducted for the risk assessment:

- **Flood**—The August 2023 draft floodplain mapping from FEMA was used to estimate the potential losses from the 1%-annual-chance and 0.2%-annual-chance flood events.
- **Earthquake**—Earthquake ShakeMaps data prepared by the U.S. Geological Survey (USGS) were used for the analysis of this hazard. National Earthquake Hazard Reduction Program (NEHRP) soils and liquefaction susceptibility information from Washington State Department of Natural Resources (WA DNR) were utilized in the Hazus model.

7.7.3 Other Local Hazard Data

Locally relevant information on hazards was gathered from a variety of sources. Frequency and severity indicators include past events and the expert opinions of geologists, emergency management specialists, and others. Data sources for specific hazards were as follows:

- **Avalanche**—No GIS format avalanche area datasets were identified for Chelan County.
- **Dam or Levee Failure**—No GIS format dam failure or levee failure data were provided to Chelan County.
- **Landslide**—Landslide compilation data was provided by DNR.
- **Seiche**—No GIS format seiche area datasets were identified for Chelan County.
- **Severe Storm**—No GIS format severe storm area datasets were identified for Chelan County.
- **Wildfire**—The 2022 Pacific Northwest Quantitative Wildfire Risk Assessment was used to assess the risk that radiant heat and short-range and long-range ember cast can pose to structures.

7.7.4 Data Used for Spatial Analysis

Table 7-1 describes the data used for spatially based exposure and vulnerability assessments. If no database was available, it was noted as a gap.

Table 7-1. Summary of Data Used

Data	Source	Date	Format
Parcels	Chelan County	2024	Digital (GIS) format
Address Points	Chelan County	2024	Digital (GIS) format
2023-24 Certified Assessment Roll	Chelan County	2023	Digital (GIS) format
Building replacement cost	RS Means	2024	Paper format. Updated RS Means values
Population data	FEMA Hazus version 6.0	2024	Digital (GIS and tabular) format
FEMA Draft DFIRM Floodplains and Depth Grids	FEMA/Atkins	2023-2024	Digital (GIS) format
1-meter LiDAR DEM for Chelan County	Oregon Department of Geology and Mineral Industries	2015	Digital (GIS) format
10-meter DEM	USGS	Downloaded 2024	Digital (GIS) format

Cascadia Megathrust M9.34 ShakeMap	USGS Earthquake Hazards Program website	2017	Digital (GIS) format
Chelan M7.2 ShakeMap	WA DNR	2009	Digital (GIS) format
Seismic Ground Response – Liquefaction Susceptibility (Open File Report 2004-20)	WA DNR	2010	Digital (GIS) format
Seismic Ground Response – Seismic Site Class (Open File Report 2004-20)	WA DNR	2010	Digital (GIS) format
Washington State Landslide Inventory Database – Digital Data Series 29 (DS-29)	WA DNR	2023	Digital (GIS) format
2022 Pacific Northwest Quantitative Wildfire Risk Assessment	Oregon State University	2023	Digital (GIS) format
Critical Facilities and Assets			
Police Station Facilities	Hazus v6.1	Various	Digital (GIS) format
Fire Station Facilities	Hazus v6.1	Various	Digital (GIS) format
Fire and Emergency Medical Service Station	HIFLD	Downloaded 2024	Digital (GIS) format
EOC Facilities	Hazus v6.1	Various	Digital (GIS) format
Publicly-owned properties	City of Chelan	Provided 2024	Digital (GIS) format
Courthouses	HIFLD	Downloaded 2024	Digital (GIS) format
School Facilities	Hazus v6.1	Various	Digital (GIS) format
Public Refrigerated Warehouses	HIFLD	2014	Digital (GIS) format
Convention Centers and Fairgrounds	HIFLD	2020	Digital (GIS) format
Medical Care Facilities	Hazus v6.1	Various	Digital (GIS) format
Clinics	WA DOH	Downloaded 2024	Digital (GIS) format
WIC Clinics	WA DOH	Downloaded 2024	Digital (GIS) format
Kidney Dialysis Centers	WA DOH	Downloaded 2024	Digital (GIS) format
Pharmacies	WA DOH	Downloaded 2024	Digital (GIS) format
Nursing Homes	HIFLD	2022	Digital (GIS) format
Power Plants	HIFLD	2022	Digital (GIS) format
Natural Gas Receipt Delivery Points	HIFLD	2019	Digital (GIS) format
Communications Facilities	Hazus v6.1	Various	Digital (GIS) format
Cellular Towers	HIFLD	2021	Digital (GIS) format
FDIC Insured Banks	HIFLD	2019	Digital (GIS) format
NCUA Insured Credit Unions	HIFLD	2017	Digital (GIS) format
Rail Facilities	Hazus v6.1	Various	Digital (GIS) format
WSDOT – Aviation Non-Military Airports	WSDOT	2012	Digital (GIS) format

Aviation Facilities	HIFLD	Downloaded 2024	Digital (GIS) format
Ferry Facilities	Hazus v6.1	Various	Digital (GIS) format
Highway Tunnels	Hazus v6.1	Various	Digital (GIS) format
Highway Bridges	Hazus v6.1	Various	Digital (GIS) format
Railway Bridges	Hazus v6.1	Various	Digital (GIS) format
EPA Toxic Release Inventory (TRI) Facilities	EPA	Downloaded 2024	Digital (GIS) format
Potable Water Facilities	Hazus v6.1	Various	Digital (GIS) format
Wastewater Facilities	Hazus v6.1	Various	Digital (GIS) format

7.8 LIMITATIONS

7.8.1 General Limitations

Loss estimates, exposure assessments and hazard-specific vulnerability evaluations rely on the best available data and methodologies. However, results are subject to uncertainties associated with the following factors:

- Incomplete scientific knowledge about natural hazards and their effects on the built environment
- 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
- The amount of advance notice residents have to prepare for a specific hazard event

Hazus currently represents the industry best management practice for assessing risk in support of hazard mitigation planning. However, Hazus and other models used for this risk assessment are limited by the availability of data to support their working components. Such models must assumptions where firm data are not available. Assumptions are used, for example, to estimate ground deformation caused by liquefaction. These model limitations can lead to an understatement or overstatement of risk.

These factors can affect loss estimates by a factor of two or more. Therefore, potential exposure and loss estimates are approximate and should be used only to understand relative risk. Over the long term, Chelan County and its planning partners will collect additional data to assist in estimating potential losses associated with other hazards.

7.8.2 Specific Limitations Noted During the Planning Process

The following are limitations specific to the datasets used in this planning process:

- Chelan County assessor data lacked detailed information on building type and foundation type (e.g. masonry construction and slab-on-grade, respectively). Default information was used, which impacts the accuracy of vulnerability estimates because building and foundation type play a major role in how structures will behave during hazard events.

- Model data input requirements necessitate the representation of buildings as single point features. Building locations are represented by single points located at the address point (as identified for 911 purposes), or in the centroid of the parcel.

Part 2. Risk Assessment

Local Plan Requirement B1— 44 CFR 201.6(c)(2)(i)	Local Plan Requirement B2— 44 CFR 201.6(c)(2)(ii)
The risk assessment shall include a description of the type, location, and extent of all natural hazards that can affect the jurisdiction. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.	***The risk assessment shall include a description of the jurisdiction's vulnerability to the hazards described in paragraph (c)(2)(i). This description shall include an overall summary of each hazard and its impact on the community.***

8. AVALANCHE

8.1 GENERAL BACKGROUND

8.1.1 Causes

Avalanches can occur whenever a sufficient depth of snow is deposited on slopes steeper than about 20 degrees, with the most dangerous coming from slopes in the 35- to 40-degree range. Avalanche-prone areas can be identified with some accuracy, since they typically follow the same paths year after year, leaving scarring on their paths. However, unusual weather conditions can produce new paths or cause avalanches to extend beyond their normal paths.

In the spring, warming of the snowpack occurs from below (from the warmer ground) and above (from warm air, rain, etc.). Warming can be enhanced near rocks or trees that transfer heat to the snowpack. The effects of a snowpack becoming weak may be enhanced in steeper terrain where the snowpack is shallow, and over smooth rock faces that may focus meltwater and produce "glide cracks." Such slopes may fail during conditions that encourage melt.

Wind can affect the transfer of heat into the snowpack and associated melt rates of near-surface snow. During moderate to strong winds, the moistening near-surface air in contact with the snow is constantly mixed with drier air above through turbulence. As a result, the air is continually drying out, which enhances evaporation from the snow surface rather than melt. Heat loss from the snow necessary to drive the evaporation process cools off near-surface snow and results in substantially less melt than otherwise might occur, even if temperatures are well above freezing.

When the snow surface becomes uneven in spring, air flow favors evaporation at the peaks, while calmer air in the valleys favors condensation there. Once the snow surface is wet, its ability to reflect solar energy drops dramatically; this becomes a self-perpetuating process, so that the valleys deepen (favoring calmer air and more heat transfer), while more evaporation occurs near the peaks, increasing the differential between peaks and valleys. However, a warm wet storm can quickly flatten the peaks as their larger surface area exposed to warm air, rain or condensation hastens their melt over the sheltered valleys.

8.1.2 Types

Avalanches are basically of two types:

- **Loose snow avalanches** start at a point or over a small area. Slab avalanches, on the other hand, start when a large area of snow begins to slide at the same time. Snow avalanches grow in size and the quantity of snow involved increases as they descend. Steep slopes, usually from 30 to 50 degrees, and snow, are the only requirement for avalanches. The forces generated by moderate or large avalanches can damage or destroy most man-made structures. Loose avalanches occur when grains of snow cannot hold onto a slope and begin sliding downhill, picking up more snow and fanning out in an inverted V. Slab avalanches occur when a cohesive mass of snow breaks away from the slope all at once.

- **Dry slab avalanches** occur when the stresses on a slab overcome the internal strength of the slab and its attachment to surrounding snow. A decrease in strength caused by warming, melting snow, or rain, or an increase in stress produced by the weight of additional snowfall, a skier or a snowmobile cause this type of avalanche. Dry slab avalanches can travel 60 to 80 miles per hour, reaching these speeds within five seconds after the fracture; they account for most avalanche fatalities. Wet slab avalanches occur when water percolating through the top slab weakens it and dissolves its bond with a lower layer, decreasing the ability of the weaker, lower layer to hold on to the top slab, as well as decreasing the slab's strength.

8.1.3 Zones

Avalanches can reach speeds of up to 200 miles an hour and can exert forces great enough to destroy structures and uproot or snap off large trees. Avalanche paths consist of three zones:

- Starting Zone—A zone near the top of a ridge, bowl or canyon, with steep slopes of 25 to 50 degrees.
- Track Zone—A reach with mild slopes of 15 to 30 degrees and the area where the avalanche will achieve maximum velocity and considerable mass.
- Run-Out Zone—An area of gentler slopes (5 to 15 degrees) at the base of the path, where the avalanche decelerates, and massive snow and debris deposition occurs.

8.2 HAZARD PROFILE

8.2.1 Location

Much of Chelan County is located in the Cascade Mountains, which receive extensive precipitation due to their size and orientation to the flow of Pacific marine air. The winter snowpack is among the deepest recorded in the United States. There are primarily two areas where avalanches occur that affect the citizens and infrastructure of Chelan County—transportation routes and recreation areas. Stevens Pass and Tumwater Canyon along U.S. Highway 2 and Blewett Pass along U.S. Highway 97 are located in avalanche-prone areas. WSDOT has also mapped avalanche areas along U.S. Highway 97A and SR 971, on the south shore of Lake Chelan. Additionally, avalanches threaten backcountry recreation areas. With better equipment allowing more people to explore further into the wilderness, areas threatened by avalanche are those accessible by skiers, snowshoers, snowboarders, climbers, and snowmobilers outside developed ski resorts in the mountains of Washington. shows avalanche hazard areas in Washington. Figure 8-1 shows areas at highest risk of avalanche. Figure 8-2 and Figure 8-3 show avalanche risk areas that are monitored and controlled by WSDOT on U.S. Highway 2.

Source: (Avalanche.org 2024)

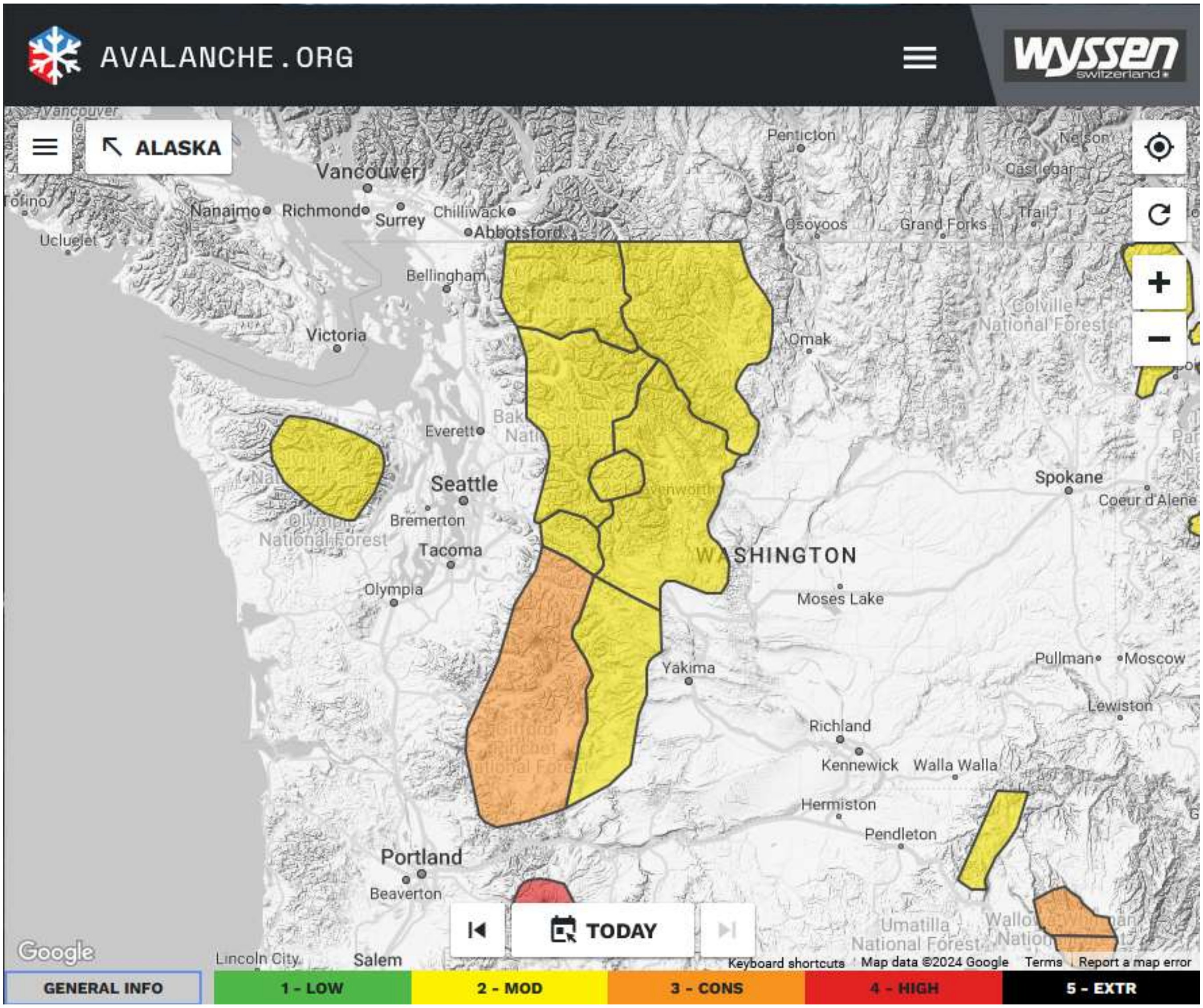


Figure 8-1. Areas Vulnerable to Avalanche

Source: (WSDOT 2010)

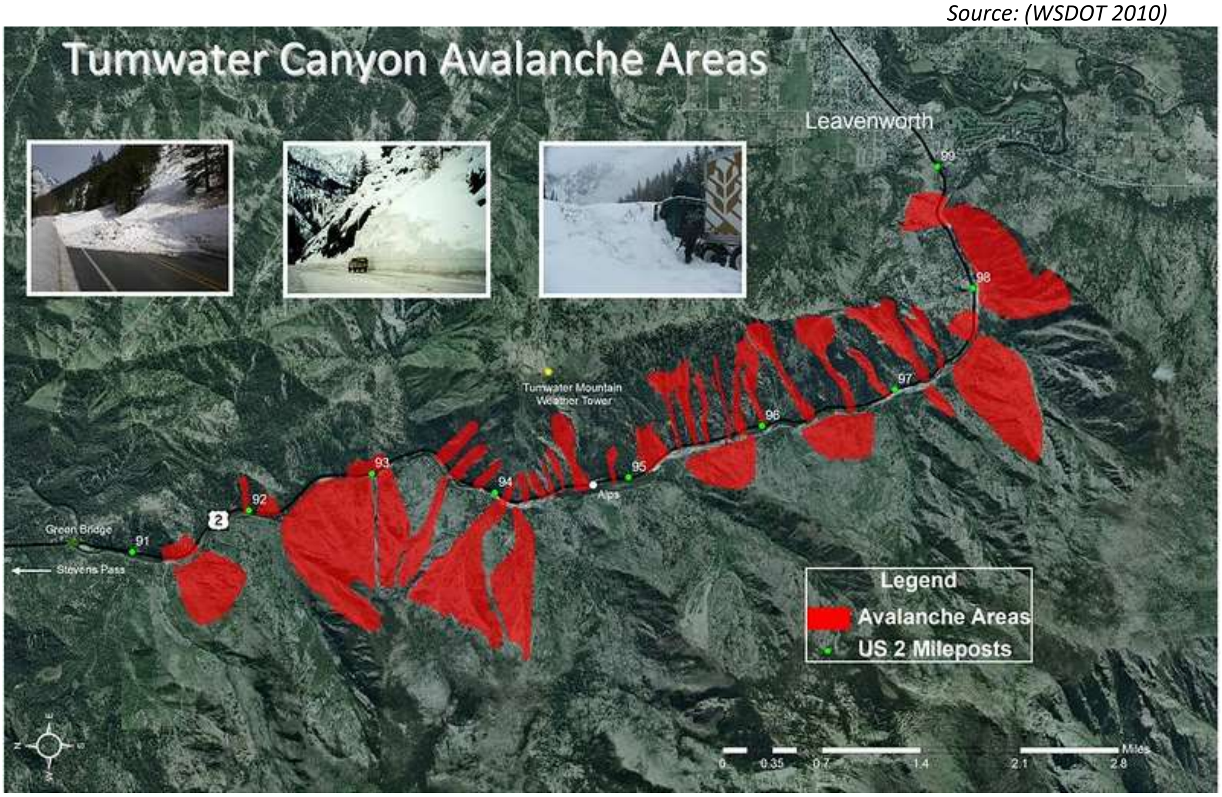


Figure 8-2. U.S. 2 Tumwater Canyon Avalanche Areas

Source: (WSDOT 2010)

Figure 8-3. U.S. 2 Stevens Pass Avalanche Areas (WSDOT 2010)

8.2.2 Extent

Large external lateral loads can cause significant damage to structures and fatalities. Table 8-1 indicates the estimated potential damage for a given range of impact pressures.

Table 8-1. Impact Pressures Related to Damage

Impact Pressure (pounds per square foot)	Potential Damage
40-80	Break windows
60-100	Push in doors, damage walls, roofs
200	Severely damage wood frame structures
400-600	Destroy wood-frame structures, break trees
1,000-2,000	Destroy mature forests
>6,000	Move large boulders

Source: (Avalanche.org 2024)

The BNSF Railway follows essentially the same east-west route as SR-2. The potential for rail service interruption, or for damage to a train carrying hazardous cargo in populated or environmentally sensitive areas, is of concern.

The following weather and terrain factors affect avalanche severity and danger:

- Storms—A large percentage of all snow avalanches occur during and shortly after storms.
- Rate of snowfall—Snow falling at a rate of 1 inch or more per hour rapidly increases avalanche danger.
- Temperature—Storms starting with low temperatures and dry snow, followed by rising temperatures and wetter snow, are more likely to cause avalanches than storms that start warm and then cool with snowfall.
- Wet snow—Rainstorms or spring weather with warm, moist winds and cloudy nights can warm the snow cover, resulting in wet snow avalanches. Wet snow avalanches are more likely on sun-exposed terrain (south-facing slopes) and under exposed rocks or cliffs.
- Ground cover—Large rocks, trees and heavy shrubs help anchor snow.
- Slope profile—Dangerous slab avalanches are more likely to occur on convex slopes.
- Slope aspect—Leeward slopes are dangerous because windblown snow adds depth and creates dense slabs. South-facing slopes are more dangerous in the springtime.
- Slope steepness—Snow avalanches are most common on slopes of 30 to 45 degrees.

8.2.3 Previous Occurrences

Avalanches occasionally occur along state transportation routes at Blewett Pass, Stevens Pass, and Tumwater Canyon, although these events are usually cleared within a few hours. Backcountry avalanches have also occurred, including some at Mission Ridge Ski Resort in southern Chelan County. There have been some fatalities in Chelan County as a result of avalanches. On March 1, 1910, the Wellington disaster occurred just west of the County line, on Stevens Pass. Two stranded passenger trains were swept away and buried by an avalanche. 96 people lost their lives in this disaster. In February of 2023, a six-person group attempted to summit Colchuck Peak in the Cascade Mountains. An avalanche occurred and three of the climbers died. Their bodies were buried by additional slides that began after the initial avalanche and rescue personnel was initially unable to recover the dead climbers due to hazardous avalanche conditions (Adshar and Wolfe 2023). Table 8-2 summarizes other avalanche fatalities in Chelan County.

Table 8-2. Avalanche Fatalities

Year	Location	Fatalities
1910	Stevens Pass (just across County line in King County)	96
1962	Stevens Pass	2
1971	Stevens Pass/Yodelin	4
1978	Mission Ridge	1
1994	Mission Ridge	1
2012	Tunnel Creek	3
2023	Colchuck Peak	3

8.2.4 Overall Probability

Avalanche season in Chelan County can extend from November to early summer. At lower elevations of the Cascades, the avalanche season begins in November and continues until the last remnants of snow have melted in early summer. In the high alpine regions, the hazard continues year-round. Hundreds of thousands of avalanches are thought to occur each year in the Cascades; however, many are unseen and go unrecorded. Based on historic frequency and future conditions, there is a high probability that future avalanches will occur on an annual basis.

8.2.5 Warning Time

The Northwest Weather and Avalanche Center provides daily forecasts as well as information regarding significantly increased avalanche danger that may serve as advanced warning for individuals participating in activities where avalanches may occur. These warning are generalized and simply alert exposed individuals to an increased risk of occurrence.

The time of an avalanche release depends on the condition of the snow pack; which can change rapidly during a day and particularly during rainfall. Research in the Cascade Mountains has shown that most natural avalanches occurred less than one hour after the onset of rain; in these cases, the snow pack was initially weak. In cases where the snow pack was stronger, avalanche activity was delayed or did not occur. Nonetheless an avalanche can occur with little or no warning time, and many occur due to disturbance from backcountry users, which makes them particularly deadly.

8.2.6 Climate Change Impacts

Avalanches are caused by a combination of geological factors (like the incline of a mountain or natural events like earthquakes), weather and the structure of the snow. Warmer weather can weaken a mountain’s snow pack and make it more difficult for the layers of snow to stick together. Mix in another element, like particularly gusty wind or trembling earth, and a mountain is primed for avalanche. It has been shown that changing atmospheric conditions influence the formation and evolution of the seasonal mountain snow cover and therefore determine the avalanche hazard. The Intergovernmental Panel on Climate Change warned that warming temperatures have destabilized mountain climates, leading to more avalanches, melting glaciers, and more intense storms.

According to the Climate Mapping for a Resilient Washington (CMRW), snowpack in Chelan County is anticipated to decrease by 32% on average from 2020-2049 (Climate Mapping for a Resilient Washington 2024). A reduction in snowpack may lead to weaker snow layers, which are more susceptible to triggering an avalanche. In addition, warming temperatures will lead to more rain-on-snow events, which increase the likelihood of a wet avalanche. These climate-driven changes can make avalanches less predictable and potentially, more dangerous (Berwyn 2021).

8.2.7 Future Trends in Development

Future trends in development cannot be determined until the avalanche hazard areas are accurately mapped. (University of Washington 2024). However, it is likely that future development will be predominantly concentrated in incorporated areas of the county that have limited exposure to the avalanche hazard. Any future development in more remote and mountainous areas of the County, such as in scenic or resource/recreation designations, may result in a limited increase in exposure. With more and more recreationists visiting Chelan County at all times of the year, those people put themselves and their rescuers at a greater risk.

8.3 SECONDARY HAZARDS

Avalanches can cause blocked roads, which can isolate residents and businesses and delay commercial, public and private transportation. This could result in economic losses for businesses. Other potential problems resulting from avalanches are power and communication failures. Avalanches also can damage rivers or streams, potentially harming water quality, fisheries, and spawning habitat.

8.4 VULNERABILITY AND IMPACTS

8.4.1 People

Due to the presence of key transportation routes and recreation areas in the Cascades, Chelan County is one of the most vulnerable counties in the state to avalanche disasters; however, avalanches in Chelan County do not typically adversely affect significant populations. Most avalanche victims are participating in recreational activities in the backcountry where there is no avalanche control. Only one-tenth of 1% of avalanche fatalities occur on open runs at ski areas or on highways (Emergency Management Division of Washington State 2024). However, due to increased winter recreational use in the Wenatchee National Forest and other adjacent lands in Chelan County, a larger amount of people are becoming vulnerable to avalanche risks.

More and more people are working and building in or using the high mountain areas of the Cascades, in potential avalanche areas. The general public does not often have experience with, caution regarding, or preparation for, avalanche conditions. These types of individuals who venture in the backcountry are at higher risk, due to lack of knowledge. Experienced backcountry skiers and snowmobilers generally have a great depth of knowledge and preparation for avalanches. However, despite the best preparations, avalanches still occur every year, killing some of the most experienced and well-versed. The increasing development of recreational sites in the mountains brings added exposure to the people using these sites and the access routes to them. The risk to human life is especially great at times of the year when rapid warming follows heavy, wet snowfall. First-responders are at heightened risk when responding to avalanche casualties or injuries.

8.4.2 Structures

There is little property vulnerable to avalanches in Chelan County. Property and buildings vulnerable include National Forest huts, businesses along the highway, and temporary structures belonging to mining and forestry operations.

Few critical facilities and infrastructure in Chelan County are vulnerable to avalanches. The state highway system is most vulnerable to avalanches. However, WSDOT proactively manages avalanches to ensure that no avalanches occur without warning. Road closures for avalanche control are generally scheduled and efficient to reduce the impact to traffic. There is a small amount of infrastructure that could be blocked by avalanches, including hiking trails, fire roads, and logging roads. The same structures that are vulnerable to avalanches are those that may be impacted.

8.4.3 Systems

Some networks, capabilities, and systems within Chelan County are vulnerable to or likely to be impacted by avalanches. A negligible amount of the tax base, and therefore fiscal capabilities, may be vulnerable if an avalanche were so severe that the revenue stream from winter recreation activities was interrupted for an extended period. During a severe avalanche, emergency services including first responders and public works may have limited capacity to respond to the event. In addition, transportation routes such as U.S. Highway 2 and Blewett Pass along U.S. Highway 97 may be impacted by avalanches, which could lead to road closures and delay in transportation of goods, negatively affecting local businesses. Avalanches could also damage power lines and cause power outages.

8.4.4 Natural, Historic, and Cultural Resources

All natural, historic, and cultural resources in avalanche prone areas are vulnerable. Avalanches are a natural event, but they can negatively impact the environment by causing damage to vegetation. This includes trees located on steep slopes. A large avalanche can knock down many trees and kill the wildlife that lives in them. In spring, this loss of vegetation on the mountains may weaken the soil, causing landslides and mudflows.

Historic and cultural resources may be impacted if the avalanche can physically destroy the asset. In the backcountry, there are limited historic and cultural assets. However, culturally and historically significant sites, such as gathering sites or logging camps, may sustain some damage due an avalanche.

8.4.5 Activities That Have Value to the Community

Winter recreation activities including snowboarding, skiing, and snowmobiling are significant economic drivers in the state, including Chelan County (Washington State Recreation and Conservation Office 2023). If these activities are interrupted by an avalanche, communities in the surrounding area may be impacted financially due to lost visitor revenue streams (e.g., lift tickets, overnight lodging, equipment rental, etc.).

8.4.6 Agriculture

Avalanches have the potential to destroy crops, damage agriculture infrastructure (irrigation systems, barns, etc.), threaten livestock, or disrupt transportation of goods. However, the land zoned within the planning area for agricultural uses does not interface with areas know to be susceptible to avalanches with the planning area. Therefore, it is not likely that future avalanches would significantly impact the agriculture industry, other than indirectly by obstructing transportation corridors for a short-term following event. Direct impacts are assumed to be none.

8.4.7 National Risk Index

According to the National Risk Index (NRI), Chelan County has a "Relatively Moderate" risk index for the avalanche hazard. Table 8-3 provides the risk factor breakdown. See Section 7.2 for a description of the components of the NRI.

Table 8-3. NRI Scoring for Avalanche in Chelan County

Expected Annual Loss	Risk Index Rating	Community Resilience	Social Vulnerability	Risk Value	Risk Index Score
$568,904	Relatively Moderate	Relatively Moderate	Relatively High	$693,178	85.1

8.5 SCENARIO

In a worst-case scenario, an avalanche would occur in the Cascade Mountains after a series of storms. Storms starting with low temperatures and dry snow, followed by rising temperatures and wetter snow, are more likely to cause avalanches than storms that start warm and then cool with snowfall.

8.6 ISSUES

Avalanches pose a threat to recreational users and property and can disrupt the east-west transportation network. Specially trained Washington Department of Transportation avalanche-control teams use active and passive means to reduce the avalanche hazard near Snoqualmie and Stevens Pass each year. Their efforts limit the number and duration of highway closures. The state posts warning signs in key locations warning recreation users of avalanche dangers, although these signs are commonly ignored. There is no effective way to keep the public out of avalanche-prone recreational areas, even during times of highest risk. A coordinated effort is needed among state, county and local law enforcement, fire, emergency management, and public works agencies and media to provide better avalanche risk information.

A national program to rate avalanche risk has been developed to standardize terminology and provide a common basis for recognizing and describing hazardous conditions. This United States Avalanche Danger Scale relates degree of avalanche danger (low, moderate, considerable, high, extreme) to descriptors of avalanche probability and triggering mechanism, degree and distribution of avalanche hazard, and recommended action in backcountry. Figure 8-4 shows key elements of the danger scale. This information, updated daily, is available during avalanche season from the joint NOAA/U.S. Forest Service Northwest Weather and Avalanche Center and can be obtained from Internet, NOAA weather wire, and Department of Transportation sources. Avalanche danger scale information should be explained to the public and made available through appropriate county and local agencies and the media.

The state maintains over 50 years of detailed records to help technicians forecast how snow might behave; however, climate change will likely alter the frequency and magnitude of avalanche events in the planning area. Methods will need to be developed to integrate forward-looking standards and best practices for avalanche management techniques.

The Northwest Weather and Avalanche Center provides a source of information to recreational users regarding current conditions and danger levels as well as incident summaries by date and location and additional resources. Measures that have been used in other jurisdictions to reduce avalanche threat include monitoring timber harvest practices in slide-prone areas to ensure that snow cover is stabilized as well as possible, and encouraging reforestation in areas near highways, buildings, power lines and other improvements. The development of a standard avalanche report form, and the maintenance of a database of potential avalanche hazards likely to affect proposed developments in mountain wilderness areas, would be of significant value to permitting agencies.

Avalanche Safety Basics

Avalanches don't happen by accident *and most human involvement is a matter of* ***choice*** *not chance. Slab avalanches, which are triggered by the victim or a member of the victim's party, cause most avalanche accidents. However, any avalanche may cause injury or death and even small slides may be dangerous. Hence, always practice safe route finding skills, be aware of changing conditions, and carry avalanche rescue gear. Learn and apply avalanche terrain analysis and snow stability evaluation techniques to help minimize your risk. Remember that avalanche danger rating levels are only general guidelines. Distinctions between geographic areas, elevations, slope aspect and slope angle are approximate, and transition zones between dangers exist. No matter what the current avalanche danger is, there are avalanche-safe areas in the mountains.*

UNITED STATES AVALANCHE DANGER DESCRIPTORS

Danger Level (Color)	Avalanche Probability and Avalanche Trigger	Degree and Distribution of Avalanche Danger	Recommended Action in the Back Country
Low (Green)	Natural Avalanches very unlikely. Human avalanches unlikely.	Generally stable snow. Isolated areas of instability.	Travel is generally safe. Normal caution advised.
Moderate (yellow)	Natural avalanches unlikely. Human triggered avalanches possible.	Unstable slabs possible on steep terrain.	Use caution on steeper terrain on certain aspects
Moderate to High (orange)	Natural avalanches possible. Human triggered avalanches possible.	Unstable slabs possible on steep terrain.	Be increasingly cautious in steep terrain.
High (red)	Natural and human triggered avalanches likely.	Unstable slabs likely on a variety of aspects and slope angles	Travel in avalanche terrain is not recommended. Safest travel on windward ridges of lower angle slopes without steeper terrain above.
Extreme (red with black border)	Widespread natural or human triggered avalanches are certain	Extremely unstable slabs are certain on most aspects and slope angles. Large destructive avalanches possible.	Travel in avalanche terrain should be avoided and travel confined to low angle terrain well away from avalanche path run-outs.

Figure 8-4. United States Avalanche Danger Scale

8.7 MITIGATING THE HAZARD

Table 8-4 presents a range of potential opportunities for mitigating the avalanche hazard.

Table 8-4. Potential Opportunities to Mitigate the Avalanche Hazard

Community Scale	Organizational Scale	Government Scale
	Manipulate the Hazard	
None	None	None
	Reduce Exposure and Vulnerability	
• Locate structures outside of hazard area (away from avalanche prone- areas) • Retrofit homes on avalanche-prone slopes • Monitor avalanche reports before any winter-related outdoor activities	• Locate structures outside of hazard area (away from avalanche prone- areas) • Retrofit at risk facilities	• Locate structures outside of hazard area (away from avalanche prone- areas) • Adopt higher regulatory standards for new development within avalanche-prone areas • Armor/retrofit critical infrastructure from the impact of avalanches • Controlled avalanches as necessary (i.e., triggering an avalanche through detonation) • Install static defense structures in avalanche areas • Construct snow sheds over highways and railroads that cross potential avalanche paths • Have proper equipment to support rescue, mitigate head injuries, and create air pockets (avalanche beacon, portable shovel, avalanche probe and airbags)
	Build Local Capacity	
• Subscribe to warning system and develop evacuation plan • Increase capability by having cash reserves for reconstruction • Educate yourself on risk reduction techniques for avalanche hazards	• Institute warning system and develop evacuation plan • Increase capability by having cash reserves for reconstruction • Develop and implement a Continuity of Operations Plan (COOP) • Educate your employees on the potential exposure to avalanche hazards and your emergency response protocol	• Produce better hazard maps • Provide technical information and guidance • Enact tools to help manage development in hazard areas: better land controls, tax incentives, information • Develop strategy to take advantage of post-disaster opportunities • Warehouse critical infrastructure components • Develop and adopt a Continuity of Operations Plan (COOP) • Educate the public on the avalanche hazard and appropriate risk reduction alternatives
	Nature-based Opportunities	
• Restrict or prohibit new development downslope of areas susceptible to avalanche and preserve these areas for open space/recreation uses. • Preserve forest ecosystems in avalanche-prone areas to provide a resistance buffer area to absorb impacts from avalanches.		

9. DAM OR LEVEE FAILURE

9.1 GENERAL BACKGROUND

9.1.1 Dams

Dam failures can be caused by natural events, such as flooding or an earthquake, but they are predominantly caused by human error such as poor construction, operation, maintenance or repair. The effects of a dam failure are highly variable, depending on the dam, the amount of water stored behind the dam, the current stream flow, and the size and proximity of the downstream population. There are many effects of a major dam failure: loss of life, destruction of homes and property, damage to roads, bridges, power lines and other infrastructure, loss of power generation and flood control capabilities, disruption of fish stock and spawning beds, and the erosion of stream and river banks.

9.1.2 Levees

Levees are a basic means of providing flood protection along waterways in regions where development exists or is planned, and in agricultural areas. Levees typically confine floodwaters to the main river channel. Failure of a levee can lead to inundation of surrounding areas. The causes of levee failures are structural failures, foundation failures of underlying soils, and overtopping by flood flows and waves. Contributing factors include poor construction materials, erosion by current and wave action, seepage through or under the levee, burrowing rodents, and improper repairs. Lack of adequate and regular maintenance to correct these problems also contributes to levee failure, including vegetation. Most failures are composites of several of these factors.

FEMA accredits levees as providing adequate risk reduction if levee certification and an adopted operation and maintenance plan are adequate. The criteria for which a levee can be accredited are specified in 44 CFR Section 65. Section 65.10 provides the minimum design, operation and maintenance standards levee systems must meet in order to be recognized as providing protection from the base flood on a Flood Insurance Rate Map. In order for a levee to be accredited, the owner must provide data and documentation to demonstrate that the levee complies with these requirements.

An area impacted by an accredited levee is shown as a moderate-risk area and labeled Zone X on a Flood Insurance Rate Map (FIRM). This accreditation affects insurance and building requirements. The NFIP does not require flood insurance for areas protected by accredited levees, although FEMA recommends the purchase of flood insurance in these areas due to the residual risk of flooding from levee failure or overtopping. If a levee is not accredited, the area it protects will still be mapped as a high-flood-risk area, and the federal mandatory purchase of flood insurance will apply (FEMA 2020)

Even with levee certification and FEMA accreditation, there is a flood risk associated with levees. While levees are designed to reduce risk, even properly maintained levees can fail or be overtopped by large flood events. Levees reduce risk, they do not eliminate it.

9.2 HAZARD PROFILE

9.2.1 Location

Dams

Washington State's Downstream Hazard Classification system for dams assigns a hazard rating of "Low," "Significant" or "High" for areas at risk of economic loss and environmental damage should a dam fail. For high hazard dams, inundation mapping is included in their emergency action plans. However, the inundation data is not readily available to local governments for public access in a format that can support planning. Emergency management agencies typically have this data to support emergency response functions, however there can be limitations on the use and distribution of this data due to security concerns.

According to the Washington Department of Ecology's Dam Safety Office's (DSO) inventory of dams, there are 46 dams in or adjacent to Chelan County. Many of them serve more than one purpose, such as hydroelectric power generation, irrigation and recreation. Of the 46 state inventoried dams within Chelan County, 34 are rated high hazard or significant hazard (see Table 9-1). High hazard dams are subclassified into 1A with more than 300 lives at risk within the inundation area, 1B have more than 31 to 300 lives at risk, and 1C have 7-30 lives at risk. Significant hazard dams are rated as 2D and have 1-6 lives at risk. Failure of any of these dams could inundate major transportation routes and industries, cause damage to downstream structures, and have long-term effects on water quality and wildlife.

The DSO provided a detailed summary of the dams for this planning process. Due to the number of high hazard potential dams, DSO was not able to provide inundation areas or other information specific to each dam. Additionally, not all dams have updated inundation mapping.

Table 9-1. High and Significant Hazard Dams in Chelan County

Name[a]	Water Course	Owner	Year Built	Crest Length (feet)	Height (feet)	Max Storage (acre-feet)	Drainage area (sq. mi.)	High Hazard Class[a]
3 Amigos Reservoir	Stemilt Creek, off stream	Kyle Mathison Orchards, Inc.	2003	2400	18	128	1.16	1C
Antilon Lake Dam	Tributary, Johnson Creek	Lake Chelan Reclamation District	1913	1150	340	2475	2.46	1B
Asamaera-Cannon Mine Tailings Dam	Dry Gulch	ConocoPhillips	1986	1150	340	950	1.76	1A
Bear Mountain Dam	Unnamed watercourse	Bear Mountain Golf Course	2003	245	11.5	19	0.21	1C
Beehive Dam	Tributary, Squilchuck Creek	Beehive Irrigation District	1953	300	38	300	0.11	1B
Behive Saddle Dam	Tributary, Squilchuck Creek	Beehive Irrigation District	1953	380	10	300	.11	1C
Chelan Dam[b]	Chelan River	Chelan Co. PUD. #1	1928	490	30[c]	677,400[c]	952	1B

Clear Lake Dam	Tributary, Stemilt Creek to Columbia River	Stemilt Irrigation District	1888	300	13	60	.03	1B
Clear Lake Saddle Dam	Tributary, Stemilt Creek to Columbia River	Stemilt Irrigation District	1888	240	8	48	0.03	1C
Colchuck Lake Dam	Colchuck Creek	Icicle & Peshastin Irrigati on District	1930	68	17.62	1548	1.41	1B
Eightmile Lake Outlet dam	Eightmile Creek	Icicle & Peshastin Irrigation District	1933	200	22	1610	5.85	1B
Great Depression Dam	Squilchuck Creek, off stream	Stemilt Ag Services	1998	unknow n	22	32	0.06	1B
H & H Reservoir Dam No 1	Tributary, Squilchuck Creek	Stemilt Agriculture Services	1926	800	19	60	0.08	2D
Klonaqua Lake Dam	French Creek	Icicle & Peshastin Irrigation District	1933	130	35.1	1223	0.77	2D
Lilly Lake Dam	Tributary, Stemilt Creek to Columbia River	Stemilt Irrigation District	1892	500	14	420	0.43	1B
Meadow Lake Dam	Tributary, Columbia River	Galler Ditch Co.	1920	350	17	578	5.00	1C
Rock Island Dam[b]	Columbia River	Chelan Co. PUD #1	1933	3580	80[d]	113,700[d]	94,900	1A
Rocky Reach[b]	Columbia River	Chelan Co. PUD #1	1962	3820	135[e]	387,500[e]	94,100	1B
Shiflett Reservoir No. 2	Middle Creek, off stream	Steven Shiflett Orchard Inc	1945	Unknow n	19	29	0.08	2D
Spring Hill Dam	Tributary, Stemilt Creek, off stream	Wenatchee Heights Reclamation District	1918	800	30	560	0.30	1C
Spring Hill Saddle Dam	Tributary, Stemilt Creek, off stream	Wenatchee Heights Reclamation District	1918	300	12	560	0.30	1C
Square Lake Dam	Prospect Creek	Icicle & Peshastin Irrigation District	1938	104	7	913	1.20	2D
Steffen Brothers Reservoir Dam	Little Stemilt Creek	Kyle Mathison Orchards	1947	500	15	34	0.04	2D
Stemilt Equalizing Reservoir	Tributary, Stemilt Creek, off stream	Stemilt Irrigation District	1985	N/A	24	43	0.04	1C
Stemilt Main Dam	Orr Creek, off stream	Lower Stemilt Irrigation District	1962	1000	65	670	.25	1B
Stemilt Saddle Dam	Orr Creek, off stream	Lower Stemilt Irrigation District	1962	210	9	200	.25	1C
Upper Loop Reservoir	Tributary, Stemilt Creek, off stream	Kyle Mathison Orchards	2015	1200	46.5	118	Unknow n	1C
Upper Wheeler Dam	Orr Creek	Wenatchee Heights Reclamation District	1922	750	65	833	2.3	1B

Upper Wheeler Saddle Dam	Orr Creek	Wenatchee Heights Reclamation District	1992	150	15	495	2.24	1B
Wapato Lake Dam	Tributary, Lake Chelan	Lake Chelan Reclamation District	1912	N/A	40	3500	15.3	1C
Wenatchee Heights Reservoir No. 2 Dam	Orr Creek, off stream	Wenatchee Heights Reclamation District	1998	1200	25	94	0.02	2D
West Dam East	Columbia River	PUD Douglas County No1	1967	4105	196	500,000	85,300	1A
Woods Reservoir Dam No 1	Stemilt Creek, off stream	A & T Mathison Ranch Inc	1991	240	22	60	0.02	1C
Woods Reservoir Dam No 2	Tributary, Stemilt Creek, off stream	Kye Mathison Orchards Inc.	1989	535	22	32	0.02	2D

a. Dams listed are those with downstream Hazard Class High and Significant. High hazard dams are subclassified into 1A with more than 300 lives at risk within the inundation area, 1B have more than 31 to 300 lives at risk, and 1C have 7-30 lives at risk. A dam classified as significant hazard are those classified as 2, 2D, and 2E that have 1 to 6 lives at risk. This refers to the potential effect in the case of a dam failure. It does not indicate a high probability of such failure.
b. According to Chelan County PUD dam break studies, in an event of a dam-break at these dams, the water surface/flood wave will be maintained within the PUD's project boundaries, so the potential loss of life is near zero.
c. Height measured from deck (1,109) to riverbed (apron at 1,079), storage capacity provided by PUD.
d. Height measured from deck (616) to foundation of north abutment wall (536), storage capacity provided by PUD.
e. Height measured from parapet wall (720) to foundation (585), storage capacity provided by PUD.

Source: (Washington Department of Ecology 2023) (Chelan County Public Utility District 2016)

Table 9-2 shows the number of dams per watercourse and number of people at risk.

Table 9-2. Number of High or Significant Hazard Dams per Watercourse

Watercourse	Region	Number of Dams	Number of People at Risk[a]
Columbia River	Entiat, Wenatchee	3	N/A
Chelan River	Chelan	1	N/A
Dry Gulch	Wenatchee	1	303
Icicle Creek	Leavenworth	4	150
Squilchuck Creek	Wenatchee	4	30
Stemilt Creek System Total	Malaga	17	60
Stemilt Creek	Malaga	10	30
Orr Creek	Malaga	5	60
Little Stemilt Creek	Malaga	1	6
Middle Creek	Malaga	1	3
Other	Chelan, Malaga	4	150

[a] Number of people at risk is based on the dam with the highest number of people at risk for each watercourse. Many dams along the same watercourse will have the same inundation area. Therefore, adding together the number of people at risk for each dam is an over estimation. For each dam, use the hazard classification in Table 9-1 to determine the approximate risk at people.

Source: (Washington Department of Ecology 2023)

Levees

In Chelan County, there are three levee segments that provide protection against floods of 25-year or more frequent recurrence intervals. These levee segments are located within the City of Cashmere and a portion of unincorporated Chelan County along the Wenatchee River. Information on these levee segments is provided in Table 9-3. None of these levee segments are accredited by FEMA. Two of the three are fully accepted under the U.S. Army Corps of Engineers PL 84-99 Program.

Table 9-3. Levee Profiles

Levee Segment Name	Length (feet)	Top Width (feet)	Level of Protection (% chance of exceedance)	Buildings & People Protected	Property Value Protected	PL 84-99 Rating
Cashmere Segment 1 (partially in unincorporated county)	675	12-50	20	4 buildings 2 beople	$2 Million	Minimally Acceptable
Cashmere Segment 2	1,450	10-20	10	28 buildings 76 people	$6 Million	Minimally Acceptable
Cashmere Segment Sewage Treatment Plant	3,400	10	10	2 buildings No people	$10 Million	Unacceptable

Source: (USACE 2024)

9.2.2 Extent

In 1996, a task group finalized a universal standardized dam safety hazard classifications. This classification ensures dams throughout the United States are classified using a consistent methodology and rating system. The classification descriptions are shown in Figure 9-1.

Source: (ASCE 2021)

Figure 9-1. Dam Hazard Potential Classifications

The DSO classifies regulated dams in Washington by hazard class, based on the at-risk population living in the area that could be inundated if the dam fails. The number of lives at risk are determined by counting residential structures and assuming three people per household (Department of Ecology 2019). The hazard class definitions and number of Chelan County dams in each class are as follows (Washington Department of Ecology 2023).

- 3 Hazard Class 1A (High—a downstream at-risk population of more than 300)
- 12 Hazard Class 1B (High—a downstream at-risk population of 31 to 300)
- 12 Hazard Class 1C (High—a downstream at-risk population of 7 to 30)
- 7 Hazard Class 2D (Significant—a downstream at-risk population of 1 to 6)
- 0 Hazard Class 2E (Significant economic or environmental risk, no lives at risk)
- 11 Hazard Class 3 (Low—no downstream at-risk population).

The hazard classification is not an indicator of the condition of the dam, only the number of people at risk downstream. A high hazard dam can be low risk if it is in good condition. In addition to the hazard classification, all dams are given a condition rating of satisfactory, fair, or poor. In Chelan County, 30 of the high or significant hazard potential dams are rated as either Satisfactory or Fair. The four dams rated as poor quality are at higher risk of failure. The dams with a poor condition have from 6 to 150 people at risk downstream. All four dams are prioritized by DSO for FEMA's High Hazard Potential Dam Grant program and other grant sources which will provide funding to perform the necessary studies or repairs to the dams (Goodman 2024).

9.2.3 Previous Occurrences

Many dam failures have occurred in Washington State over the last 40 years, but none have been in or affected Chelan County. In 2018, a potential dam failure was averted on the 95-year-old Eightmile Lake dam, located in the Alpine Lakes Wilderness, part of the Okanogan-Wenatchee National Forest. About 25 years ago, the high waters overtopped the spillway and caused erosion of the earthen embankment, creating concerns for further erosion and reducing the storage capacity of the lake by over 500 acre-feet. In 2017, the Jack Creek Fire burned in the Eightmile Lake watershed, creating concerns about debris flows and peak runoff into the lake. In 2018, there was an eminent threat of a potential dam failure on Eightmile Lake as the severely burnt watershed surrounding the lake filled the lake with sediment and increased runoff taxing the storage capacity of the lake and causing further erosion and damage. Federal, state and local flood fighting efforts and emergency dam repairs helped to avert a potential disaster downstream of the dam. The owner of the dam, the Icicle-Peshastin Irrigation District completed emergency repairs to the dam in the summer of 2018 to stabilize the dam (see Figure 9-2). Since then, the plan for permanent repairs have been under environmental review and analysis. The Department of Ecology Office of the Columbia River released a Final EIS on June 21, 2024. The preferred alternative (Alternative 2) includes replacing the existing dam with an earthen embankment and a reinforced concrete dam (Department of Ecology 2024). The project is now moving into design, then permitting and construction.

<u>**Disaster and Emergency Declarations**</u>

The following summarizes disaster declarations or emergency proclamations related to the dam or levee failure hazard.

- Federal DR or EM Declaration, 1953-2023: 0 events classified as dam or levee failure

Source: (Washington State Department of Ecology 2024)

Figure 9-2. Eightmile Lake Dam after 2018 emergency repairs

9.2.4 Overall Probability

Dam failure events are low probability, high consequence events and often coincide with other hazard events that cause them, such as earthquakes, landslides and excessive rainfall and snowmelt. There is a “residual risk” associated with dams. Residual risk is the risk that remains after safeguards have been implemented. For dams, the residual risk is associated with events beyond those that the facility was designed to withstand. However, the probability of any type of dam failure is low in today’s dam safety oversight environment. Based on historic frequency and future conditions, the probability of future dam or levee failures is less than one event every 100 years.

9.2.5 Warning Time

Warning time for dam failure varies depending on the cause of the failure. In events of extreme precipitation or massive snowmelt, evacuations can be planned with sufficient time. In the event of a structural failure due to earthquake, there may be no warning time. A dam’s structural type also affects warning time. Earthen dams do not tend to fail completely or instantaneously. Once a breach is initiated, discharging water erodes the breach until either the reservoir water is depleted, or the breach resists further erosion. Concrete gravity dams also tend to have a partial breach as one or more monolith sections are forced apart by escaping water. The time of breach formation ranges from a few minutes to a few hours.

The DSO provided warning potential rating for each high hazard dam. The ratings are shown in Table 9-4.

Table 9-4. Warning Potential Ratings

Warning Potential Rating	Description	Number of Dams	Number of People at Risk
Adequate	Warning time is greater than 30 minutes	12	561
Marginal	Warning time is between 10-30 minutes	6	246
Inadequate	Warning time is less than 10 minutes	8	474
Unknown		4	99

Source: (Goodman 2024)

9.2.6 Climate Change Impacts

On average, changes in annual precipitation levels are not expected to be dramatic. From 2020-2049 the CMRW anticipates a 5% increase in the heavy precipitation magnitude (Climate Mapping for a Resilient Washington 2024). However, small changes may have significant impacts for water resource systems, including dams. Dams are designed partly based on assumptions about a river's flow behavior, expressed as hydrographs. Changes in weather patterns can have significant effects on the hydrograph used for the design of a dam. If the hygrograph changes, it is conceivable that the dam can lose some or all of its designed margin of safety, also known as freeboard.

If freeboard is reduced, dam operators may be forced to release increased volumes earlier in a storm cycle in order to maintain the required margins of safety. Such early releases of increased volumes can increase flood potential downstream.

Dams are constructed with safety features known as "spillways." Spillways are put in place on dams as a safety measure in the event of the reservoir filling too quickly. Spillway overflow events, often referred to as "design failures," result in increased discharges downstream and increased flooding potential. The majority of streams in Chelan County have an anticipated increase in peak streamflow of 4-6% (Climate Mapping for a Resilient Washington 2024). Although climate change will not increase the probability of catastrophic dam failure, it may increase the probability of design failures.

9.2.7 Future Trends in Development

Land use in the planning area will be directed by local comprehensive plans adopted under state law. The planning partners have established comprehensive policies regarding sound land use in identified flood hazard areas. While some of the areas vulnerable to the more severe impacts from dam failure intersect the mapped flood hazard areas, the inundation areas from a dam failure cover a much larger portion of the planning area. Flood-related policies in these comprehensive plans and in the local municipal code will help to reduce the risk associated with the dam failure hazard for development in the planning area but will be unlikely to help reduce risk to all structures within the dam inundation area.

9.3 SECONDARY HAZARDS

Dam failure can cause severe downstream flooding, depending on the magnitude of the failure. Other potential secondary hazards of dam failure are landslides around the reservoir perimeter, bank erosion on the downstream watercourse, and destruction of downstream habitat. Hazardous materials spills are also a potential secondary hazard of dam failure if storage tanks rupture and spill.

9.4 VULNERABILITY AND IMPACTS

Data for the vulnerability and impacts analysis was gathered from DSO. Due to the number of high hazard potential dams in the County, DSO was unable to provide individual inundation mapping or other individual documentation for each dam. DSO provided a summary of dam information that describes the date of the most recent EAP, owner inspection, DSO assessment, warning potential rating, and the estimated population at risk. This information exceeded the information available in the public dam inventory documents.

9.4.1 People

According to the data provided by DSO, each dam has from 3 to 303 people at risk, with an average of 46 persons per dam. The dams in poor condition have from 6 to 150 people at risk. One of these dams has an inadequate rating for warning time, and the other three are unknown.

Vulnerable populations are all populations downstream from dam failures that are incapable of escaping the area before floodwaters arrive. This population includes the elderly and young who may be unable to get themselves out of the inundation area. The vulnerable population also includes those who would not have adequate warning from a television, radio emergency warning system, siren, or cell phone alert, and would need to rely on door to door notifications.

9.4.2 Structures

Vulnerable structures, including critical facilities, are those within the dam inundation zone. These structures would experience the largest, most destructive surge of water. Low-lying areas are also vulnerable since they are where the dam waters would collect. Structures would be impacted by flooding and velocity flows, which may cause damage or erosion around the structure. Structures in the dam inundation zone that are built to National Flood Insurance Program (NFIP) minimum construction standards may have some level of protection against dam inundation, depending on the velocity and elevation of the inundation waters. These structures also are more likely to have flood insurance.

The number of residential structures at risk for each dam ranges from 1 to 101. The average number of structures at risk is 15 structures.

Critical facilities within the dam inundation area could receive significant damage from an event. This could result in significant down-time of identified critical facilities and infrastructure, such as power infrastructure. Damage to roads and bridges could isolate populations.

9.4.3 Systems

Transportation routes are vulnerable to dam inundation and have the potential to be impacts. These routes may be wiped out, creating isolation issues and significant disruption to travel, including all roads, railroads and bridges in the path of the dam inundation. Those that will be the most impacted are those that are already in poor condition and would not be able to withstand a large water surge. Utilities such as overhead power lines, cable and phone lines in the inundation zone could also be vulnerable. If phone lines were lost, significant communication issues may occur in the planning area due to limited cell phone reception in many areas. In addition, emergency response would be hindered due to the loss of transportation routes as well as some protective-function facilities located in the inundation zone. Recovery time to restore many critical functions after an event may be lengthy, as wastewater, potable water, and other community facilities are located in the dam inundation zone.

9.4.4 Natural, Historic, and Cultural Resources

All natural, historic, and cultural resources in the dam inundation zone are at risk from the dam failure hazard. The dam inundation zone may include critical habitat for endangered and priority species, including the marbled murrelet, northern spotted owl, and aquatic species. The environment would be vulnerable to several risks in the event of dam failure. The inundation could introduce foreign elements into local waterways, resulting in destruction of downstream habitat and detrimental effects on many species of animals, especially endangered species such as the tidewater goby.

Historic and cultural resources may be destroyed, eroded, or washed away by inundation waters.

9.4.5 Activities That Have Value to the Community

Many of the watercourses downstream of dams are recreation areas. The inundation waters may be so damaging to these watercourses that river recreation could be impacted for some time. This would greatly impact recreational opportunities on rivers and streams.

9.4.6 Agriculture

Dam failure can have significant damage on agriculture. The level of damage depends on the location, size of dam, and time of year. One of the most immediate consequence of dam failure is flooding downstream. Depending on the location of the dam, this can inundate agricultural fields, destroy crops, wash away top soil and cause significant erosion.

Almost all dams listed above provide irrigation water to the orchard and farms in their respective area. If the dam were to fail, the loss of irrigation water may be devastating to crops and impact crop yields. Furthermore, when dam failure occurs, sediment may cover agricultural land, smothering crops, disrupting irrigation systems, and decreases soil fertility.

As shown in Table 9-1, there are 34 high or significant hazard dams within the planning area. As noted in this chapter, the true risk associated with these dams is not currently known, as the mapping needed to assess that risk is not readily available. However, since the floodplains of these river and stream systems that have these high and significant hazard dams are often ideally suited to support agricultural production, it is a logical assumption that a dam failure on any of these 34 high hazard facilities would have a negative impact on agriculture in the inundation area. However, because the risk of dam failure is low, the risk to agriculture from a dam failure would also be low due to the low probability of occurrence for these type events.

9.5 HIGH HAZARD POTENTIAL DAM GRANT PROGRAM COMPLIANCE

This HMP is intended to meet the planning requirements for the High Hazard Potential Dam grant program. With four dams in the County eligible for the program and currently prioritized to receive HHPD grant funding, it is important to demonstrate how compliance has been reached. This section summarizes how each planning requirement has been addressed.

9.5.1 HHPD1: Incorporation of Existing Data

In 2021, the previous HMP was updated to create eligibility for the HHPD grant program. Under the previous criteria, the plan only needed to address the dams eligible for the grant programs. The DSO provided detailed information to the County on the four dams in poor condition and eligible for the grant program, and one ineligible dam in poor condition.

The new guidance requires the chapter to assess all high hazard potential dams, even if they are in good condition or otherwise not eligible for the HHPD grant program. The planning team and DSO discussed the availability of dam data for all 34 high and significant hazard dams, such as inundation mapping. DSO encouraged the planning team to use summary data instead of detailed data for a couple reasons: inundation data is not available for all dams, data would have been provided on PDFs and not GIS data, and it would have been a large effort by DSO staff to gather everything. Instead of providing individual data for the 34 high and significant hazard dams, DSO provided additional summary data not available through public sources, such as the exact number of people at risk downstream, the number of structures at risk, and the estimated warning time. Because DSO maintains and manages all dam data, communication occurred directly with DSO instead of the individual dam owners and operators.

9.5.2 HHPD2: Address HHPDs in the Risk Assessment

Volume 1, Chapter 9 describes risk and vulnerabilities from high hazard potential dams. The assessment discusses the causes of dam failure, the numerous impacts that can occur due to dam failure, where most high and significant hazard dams are located, the warning time, and the number of structures and people at risk downstream of the dams.

The assessment was limited by not having access to inundation mapping for all high and significant hazard dams. In Washington state, inundation mapping is not readily available online like in other states. Instead of performing a mapping exercise, the assessment was based on the location of the dams and the summary information provided. Until DSO is able to complete inundation mapping for all dams and make the information readily available in GIS format, the lack of inundation extent data will continue to be an issue.

9.5.3 HHPD3: Mitigation Goals

All goals are intended to address the dam failure hazard. Goal #1 specifically mentions dams in the goal statement: “**To Protect People and Property** by making Chelan County homes, businesses, infrastructure, critical facilities, dams and their related infrastructure, and other property more resilient and resistant to losses from current and future natural hazard conditions.”

Actions for mitigating high hazard potential dams are within the Chelan County Annex in Volume 2. The actions specific to high hazard dams link to goal #1. Actions specific to the HHPD grant program eligible dams were discussed with the DSO to ensure the mitigation actions were accurate. Even though the dams are not owned by Chelan County, the County will be the applicant for HHPD grant program applications. The DSO writes the grant application on behalf of the dam owner, who is ultimately responsible for administering the mitigation project.

All dam hazard mitigation actions were prioritized using the same process as all other mitigation actions. However, DSO also has a statewide prioritization process to identify which eligible dams are prioritized for HHPD grant funding. The DSO has currently prioritized the four HHPD grant program eligible dams in Chelan County for funding; therefore, they are also a high priority to Chelan County.

9.6 SCENARIO

An earthquake in the region could lead to liquefaction of soils around a dam. This could occur without warning during any time of the day. A human-caused failure such as a terrorist attack also could trigger a catastrophic failure of a dam. Wildfire burn scars can cause increased runoff and debris flows that fill lakes and cause dam failure.

While the probability of dam failure is very low, the probability of flooding associated with changes to dam operational parameters in response to climate change is higher. Dam designs and operations are developed based on hydrographs from historical records. If these hydrographs experience significant changes over time due to the impacts of climate change, dam design and operations may no longer be valid for the changed condition. This could have significant impacts on dams that provide flood control. Specified release rates and impound thresholds may have to be changed. This would result in increased discharges downstream of these facilities, increasing the probability and severity of flooding.

9.7 ISSUES

In the late 1980s, the Department of Ecology DSO was reorganized to better use its resources to minimize public safety problems. The DSO has recognized the key role of other government agencies in carrying out its public safety charge. For example, the dam approval process now requires that dams located above populated areas develop emergency action plans in conjunction with local and county emergency management agencies.

The most significant issue associated with dam failure involves properties and populations in the inundation zones. Flooding because of a dam failure would significantly impact these areas. In certain scenarios there would be little or no warning time. Dam failure events are frequently associated with other natural hazard events such as earthquakes, landslides or severe weather, which limits their predictability and compounds the hazard. Important issues associated with dam failure hazards include the following:

- The lack of readily available, dam failure inundation mapping in a geospatial format has made it very difficult to fully assess the impacts of this hazards. The County and its planning partners should seek to work with dam owner/operators moving forward so that this data could be acquired to support future updates to this risk assessment.
- A buildable-lands analysis that looks at vacant lands and their designated land use within dam failure inundation areas would be a valuable tool in helping decision-makers make wise decisions about future development.
- The concept of residual risk associated with structural flood control projects should be considered in the design of capital projects and the application of land use regulations.
- It is unclear whether dam failure warning and notification strategies will be viable if dam failure occurs because of a significant earthquake that interrupts communication systems.
- Changes in hydrographs in the region because of climate change are likely to include more instances of winter flooding. This could alter dam operations and increase the potential for design failures.
- Downstream populations are often not aware that they are in a dam failure inundation area and do not know the risks associated with probable dam failure.

- Balancing the need to address security concerns and the need to inform the public of the risk associated with dam failure is a challenge for public officials.
- Dam failure inundation areas are often located outside of special flood hazard areas under the National Flood Insurance Program, so flood insurance coverage in these areas is not common.
- Most dam failure mapping required at federal levels requires determination of the probable maximum flood. While the probable maximum flood represents a worst-case scenario, it is generally the event with the lowest probability of occurrence. For non-federal-regulated dams, mapping of dam failure scenarios that are less extreme than the probable maximum flood but have a higher probability of occurrence can be valuable to emergency managers and community officials downstream of these facilities. This type of mapping can show areas potentially impacted by more frequent events, to be used in support of emergency response and preparedness measures.
- Limited financial resources for dam maintenance during economic downturns result in decreased attention to dam structure operational integrity because available funding is often directed to more urgent needs. This could increase the potential for maintenance failures.
- Unpermitted dams may exist within the planning area. As funding allows, DSO identifies dams from available aerial photos. Dams that appear large enough to require a permit but are not listed in the dam inventory are then inspected. Unpermitted dams may present risks to people and property. In 2008, Washington DOE identified 600 potential dams using aerial photos. DSO inspected 95 of the unpermitted dams – 68 were confirmed to be dams and 30 of which were classified as high hazard. Eleven of these high hazard dams (36.6%) were determined to need immediate repairs (Dininny 2008).

9.8 MITIGATING THE HAZARD

Table 9-5 presents a range of potential opportunities for mitigating the dam or levee failure hazard.

Table 9-5. Potential Opportunities to Mitigate the Dam or Levee Failure Hazard

Community Scale	Organizational Scale	Government Scale
Manipulate the Hazard		
None	• Remove dams and levees • Harden dams and levees	• Remove dams and levees • Harden dams and levees
Reduce Vulnerability and Impacts		
• Relocate out of levee and dam failure inundation areas • Elevate home to appropriate levels	• Replace earthen levees and dams with hardened structures • Flood-proof facilities within levee and dam failure inundation areas	• Replace earthen levees and dams with hardened structures • Relocate community lifelines out of inundation areas • Consider open space land use in designated levee and dam failure inundation areas • Maintain/manage vegetation on levees • Adopt higher floodplain standards in mapped dam failure inundation areas • Retrofit community lifelines within dam failure inundation areas

<table>
<tr><th>Community Scale</th><th>Organizational Scale</th><th>Government Scale</th></tr>
<tr><td colspan="3">Build Local Capacity</td></tr>
<tr><td>• Learn about risk reduction for the dam failure hazard
• Learn the evacuation routes for a dam failure event
• Educate yourself on early warning systems and the dissemination of warnings</td><td>• Educate employees on the probable impacts of a dam failure
• Develop a continuity of operations plan</td><td>• Map levee and dam failure inundation areas
• Enhance emergency operations plan to include a levee and dam failure component
• Institute monthly communications checks with dam operators
• Inform the public on risk reduction techniques
• Adopt real-estate disclosure requirements for the re-sale of property located within levee and dam failure inundation areas
• Consider the probable impacts of climate in assessing the risk associated with the levee and dam failure hazard
• Establish early warning capability downstream of listed high hazard dams
• Consider the residual risk associated with protection provided by levees and dams in future land use decisions</td></tr>
<tr><td colspan="3">Nature-Based Opportunities</td></tr>
<tr><td colspan="3">• Use soft approaches for stream bank restoration and hardening
• Set back levees on systems that rely on levee protection to allow the river channel to meander, which reduces erosion and scour potential
• Preserve floodplain storage capacity by limiting or prohibiting the use of fill in the floodplain</td></tr>
</table>

10. DROUGHT

10.1 GENERAL BACKGROUND

Drought is a normal phase in the climatic cycle of most geographical regions. Drought originates from a deficiency of precipitation over an extended period of time, usually a season or more, and results in a water shortage for some activity, group or environmental sector. Unlike most disasters, droughts normally occur slowly but last a long time.

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 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 to be 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. According to the Washington State Department of Agriculture, drought in Washington usually results from low mountain snow accumulation (from low precipitation or warm winter temperatures that causes winter precipitation to fall as rain rather than snow) or early melt of the snowpack due to warm weather in late winter or early spring (Washington State Department of Agriculture 2019).

Defining when drought begins is a function of the impacts of drought on water users and includes consideration of the supplies available to local water users as well as the stored water they may have available in surface reservoirs or groundwater basins. Different local water agencies have different criteria for defining drought conditions in their jurisdictions. Some agencies issue drought watch or drought warning announcements to their customers. Determinations of regional or statewide drought conditions are usually based on a combination of hydrologic and water supply factors. Washington has a statutory definition of drought (RCW 43.83B.400), defining an area as being in a drought condition when the water supply for the area is below 75% of normal and water uses and users in the area are likely to incur undue hardships because of the water shortage.

10.1.1 Types

There are five generally accepted operational definitions of drought:

- **Meteorological drought** is when dry weather patterns dominate an area.
- **Agricultural drought** occurs when crops become affected by drought.
- **Hydrological drought** is when low water supply becomes evident in the water system.
- **Socioeconomic drought** occurs when the supply and demand of various commodities is affected by drought.
- **Ecological drought** is when natural ecosystems are affected by drought.

10.1.2 Monitoring and Categorizing Drought

Drought is characterized by its severity, area affected, and timing. Monitoring involves observation indicators like precipitation, temperature, and soil moisture, and using indices, which are numerical representations of drought severity derived from climatic data. These indices provide essential quantitative measurements for tracking, predicting, and planning for drought impacts. The National Integrated Drought Information System (NIDIS), a multi-agency partnership that coordinates drought monitoring, forecasting, planning, and information at national, state, and local levels across the country, has determined three main methods for monitoring drought to guide early warning assessment. These methods include:

- Using a single indicator or index
- Using multiple indicator or indices
- Using composite or hybrid indicators

The U.S. Drought Monitor, a map released weekly, is a multi-indicator drought index and shows where droughts are occurring and their intensity. Impact type indicates whether a drought in a given area is short-term or long-term. Short-term is generally less than six months and impacts are expected on agriculture and grasslands. Long-term drought is typically longer than six months and impacts are seen on hydrology and ecology in the area impacted. The intensity of a drought is categorized on a scale of D0 to D4, where D0 is abnormally dry and D4 is exceptional drought (U.S. Drought Monitor 2024).

Standard indices used to measure short- and long-term drought include:

- The **Palmer Z Index** measures short-term drought on a monthly scale.
- The **Palmer Drought Severity Index** measures the duration and intensity of long-term weather patterns. The intensity of drought in a given month is dependent on current weather plus the cumulative patterns of previous months. Weather patterns can change quickly, and the Palmer Drought Severity Index can respond fairly rapidly. See Figure 10-1.
- The **Standardized Precipitation Index** is a probability index that considers only precipitation. It is computed for several timescales ranging from one to 72 months to capture the various scales of both short-term and long-term drought.
- The **Crop Moisture Index** measures short-term drought on a weekly scale and is used to quantify drought's impacts on agriculture during the growing (National Integrated Drought Information System 2024). See Figure 10-2. Source: (National Integrated Drought Information System 2024)

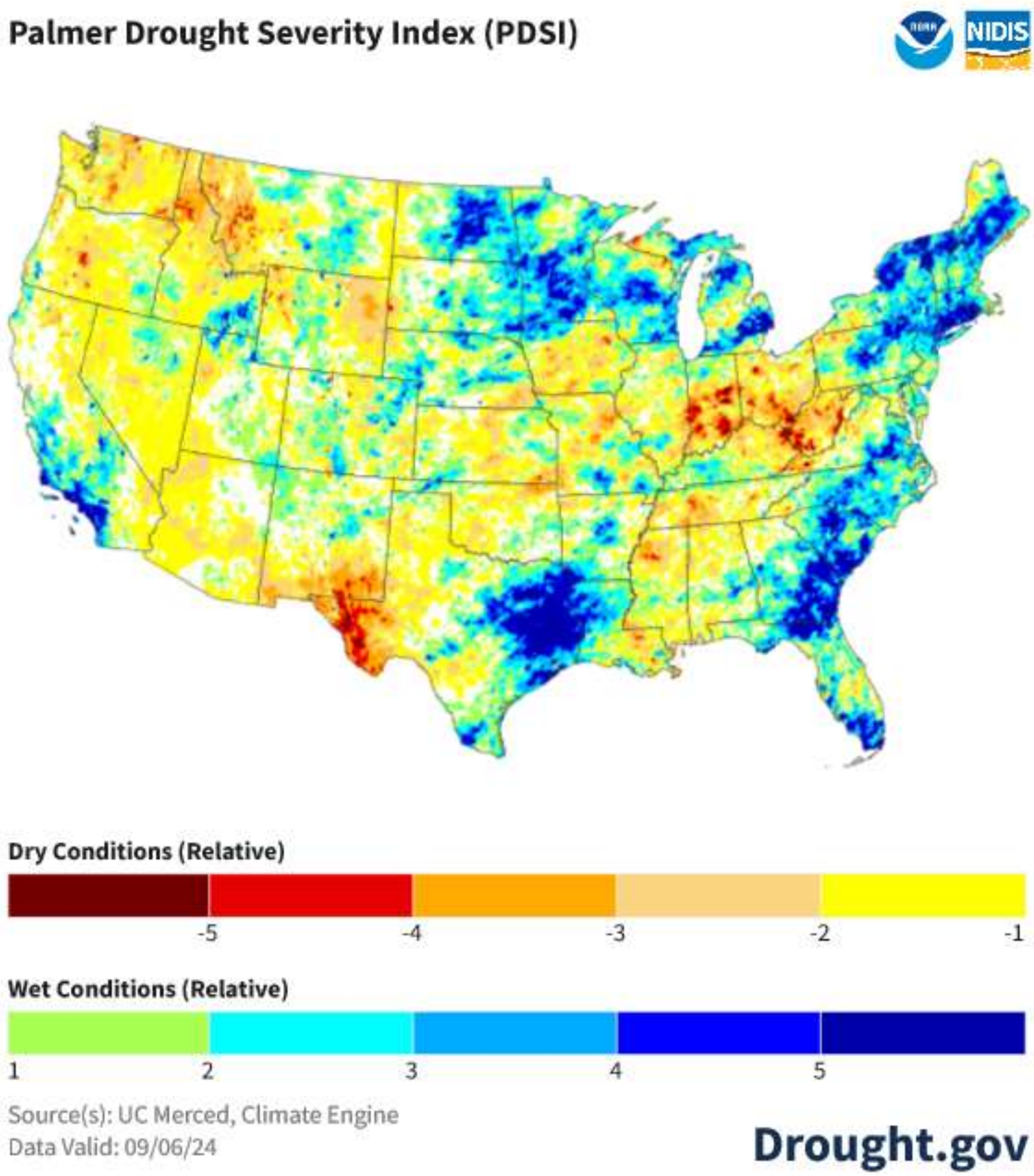


Figure 10-1. Palmer Drought Severity Index

Source: (NOAA 2024)

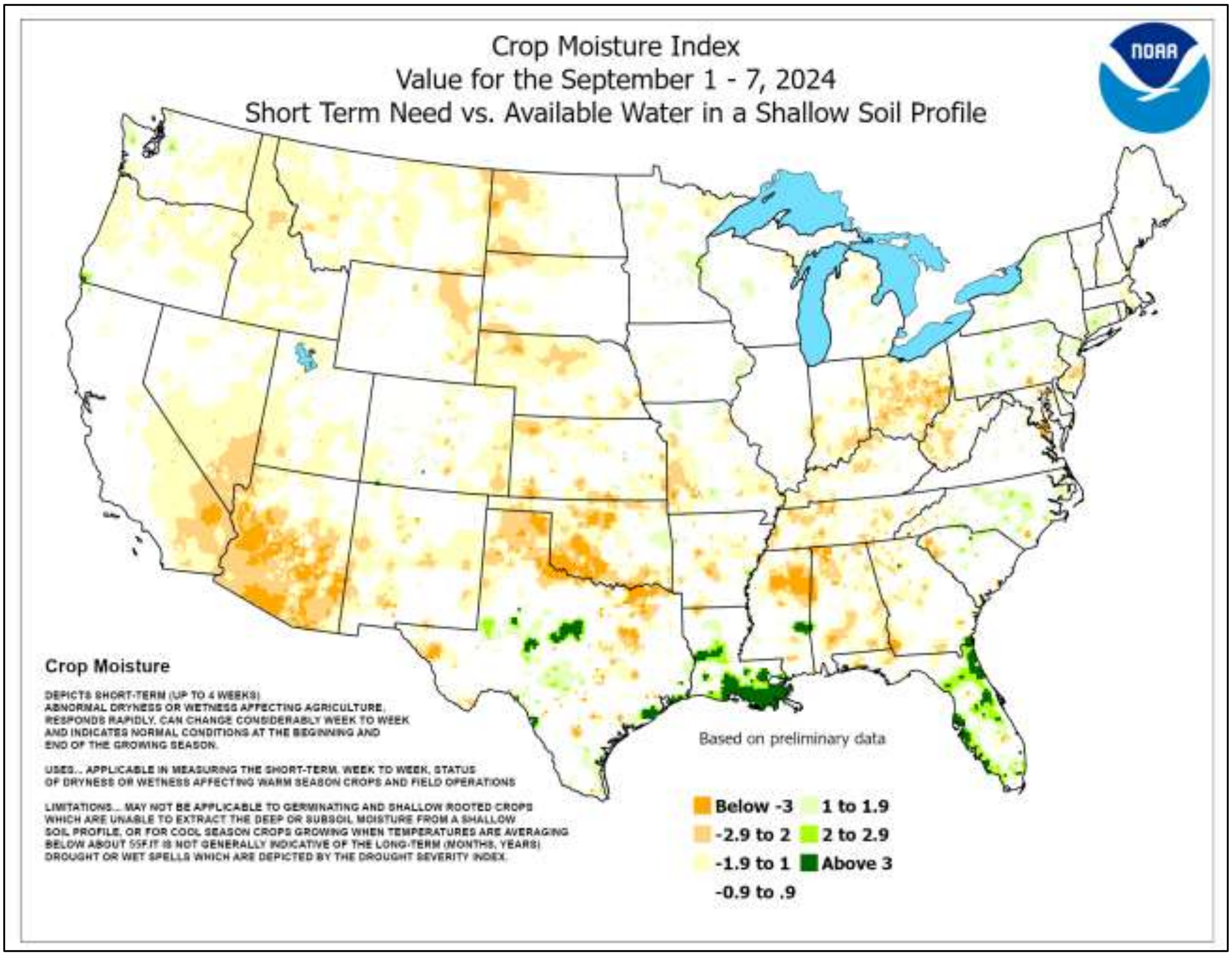


Figure 10-2. Palmer Crop Moisture Index

10.2 HAZARD PROFILE

10.2.1 Location

Drought is a regional phenomenon that has the potential to impact the entire planning area. A drought affects all aspects of the environment and the community simultaneously and has the potential to directly or indirectly impact every person in the planning area as well as adversely affect the local economy.

10.2.2 Extent

__US Drought Monitor__

There are several quantitative methods for measuring drought in the United States. How these indices measure drought depends on the drought classification and the region being considered. To update the U.S. Drought Monitor, agencies assess multiple numeric measures of drought to depict the drought conditions and locations across the United States. The U.S. Drought Monitor uses five drought intensity categories, D0 through D4, to identify areas of drought. These categories are shown on Figure 10-3. The map is shown in Figure 10-4.

Source: (Northeast Regional Climate Center n.d.)

Category	Description	Possible Impacts
D0	Abnormally Dry	Going into drought: • short-term dryness slowing planting, growth of crops or pastures Coming out of drought: • some lingering water deficits • pastures or crops not fully recovered
D1	Moderate Drought	• Some damage to crops, pastures • Streams, reservoirs, or wells low, some water shortages developing or imminent • Voluntary water-use restrictions requested
D2	Severe Drought	• Crop or pasture losses likely • Water shortages common • Water restrictions imposed
D3	Extreme Drought	• Major crop/pasture losses • Widespread water shortages or restrictions
D4	Exceptional Drought	• Exceptional and widespread crop/pasture losses • Shortages of water in reservoirs, streams, and wells creating water emergencies

Figure 10-3. U.S. Drought Monitor Categories

Source: (NOAA 2024)

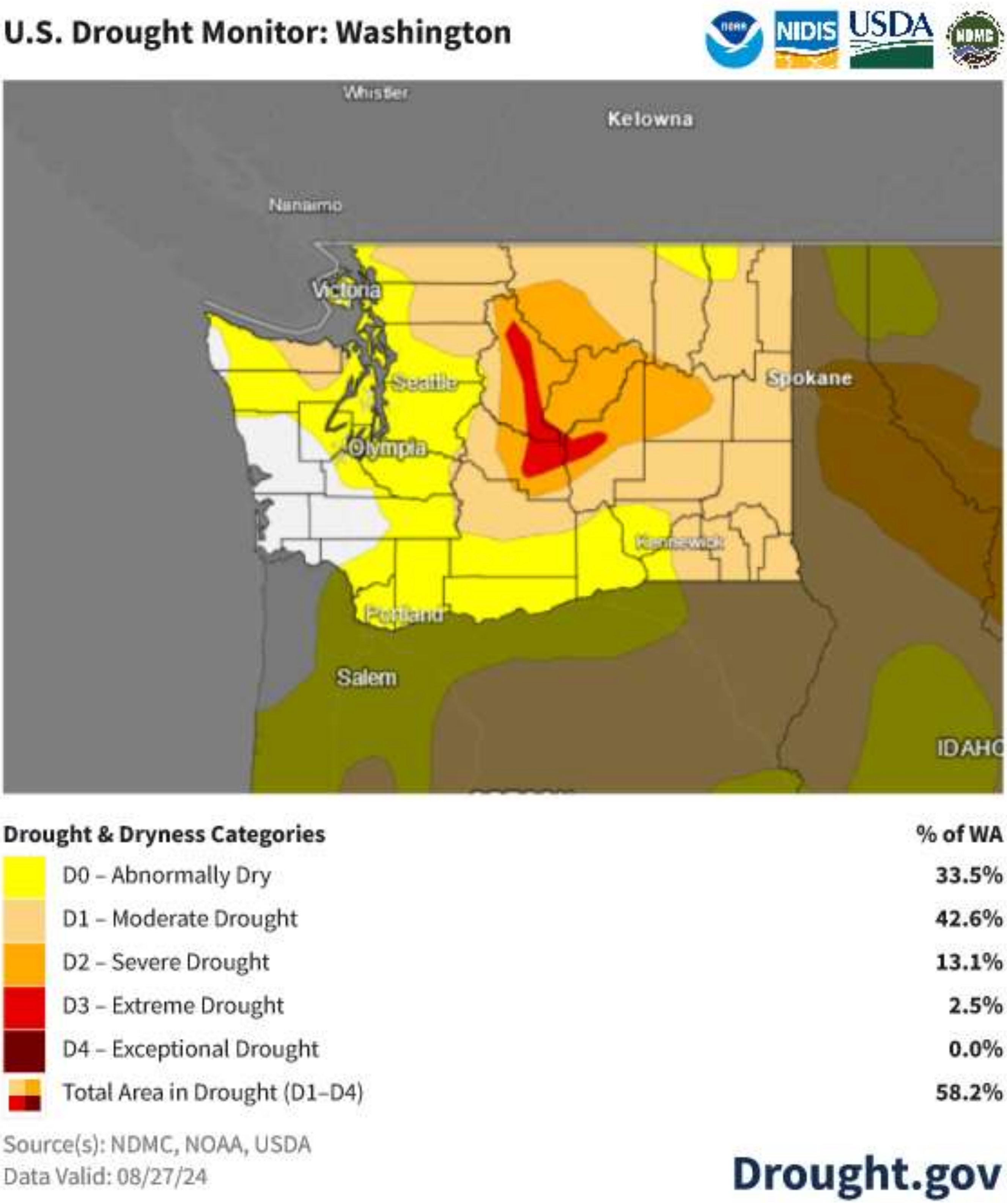


Figure 10-4. US Drought Monitor map for Washington State

Drought Impact Reporter

The National Drought Mitigation Center developed the Drought Impact Reporter in response to the need for a national drought impact database for the United States. Information comes from a variety of sources: on-line, drought-related news stories and scientific publications, members of the public who visit the website and submit a drought-related impact for their region, members of the media, and staff of government agencies. The database is being populated beginning with the most recent impacts and working backward in time.

The Drought Impact Reporter indicates 62 impacts from drought that specifically affected Chelan County from April 2014 through July 2023 (Drought Impact Reporter 2023). Most (58%) are based on reports from the Community Collaborative Rain, Hail and Snow Network.

The following are the reported numbers of impacts by category (some incidents are assigned to more than one impact category):

- Agriculture—11
- Business and Industry—3
- Energy—0
- Fire—15
- Plants and Wildlife—4
- Relief, Response, and Restrictions—17
- Society and Public Health—2
- Tourism and Recreation—2
- Water Supply and Quality—8

10.2.3 Previous Occurrences

In the State of Washington there have been 11 official drought declarations between 1980 and 2024. These dry spells have typically lasted for a period of one to two months to a period of two years. In 2021, the Department of Ecology declared a drought emergency covering most of Washington State. The precipitation March through June tied with 1926 as the second driest period since 1895. In addition, in late June, a heat dome brought triple digit temperatures, breaking heat records all throughout the state and exacerbating drought conditions (Washington State Department of Ecology 2021). In 2023, drought conditions were declared in 12 counties including those bordering Chelan County to the north, west, and south (Okanogan, Skagit, Snohomish, and Kittitas County) (Washington State Department of Ecology 2023).

On April 16, 2024, a statewide drought was declared with exceptions for Seattle, Everett and Tacoma metro areas. The state’s low snowpack and forecasts for a warm and dry spring/summer caused Ecology to declare a drought emergency for most of Washington State. Chelan River streamflow were projected to be at 52% of normal flow from April-September. There were $4.5 million available in drought response grants to respond to impacts from the current drought conditions (Washington State Department of Ecology 2024).

Between 1954 and 2022, Chelan County experienced one FEMA-declared drought-related emergency (EM-3037). This was the 1977 event, which has been identified as the worst drought in state history (FEMA 1977).

The U.S. Secretary of Agriculture is authorized to designate counties as disaster areas to make emergency loans to agricultural producers suffering losses due to drought. Although not subject to severe annual precipitation deficiencies, Chelan County periodically experiences seasonal dry spells lasting two to three months. Between

2016 and 2023, Washington has been included in 373 USDA drought declarations. Chelan County has been included in eleven declarations occurring in June 2019, April and September 2020, April-July 2021, March and April 2022, and July and August 2023 (USDA 2024). The NRI documents 273 drought events from 2000-2021.

Figure 10-5 shows the precipitation index in Chelan County from 1895-2024. D0 to D4 indicate drought conditions, and W0 to W4 indicate wet conditions.

Source: (National Integrated Drought Information System 2024)

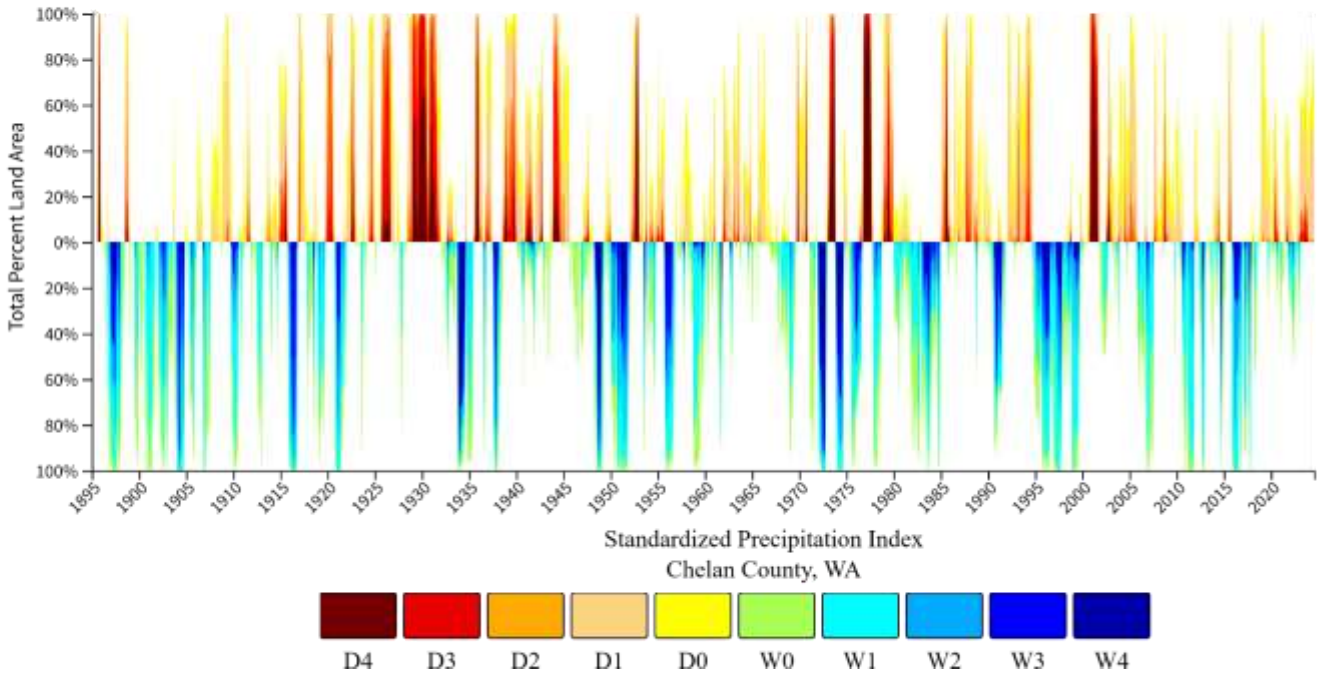


Figure 10-5. Chelan County Precipitation Index 1895-2024

Disaster and Emergency Declarations

The following summarizes disaster declarations or emergency proclamations related to the drought hazard.

- Federal DR or EM Declaration, 1953-2023: one event classified as drought
- Washington State Emergency Proclamations, 1980-2024: 11 events classified as drought
- USDA agricultural disaster declarations, 2012-2023: 11 events classified as drought

10.2.4 Overall Probability

According to the National Drought Mitigation Center, the Pacific Northwest region (Columbia, Willamette, and Snake River basins of Idaho, Oregon, and Washington, and portions of Montana and Wyoming) experiences drought more frequently than most other regions of the nation. From 1895 to 1995, much of the state was in severe or extreme drought at least 5% of the time. The east slopes of the Cascades and much of Western Washington were in severe or extreme drought from 5 to 10% of the time.

Chelan County has experienced drought conditions 10-15% from 1895 to 1995, more than 30% from 1985 to 1995, and 30-40% from 1976 to 1977. Based on historic frequency and future conditions, the probability of future drought occurrences is more than one event each year.

10.2.5 Warning Time

Droughts are climatic patterns that occur over long periods of time. Predicting drought depends on the ability to forecast precipitation and temperature. Anomalies of precipitation and temperature may last from several months to several decades. How long droughts 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.

Because drought conditions in Washington State are often related to deficiencies in snowpack accumulation, some warning is available through monitoring snowpack accumulation through the winter. The U.S. Natural Resources Conservation Service's snow survey and water supply forecasting program conducts snow surveys to develop accurate and reliable water supply forecasts (United States Department of Agriculture 2024). The system, called SNOTEL (short for Snow Telemetry), provides information for local governments, water consumers and providers, and the general public on snowpack conditions that may impact water resources in future months. When snowpack levels are below average, communities may make changes to their water management programs and practices to reduce impacts from a possible future drought.

NOAA's National Integrated Drought Information System launched a Drought Early Warning System for the Pacific Northwest in February 2016. The early warning system draws upon new and existing federal, tribal, state, local and academic partner networks to make climate and drought science readily available, easily understandable and usable for decision makers. The system improves stakeholders' abilities to monitor, forecast, plan for and cope with the impacts of drought (The National Integrated Drought Information System 2024).

10.2.6 Climate Change Impacts

The long-term effects of climate change on regional water resources are unknown, but global water resources are already experiencing the following stresses without climate change:

- Growing populations
- Increased competition for available water
- Poor water quality
- Environmental claims
- Uncertain reserved water rights
- Groundwater overdraft
- Aging urban water infrastructure.

With a warmer climate, droughts could become more frequent, more severe, and longer lasting. According to the USGS, since 2000, the western United States has experienced some of the driest conditions on record. Droughts impact a variety of sources including surface water (wetlands, lakes, rivers, and creeks) and ground water (aquifers) (USGS n.d.).

Changes in mountain snowpack can affect agriculture, winter activities, tourism, plants, wildlife, and the availability of drinking water. Change in snowpack can disrupt fish spawning and contribute to earlier and more severe wildfires. Recently, climate change is driving a decline in snowpack. From 1955 to 2022, April snowpack in the United States declined by roughly 23%, with 93% of the sites measured by the EPA seeing a decline (United States Environmental Protection Agency 2022). Figure 10-6 demonstrates the trends in April snowpack in the western United States. The likelihood of an April 1st snowpack below 75% of the normal is 20% on average in Chelan County between 2020-2049, with some areas in Chelan County having a 100% likelihood (University of Washington 2024). Lower snowpack levels are expected to reduce water availability for commercial, residential, agricultural, and hydropower generation.

In addition, the likelihood of a year with summer precipitation below 75% of the historical normal is 22% in Chelan County. Lower precipitation will reduce the amount of water available for livestock and irrigation, which has the potential to largely impact the economy in Chelan (University of Washington 2024).

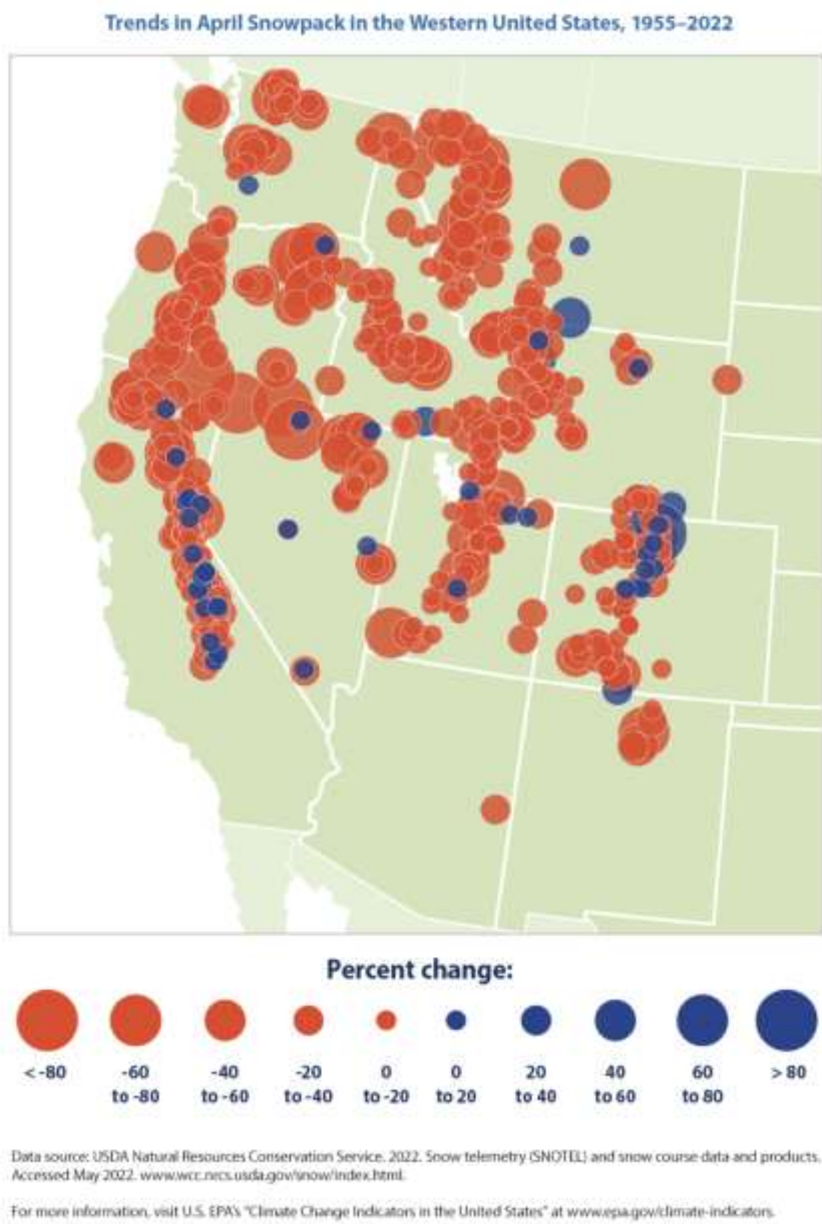


Figure 10-6. April Snowpack 1955-2022

10.2.7 Future Trends in Development

The U.S. Geological Survey's water use figures for Washington State show that public supply—domestic, commercial, industrial, and thermoelectric generation—uses about one gallon of every eight. Growing counties will find their rate of water use grow as their population grows. Chelan County has experienced a steady incline of population growth, increasing by 1.5% in from 2020 to 2023 (US Census Bureau 2024). As populations grow, the demand for water also increases. The increased demand for domestic, commercial, agricultural, and industrial purposes can exacerbate water scarcity during drought periods and may put further stress on water resources. Drought can also exacerbate economic effects by causing crop or pasture loss and reduce hydroelectric power generation.

Each municipal planning partner in this effort has an established comprehensive plan and water system plans that includes policies directing land use and dealing with issues of water supply and the protection of water resources. These plans provide the capability at the local municipal level to protect future development from the impacts of drought. All planning partners are current updating their Comprehensive Plans and assessing future needs of their water system.

10.3 SECONDARY HAZARDS

The secondary hazard most commonly associated with drought is wildfire. A prolonged lack of precipitation dries out vegetation, which becomes increasingly susceptible to ignition as the duration of the drought extends. In addition, lack of sufficient water resources can stress trees and other vegetation, making them more vulnerable to infestation from pests, which in turn, can make them more vulnerable to ignition. Millions of board feet of timber have been lost, and in many cases erosion occurred which caused serious damage to aquatic life, irrigation, and power production by heavy silting of streams, reservoirs, and rivers.

10.4 VULNERABILITY AND IMPACTS

All people, property, and environmental features in the planning area are vulnerable to the drought hazard. Drought can affect a wide range of economic, environmental, and social activities. Drought can have a widespread impact on the environment and the economy, although it typically does not result in loss of life or damage to structures, as do other natural disasters. 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. The impact on an activity to drought depends on its water demand and the water supplies available to meet the demand. The National Drought Mitigation Center uses three categories to describe likely drought impacts:

- **Economic Impacts**—These impacts of drought cost people (or businesses) money. Farmers' crops are destroyed; low water supply necessitates spending on irrigation or drilling of new wells; water-related businesses (such as sales of boats and fishing equipment) may experience reduced revenue.
- **Environmental Impacts**—Plants and animals depend on water. When a drought occurs, their food supply can shrink, and their habitat can be damaged.
- **Social Impacts**—Social impacts include public safety, health, conflicts between people when there is not enough water to go around, and changes in lifestyle (National Drought Mitigation Center n.d.)

The 2023 Washington State Hazard Mitigation Plan utilized monthly data from the U.S. Drought Monitor and determined that every county east of the Cascades experienced at least severe drought conditions at some point during 2021.

10.4.1 People

The entire population of Chelan County is vulnerable to drought events and may be impacted. Drought can affect people's health and safety, including health problems related to low water flows, poor water quality, or dust. Droughts can also lead to loss of human life (National Drought Mitigation Center n.d.). Other possible impacts include recreational impacts; effects on air quality; diminished living conditions related to energy, air quality, and hygiene; compromised food and nutrition; and increased incidence of illness and disease. (Centers for Disease Control and Prevention 2020).

People that have dust allergies, asthma, or heart and lung diseases can be impacted by the dust storms that happen during a drought. Farmers and agriculture workers are also vulnerable to drought. These individuals are reliant on agriculture and will be directly impacted financially and emotionally by reduced water availability for crops and livestock.

10.4.2 Structures

Although all structure in the planning area may be vulnerable to drought, no structures are likely to be directly impacted by drought conditions. Some structures may become more vulnerable to wildfires, which are more likely following years of drought. Droughts can also have significant impacts on landscaping, which could cause a financial burden on property owners. However, these impacts are not considered critical in planning for impacts from the drought hazard.

Community lifelines as defined for this plan will continue to be operational during a drought. The risk to community lifelines will be largely aesthetic, such as drought's effect on landscaping. Structures are at most risk from the secondary hazards exacerbated by drought, such as wildfire.

10.4.3 Systems

Systems in Chelan County such as water systems are vulnerable and may be impacted by drought. Water supply shortages affect the ability of local government to effectively fight fires or provide sufficient water and sewage services. However, local water providers have plans in place including alternate water sources and memorandums of agreement to ensure operations continue during severe drought conditions.

Drought generally does not affect groundwater sources as quickly as surface water supplies, but 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. 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 stream flows are lowest.

The economic impact of drought is largely associated with industries that use water or depend on water for their business. For example, landscaping businesses are affected as the demand for their service significantly declines because landscaping is not being watered. Livestock owners experience increased expenses for watering their herds. Agricultural industries are impacted if water usage is restricted for irrigation. Drought can lead to a reduction in power-generating capacity in hydroelectric-dominated systems, such as those found in Washington. Reductions in capacity can lead to interruptions in the power supply that may have economic impacts in the region.

10.4.4 Natural, Historic, and Cultural Resources

Environmental losses from drought are associated with damage to plants, animals, wildlife habitat, and air and water quality; forest and range fires; degradation of landscape quality; loss of biodiversity; and soil erosion. Some of the effects are short-term and conditions quickly return to normal following the end of the drought. Other environmental effects linger for some time or may even become permanent. Wildlife habitat, for example, may be degraded through the loss of wetlands, lakes and vegetation. However, many species will eventually recover from this temporary aberration. The degradation of landscape quality, including increased soil erosion, may lead to a more permanent loss of biological productivity. Although environmental losses are difficult to quantify, growing public awareness and concern for environmental quality has forced public officials to focus greater attention and resources on these effects.

Changes in water levels from drought may expose previously submerged archaeological sites or artifacts. This may increase risk of erosion and damage to cultural artifacts. Lake Chelan was originally home to the group known as the “Chelan” originally from the Wenatchi Tribe, there may be important cultural artifacts in or near Lake Chelan, belonging to the tribe. In addition, there have been many ancient Native American artifacts found along the Columbia River. The City of Cashmere has several exhibits of these important cultural artifacts on display (Ojibwa 2023).

10.4.5 Activities that Have Value to the Community

Locally, droughts have left a major impact on individuals and the agriculture, timber and hydroelectric industries. Lack of snowpack has forced ski resorts and other recreation-based companies into bankruptcy. One of the most pressing secondary impacts of drought is the extreme increase in the danger for wildfires. Secondary effects involve social and economic hardships due to crop losses, energy curtailment, temporary unemployment, domestic and municipal water shortages and increased number of major wildfires.

Because of the increased fire danger, forested and grassland areas of Chelan County can become extremely hazardous areas during prolonged drought situations. Populated areas in the county, including cities can be directly affected by low stream flows.

During low-water years, agriculture, forestry and hydroelectric interests have been impacted, particularly non-irrigated farm, range and forest land uses. Drought conditions can affect hydropower production capacity, and significant hydropower facilities exist in Chelan County, notably Rocky Reach and Rock Island Dams owned by the Chelan County Public Utility District #1.

10.4.6 Agriculture

Drought can have widespread impacts on agriculture within Chelan County. The primary effects of drought in Chelan County include loss of fruit and dryland crops, loss of range and domestic animals, wildlife and wildlife habitat. In 2015, the Washington State Department of Ecology provided funds to Washington State Department of Agriculture to conduct an assessment on the economic impacts of drought to the agriculture sector. The study focused on the Kittitas Reclamation District, Roza Irrigation District, Wapato Irrigation Project and Skagit County. The study found that drought significantly impacts crop yields, water scarcity, and increased irrigation costs (Washington State Department of Agriculture 2017).

According to the study, approximately 80% of Washington water withdrawals are for agriculture proposes. The two sources of water for irrigation are surface water (75%) and ground water (25%). However, due to the complex nature of water rights and a higher demand for water that what is available, junior water right holders are often curtailed or prorated during drought years, while senior water right holders receive their full water right. During drought years, emergency drought well permits may be issued. Ecology requires mitigation water to offset use of wells, in an effort to prevent groundwater levels from dropping (Washington State Department of Agriculture 2017).

One of the reasons that Chelan County is ideally suited to support agriculture is water supply. The presence of Lake Chelan and the Wenatchee, Entiat, and Columbia Rivers and the aquifers that supply them, support the kind of agriculture production that has helped Chelan County to flourish. Any prolonged drought in the region could possibly impact these water supplies by diverting water to downstream needs taxed by the drought. Water rights would drive that discussion, but it is not likely that the length and duration of droughts typical for the region would divert the supply beyond the needs for the agricultural production within the planning area. However, population growth and the conversion of land use from rural to more urban uses could alter these impacts.

10.4.7 National Risk Index

According to the National Risk Index (NRI), Chelan County has a “Relatively Low” risk index for the drought hazard. Table 10-1 provides the risk factor breakdown. See Section 7.2 for a description of the components of the NRI. It is important to remember that risk is based on a comparison with all counties in the United States and is based on the estimated losses to crops.

Table 10-1. NRI Scoring for Drought in Chelan County

Expected Annual Loss	Risk Index Rating	Community Resilience	Social Vulnerability	Risk Value	Risk Index Score
$21,491	Relatively Low	Relatively Moderate	Relatively High	$29,067	50.8

10.5 SCENARIO

The worst-case scenario is an extreme multiyear drought impacting the region. Combinations of low summer precipitation and low winter snowpack accumulation could stretch water resources, resulting in increased pressures to meet all users’ needs. Intensified by such conditions, wildfires could threaten the planning area, increasing the need for water. Surrounding communities, also in drought conditions, could increase their demand for water supplies relied upon by Chelan County, causing social and political conflicts. If such conditions persist for several years, the local economy could experience setbacks, especially in water-dependent industries and on local farms.

10.6 ISSUES

The planning team identified the following drought-related issues:

- If concern increases over the use of surface water, additional drawdowns to groundwater supplies may occur.
- Predicting droughts can be challenging, although warning systems are currently under development.
- Recent droughts have resulted in the need to stop pumping from some water courses due to limited stream flow.
- The planning area should plan for frequent droughts or multi-year droughts that can limit the ability to successfully recover from one drought and prepare for the next.
- Drought frequencies and durations may increase due to climate change. Changes in the timing, frequency and duration of precipitation events may present challenges for current water storage and management practices in the region.
- The promotion of active water conservation even during non-drought periods should be encouraged.
- Water resource management strategies have changed significantly over the last several decades. Managers must now consider the needs of communities, industries, power-generating facilities and the environment. Issues associated with meeting the needs of these competing demands with limited resources will likely increase as population growth continues and the impacts of climate change intensify.

10.7 MITIGATING THE HAZARD

Table 10-2 presents a range of potential opportunities for mitigating the drought hazard.

Table-10-2. Potential Opportunities to Mitigate the Drought Hazard

Community Scale	Organizational Scale	Government Scale
Manipulate the Hazard		
None	None	• Groundwater recharge through stormwater management • Develop a water recycling program • Increase “above-the-dam” regional water storage systems • Identify alternative water sources
Reduce Vulnerability and Impacts		
• Drought-resistant landscapes • Reduce water system losses • Modify plumbing systems (through water saving kits)	• Drought-resistant landscapes • Reduce private water system losses • Support alternative irrigation techniques to reduce water use and encourage use of climate-sensitive water supplies	• Water use conflict regulations • Reduce water system losses • Distribute water saving kits • Implement/expand water reuse projects

Community Scale	Organizational Scale	Government Scale
Build Local Capacity		
• Practice active water conservation	Practice active water conservation	• Public education on drought resistance • Expand recycled water network • Identify alternative water supplies for times of drought; mutual aid agreements with alternative suppliers • Develop drought contingency plan • Develop criteria “triggers” for drought-related actions • Improve accuracy of water supply forecasts • Modify rate structure to influence active water conservation techniques • Increase emergency storage capacity
Nature-Based Opportunities		
• Promote and use reclaimed water supplies • Increase capacity for stored surface water to create habitats and ecosystems for aquatic species • Promote and use active groundwater recharge		

11. EARTHQUAKE

11.1 GENERAL BACKGROUND

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. 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.

11.1.1 Types of Earthquakes

The earth's crust is divided into eight major plates and many minor plates. In Washington, the primary plates of interest are the Juan De Fuca and North American plates. The Juan De Fuca plate moves northeastward with respect to the North America plate at a rate of about 3 to 4 centimeters per year. The boundary where these two plates converge, the Cascadia Subduction Zone, lies approximately 50 miles offshore and extends from the middle of Vancouver Island in British Columbia to northern California. As it collides with North America, the Juan De Fuca plate slides beneath the continent and sinks into the earth's mantle. The collision of the Juan De Fuca and North America plates produces three types of earthquakes, as shown on Figure 11-1 and described below.

Subduction Zone Earthquakes

Subduction Zone earthquakes occur at the interface between tectonic plates. A subduction zone earthquake affecting Chelan County would be centered in the Cascadia Subduction zone off the coast of Washington or Oregon. Such earthquakes typically have a minute or more of strong ground shaking and are quickly followed by numerous large aftershocks. The potential exists for large earthquakes along the Cascadia Subduction Zone, up to an earthquake measuring 9 or more on the Richter scale. Such an earthquake would last several minutes and produce catastrophic damage in the region.

Benioff Zone (Deep) Earthquakes

Benioff Zone earthquakes occur within the Juan De Fuca plate as it sinks into the Earth's mantle. These are deep earthquakes, usually 15 to 60 miles deep. Due to their depth, aftershocks are typically not felt in association with these earthquakes. These earthquakes are caused by mineral changes as the plate moves deeper into the mantle. Minerals that make up the plates are altered to denser, more stable forms as temperature and pressure increase. This results in a decrease in the size of the plate, and stresses build up that pull the plate apart (Washington State Department of Natural Resources 2014). Deep earthquakes generally last 20 to 30 seconds and have the potential of reaching 7.5 on the Richter scale. Geologists have concluded that Benioff earthquakes are a phenomenon centered in the Puget Sound basin and as such their epicenters are at a considerable distance from Chelan County.

Source: (USGS n.d.)

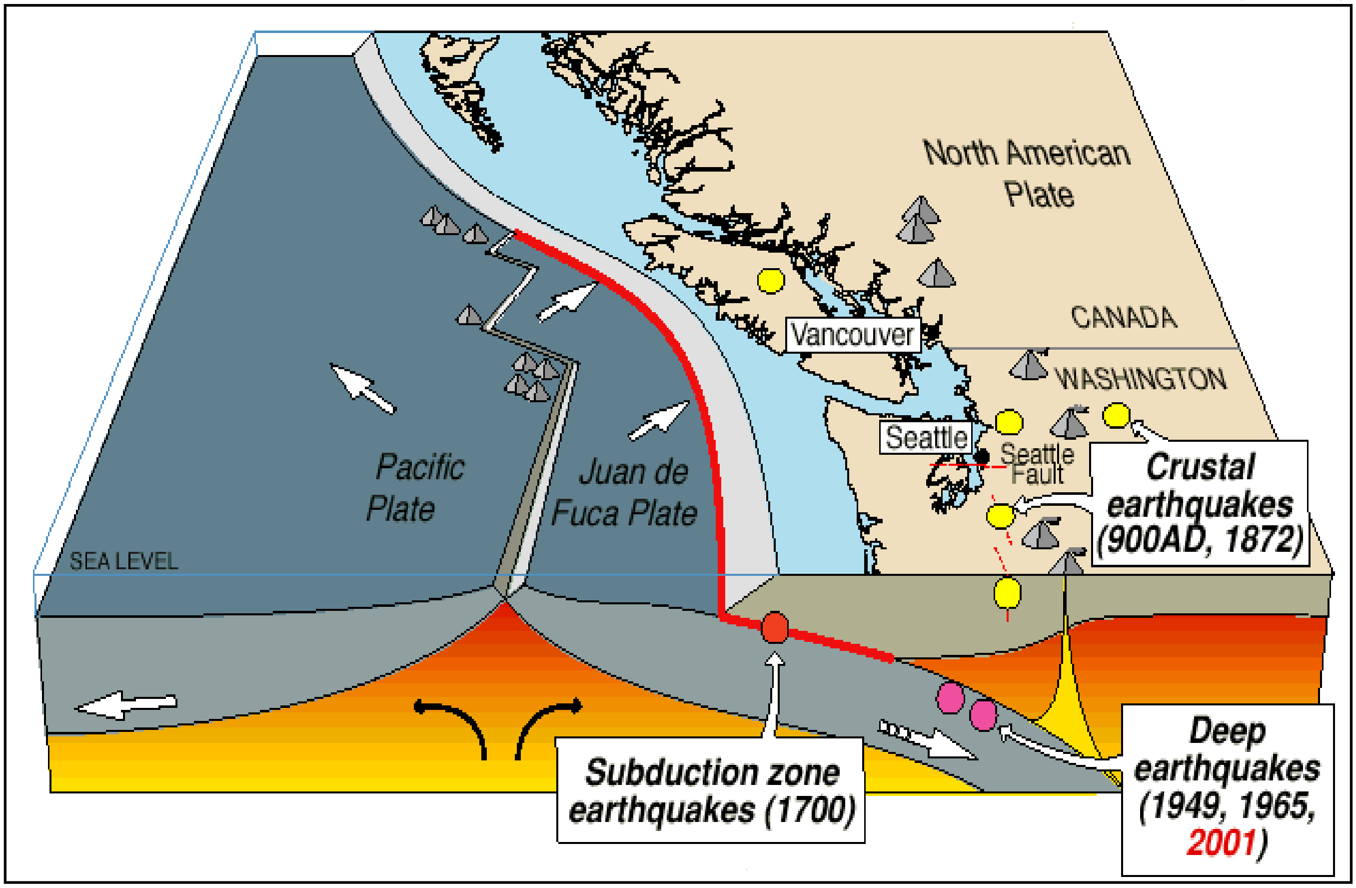


Figure 11-1. Earthquake Types in the Pacific Northwest

Shallow Crustal Earthquakes

Shallow crustal earthquakes occur within the North America plate at depths of 30 kilometers or less. Shallow earthquakes within the North America plate account for most of the earthquakes in the region around Chelan County. Most are relatively small, but the potential exists for major shallow earthquakes as well. Generally, these earthquakes are expected to have magnitudes less than 8 and last from 20 to 60 seconds. Of the three types of earthquake, crustal events are the least understood.

11.1.2 Faults

Geologists classify faults by their relative hazards. Active faults, which represent the highest hazard, are those that have ruptured to the ground surface within the last 11,000 years. Potentially active faults are those that displaced layers of rock within 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. Additionally, earthquakes may occur on faults that have not been mapped and identified.

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 displacements, and are aligned so that movement can relieve tectonic stresses. A direct relationship exists between a fault's length and location and its ability to generate damaging ground motion. Small, local faults may produce lower-magnitude quakes but strong ground shaking with significant damage to nearby surface areas. 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.

11.1.3 Earthquake Classifications

Earthquakes are typically classified in one of two ways: By the amount of energy released, measured as magnitude; or by the impact on people and structures, measured as intensity. Magnitude describes the size at the focus of an earthquake and intensity describes the overall felt severity of shaking during the event.

Magnitude

An earthquake's magnitude is a measure of the energy released at the source of the earthquake. It is expressed by ratings on the Richter scale or the moment magnitude scale. Currently, the most commonly used magnitude scale is the moment magnitude (M_W) scale, with the follow classifications of magnitude:

- Great—$M_W \geq 8$
- Major—$M_W = 7.0 – 7.9$
- Strong—$M_W = 6.0 – 6.9$
- Moderate—$M_W = 5.0 – 5.9$
- Light—$M_W = 4.0 – 4.9$
- Minor—$M_W = 3.0 – 3.9$
- Micro—$M_W < 3$

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

The intensity of an earthquake is based on the observed effects of ground shaking on people, buildings and natural features. Intensity of a given earthquake varies with location. The Modified Mercalli (MMI) scale expresses intensity of an earthquake and describes how strong a shock was felt at a particular location. Table 11-1 summarizes earthquake intensity as expressed by the Modified Mercalli scale.

Table 11-1. Mercalli Scale and Peak Ground Acceleration Comparison

Modified Mercalli Scale	Potential Structure Damage			
	Perceived Shaking	Resistant Buildings	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%

Modified Mercalli Scale	Potential Structure Damage			
	Perceived Shaking	Resistant Buildings	Vulnerable Buildings	Estimated PGA[a] (%g)
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 n.d.)

11.1.4 Ground Shaking

The ground experiences acceleration as it shakes during an earthquake. The peak ground acceleration (PGA) is the largest acceleration recorded by a monitoring station during an earthquake. PGA is a measure of how hard the earth shakes in a given geographic area. It is expressed as a percentage of the acceleration due to gravity (%g). PGA varies with soil or rock type. Earthquake risk assessment estimates the annual probability that a certain ground accelerations will be exceeded, and then summing the annual probabilities over a time period of interest.

National maps of earthquake shaking hazards provide information for creating and updating seismic design requirements for building codes, insurance rate structures, earthquake loss studies, retrofit priorities and land use planning. After thorough review of the studies, professional organizations of engineers update the seismic-risk maps and seismic design requirements contained in building codes (USGS 2001). The USGS updated the National Seismic Hazard Maps in 2014. New seismic, geologic, and geodetic information on earthquake rates and associated ground shaking were incorporated into these revised maps.

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. The determination of how great a force a structure should be able to withstand is based on probabilistic seismic mapping of the area. Such mapping identifies the probability of a given magnitude of ground shaking occurring over a specified time period. A common probabilistic rating used for building design is the level of ground shaking that has a 10 percent probability of being equaled or exceeded in a 50-year period.

Buildings, bridges, highways and utilities built to meet modern seismic standards typically can withstand earthquakes with less damage and disruption. PGA values are directly related to lateral forces that can damage “short period structures” (e.g. single-family dwellings). Longer-period components determine the lateral forces that damage larger structures with longer natural periods (apartment buildings, factories, high-rises, bridges). Table lists damage potential and perceived shaking by PGA factors, compared to the Mercalli scale.

11.1.5 Liquefaction and Soil Types

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. A program called the National Earthquake Hazard Reduction Program (NEHRP) creates maps based on soil characteristics to help identify locations subject to liquefaction. Table 11-2 summarizes NEHRP soil classifications. NEHRP Soils B and C typically can sustain ground shaking without much effect, dependent on the earthquake magnitude. The areas that are commonly most affected by ground shaking have

NEHRP Soils D, E and F. In general, these areas are also most susceptible to liquefaction. NEHRP and liquifiable soil areas are shown in Figure 11-2 and Figure 11-3.

Table 11-2. NEHRP Soil Classification System

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

11.2 HAZARD PROFILE

11.2.1 Location

Earthquakes can occur anywhere, at any time and without warning. Because most earthquakes are not associated with known faults, they are also very unpredictable. Past geological studies indicate areas prone to earthquakes may experience long periods of inactivity. These areas may be building tension which can lead to a major earthquake. Due to the unpredictability of earthquakes, forecasting when or where the next one will occur in Chelan County is impossible.

Historical Epicenter Locations

Although earthquakes are unpredictable and can occur anywhere at any time, historical and scientific data suggest there are some areas within Chelan County with a higher risk potential for future seismic activity. These higher risk areas include Lake Chelan and vicinity and the Entiat area. Historically, the Lake Chelan area is the most active earthquake area in Chelan County. Since 1946, over 130 earthquakes have occurred in or adjacent to Chelan County with a magnitude of 2.5 or greater.

Fault Locations

In October 1979, the Washington Public Power Supply System (WPPSS) completed an earthquake study prior to construction of Washington nuclear power plants 1 and 4. Parts of this study focused on identifying geologic faults found in the portion of the Cascades within Chelan County. Although presumed inactive, major faults were located at Leavenworth and Entiat Valley areas. Somewhat more active and shorter fault zones of approximately 30 km long merge into these larger faults. They are the Chumstick fault and Eagle Creek fault. An additional major fault is located in the upper Naneum Creek. However, the study concludes recent seismic activity in Chelan County has not been associated with these major faults.

The most recent fault map, updated in 2024 and shown in Figure 11-4, identifies active (color lines) and inactive faults (black lines).

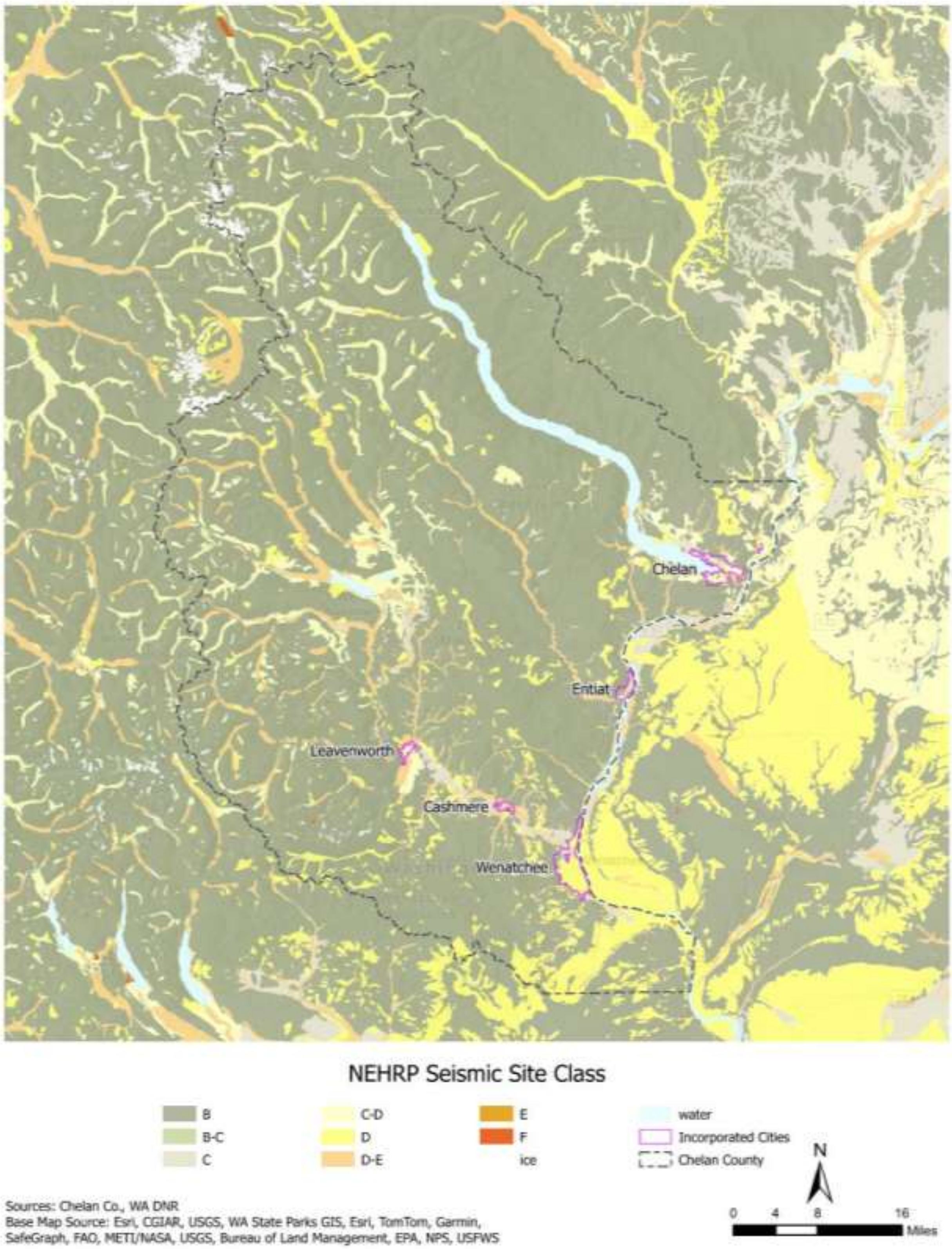


Figure 11-2. National Earthquake Hazard Reduction Program (NEHRP) Soil Class

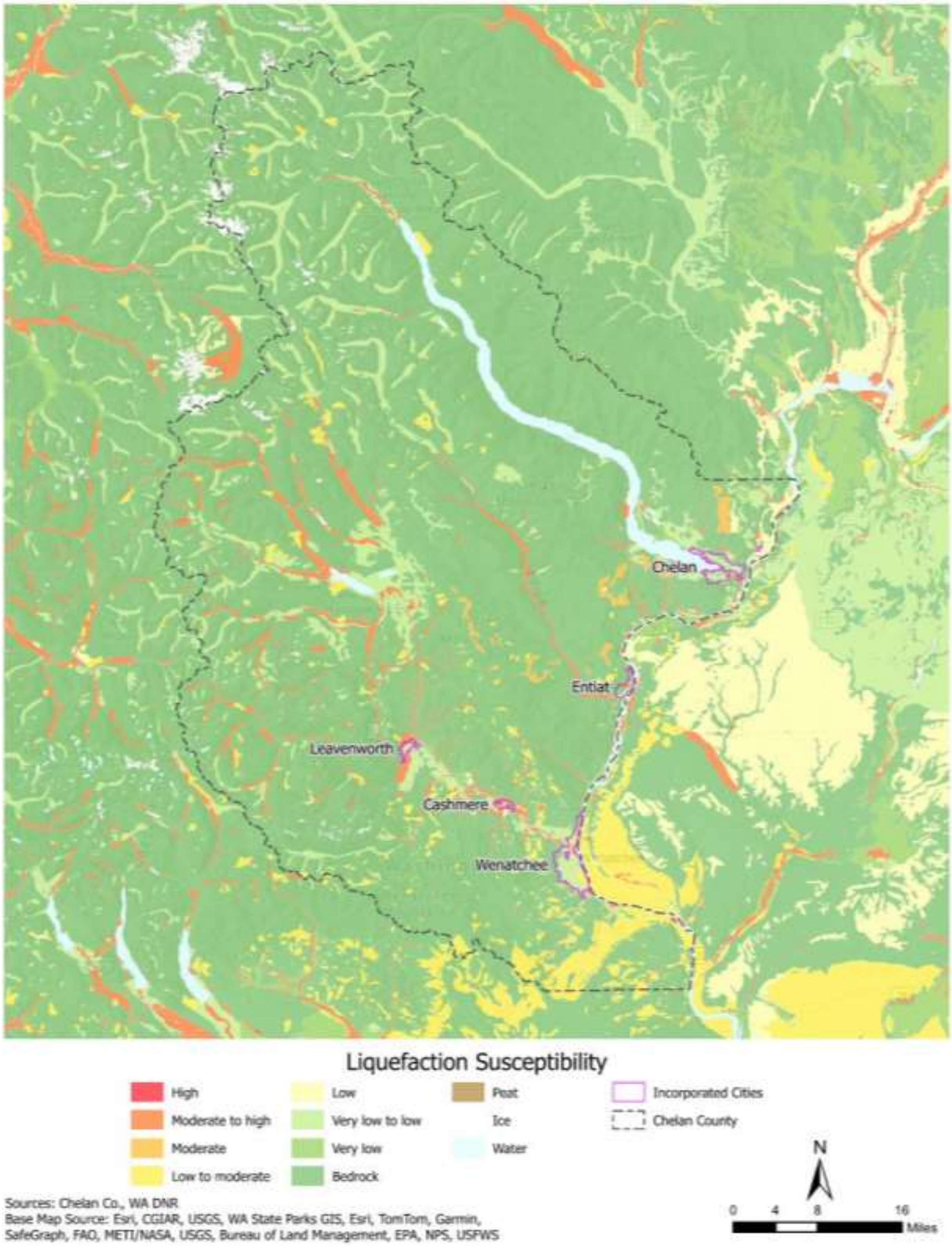


Figure 11-3. Liquefaction Susceptibility

Source: Czajkowski 2024

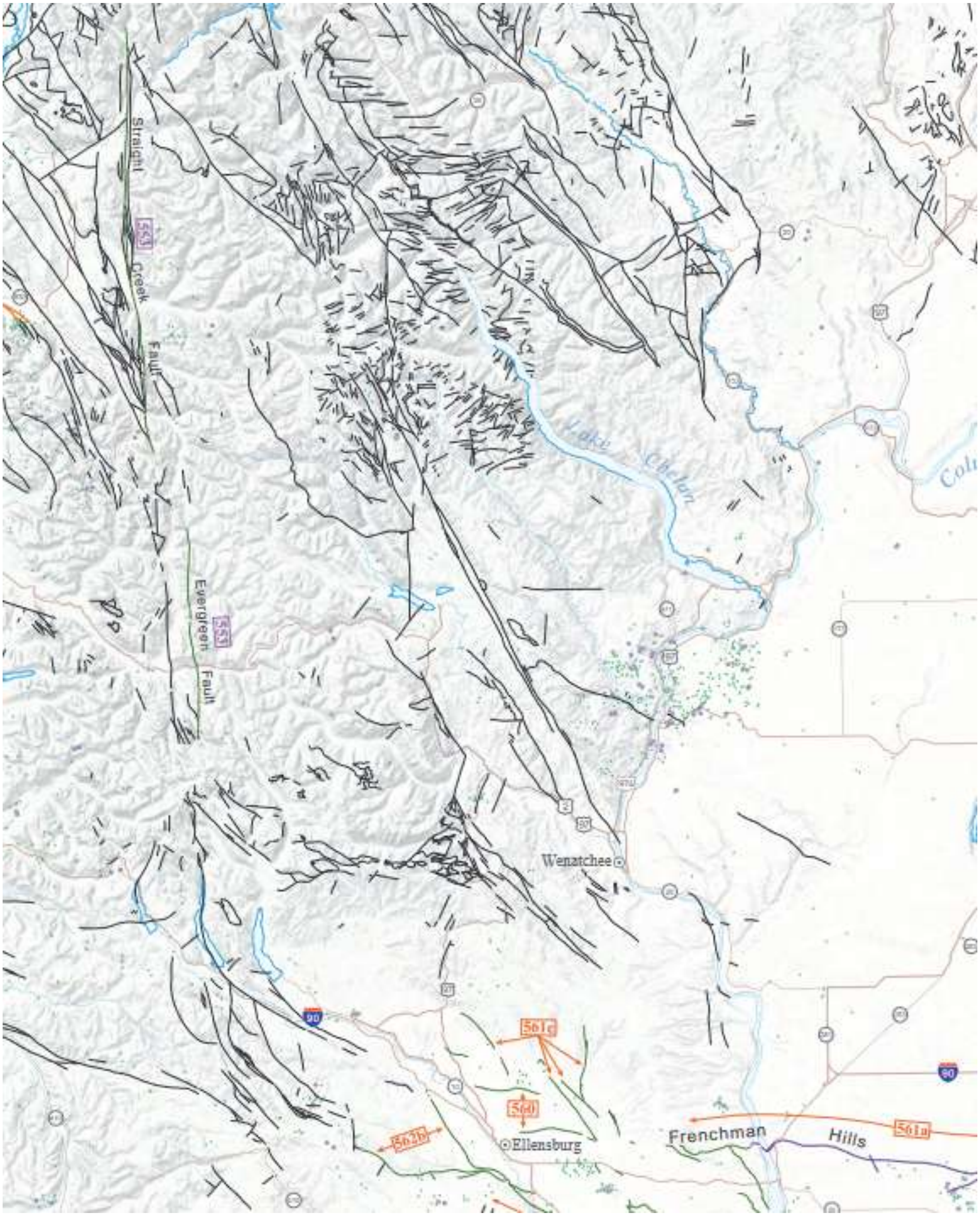


Figure 11-4. Planning Area Active Faults and Folds

11.2.2 Extent

Earthquakes in Eastern Washington have been generally small in magnitude, but much shallower in depth. These shallow, moderate magnitude earthquakes often cause considerable damage in the immediate vicinity of the earthquake. Shallow earthquakes tend to be more damaging because they do not have as far to travel under the surface and therefore, do not lose as much energy along the way (Phys.Org 2016). Chelan County is in the "Back Arc" region, where earthquakes have a shallower epicenter than on the west side of the Cascades. Seismic activity in Eastern Washington typically occur at depths less than 8 km. The shallow depths produce more aftershocks than deeper quakes. Although past earthquakes have been in the form of milder tremors, the potential for a major earthquake cannot be ruled out.

Intensity is most commonly represented by the modified Mercalli intensity scale, or MMI, based on direct and indirect measurements of seismic effects. The scale levels are typically described using Roman numerals, ranging from "I" corresponding to imperceptible events to "X" for extreme events based on observed structural damage. Figure 11-5 shows a detailed description of the modified Mercalli intensity scale (USGS n.d.).

Intensity	Shaking	Description/Damage
I	Not felt	Not felt except by a very few under especially favorable conditions.
II	Weak	Felt only by a few persons at rest,especially on upper floors of buildings.
III	Weak	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
IV	Light	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	Moderate	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI	Strong	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII	Very strong	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII	Severe	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX	Violent	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.
X	Extreme	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.

Figure 11-5. Modified Mercalli Intensity Scale for Earthquakes

USGS probabilistic ground shaking maps, based on current information about fault zones, show the PGA that has a certain probability of being exceeded in a 50-year period. The Central Washington area, including Chelan County, is in a moderate-risk area, with a 10% probability in a 50-year period of ground shaking from a seismic event exceeding 10 to 15% of gravity in some part of the County. Figure 11-6 shows the expected peak horizontal ground accelerations for this probability.

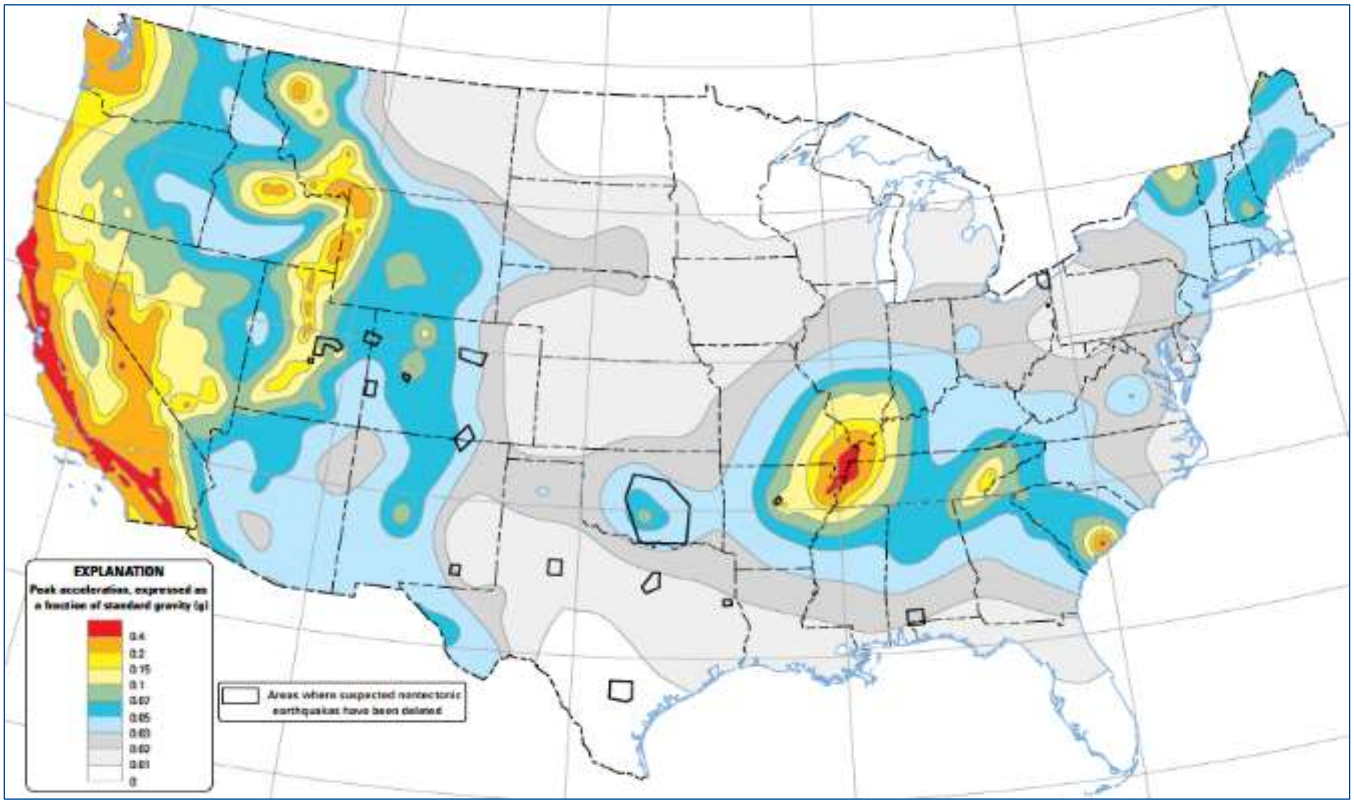


Figure 11-6. Peak Horizontal Acceleration with 10% Probability of Exceedance in 50 Years

11.2.3 Previous Occurrences

Historical Summary

From the early 1900s to the present, over 130 earthquakes have been recorded in north central Washington with magnitude of 2.5 or greater. Most of the seismic activity in Chelan County has been recorded at earthquake epicenters near Lake Chelan and Entiat. Damage by earthquakes has been low in the County. Table 11-3 lists seismic events with a magnitude of M4.0 or larger that have occurred within or adjacent to the planning area since 1958. Many more earthquakes with a M2.5 or higher magnitude have occurred within or adjacent the planning area since 1958, including 20 earthquakes near Chelan, 28 near Entiat, 10 near Leavenworth, four near Sunnyslope, 30 near Waterville, and four each near Pateros and Rock Island. The most recent earthquake occurred on March 3, 2023, near Leavenworth with a magnitude of M2.6. Since 1970, over 1400 earthquakes with magnitudes ranging from M1 and M4.3 have occurred in the Entiat vicinity. See Figure 11-7 for the earthquake epicenters, as well as the 1972 earthquake scarp (in red), and fault lines (in black).

Table 11-3. Recent Earthquakes Magnitude 4.0 or Larger Within or Adjacent to Chelan County

		Epicenter Location		
Date	**Magnitude**	**Latitude**	**Longitude**	**Nearest City**
8-6-1959	4.4	47.817	-120	2 km NNW of Chelan Falls, Washington
4-11-1984	4.3	47.535	-120.186	13 km ENE of Sunnyslope, Washington
6-27-2013	4.27	47.82417	-120.689	25 km N of Leavenworth, Washington
4-12-1958	4.1	48	-120	9 km SW of Pateros, Washington

Source: Earthquake Catalog (USGS 2024)

Source: (Sherrod, Blakely and Weaver 2021)

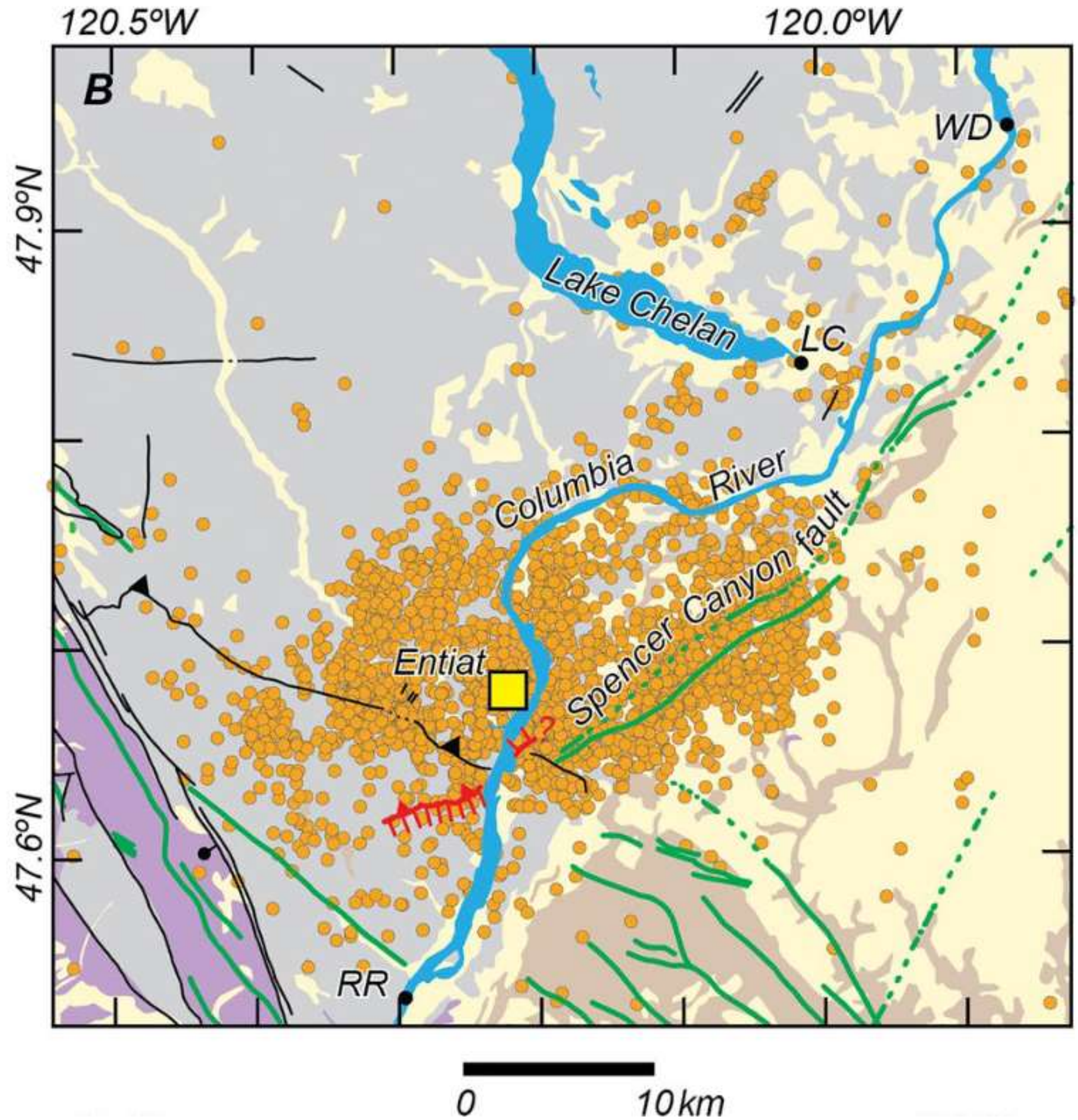


Figure 11-7. Earthquakes occurring near Entiat since the 1900s with a Magnitude between M1 and M4.3.

1872 Event

The largest shallow earthquake in the history of the Pacific Northwest occurred on December 14, 1872, at 9:40 PM in Chelan County. Because the earthquake occurred in a predominately frontier area and the ground shaking was widespread over the Pacific Northwest, scientists grappled with finding the exact location for many years.

However, recent research and field investigation has revealed a scarp and a fault in Spencer Canyon, near Entiat, that scientists believe confirms the epicenter for the earthquake is near Entiat (Sherrod, Blakely and Weaver 2021).

The earthquake was felt from British Columbia to Oregon and from the Pacific Ocean to Montana in approximately a 400 mile radius from Entiat. It occurred in a wilderness area, which in 1872 had only a few inhabitants—local Indian tribes, trappers, traders, and military men. Because there were few man-made structures in the epicenter area near Lake Chelan, most of the information available is about ground effects, including huge landslides, massive fissures in the ground, and a 27-foot high geyser.

Extensive landslides occurred in the slide-prone shorelines of the Columbia River. One massive slide, at Ribbon Cliff between Entiat and Winesap, blocked the Columbia River for several hours. A field reconnaissance to the Ribbon Cliff landslide area in August 1976 showed remnants of a large landslide mass along the west edge of Lake Entiat (a reservoir of the Columbia River), below Ribbon Cliffs and about three kilometers north of Entiat. Although the most spectacular landslides occurred in the Chelan-Wenatchee area, slides occurred throughout the Cascade Mountains.

Ground fissures formed in several locations. Most of the ground fissures occurred in the following areas: at the east end of Lake Chelan in the area of the Indian camp; in the Chelan Landing-Chelan Falls area; on a mountain about 12 miles west of the Indian camp area; on the east side of the Columbia River (where three springs formed); and near the top of a ridge on a hogback on the east side of the Columbia River. Slope failure, settlements, or slumping in water-saturated soils may have produced the fissures in areas on steep slopes or near bodies of water. Sulfurous water was emitted from the large fissures that formed in the Indian camp area. At Chelan Falls, “a great hole opened in the earth” from which water spouted as much as 27 feet in the air, thought to be a combination of liquefaction and water pressure. The geyser activity continued for several days, and, after diminishing, left permanent springs.

In the area of the epicenter, the quake damaged one log building near the mouth of the Wenatchee River. Ground shaking threw people to the floor, waves were observed in the ground, and loud detonations were heard. About two miles above the Ribbon Cliff slide area, the logs on another cabin caved in.

Because the earthquake was shallow, aftershocks continued to shake the Pacific Northwest. Within the first nine hours after the earthquake, aftershocks were felt as far away as Deer Lodge, Montana, Henry House, Alberta, and Portland, Oregon (Brocher, et al. 2018). Some of the reports include:

- In Wenatchee, 64 aftershocks were reported before daybreak the next morning.
- In Snoqualmie, 13 aftershocks were felt before daybreak, and at least 10 more aftershocks were felt in the next three days.
- In Olympia, 10 distinct shocks occurred during the night and six occurred the next day. The last recorded aftershock was felt in March 1873.
- Colville experienced daily aftershocks for months.
- Chelan experienced daily aftershocks for the next year.
- In Whitestone (north of Omak), 142 aftershocks were recorded in the first 42 days.
- In Entiat, aftershocks occurred for four or five years after the earthquake, forming many new fissures in the surrounding mountains.

Disaster and Emergency Declarations

The following summarizes disaster declarations or emergency proclamations related to the earthquake hazard.

- Federal DR or EM Declaration, 1953-2023: 1 event (DR-1361-WA) classified as earthquake
- Washington State Emergency Proclamations, 2014-2023: 0 events classified as earthquake

11.2.4 Overall Probability

Earthquakes along the Cascadia Subduction Zone occur on average every 500 to 600 years, although the frequency appears to be irregular. The intervals between earthquakes in this subduction zone have ranged from 200 years to more than 1,000 years. The probability of a magnitude 6.5 or higher earthquake occurring along the subduction zone in the Puget Sound Region is estimated to be about 84% in the next 50 years (Cascadia Region Earthquake Workgroup (CREW) n.d.)

For the Central Washington area, research suggests that stress profiles obtained for a 1979 WPPSS earthquake study based on regional gravity data identify the Chelan area as a high potential earthquake epicenter zone. The probability that an earthquake will occur in Chelan County is high. Based on historic frequency and future conditions, the probability of future earthquake of M2.5 is almost two events per year. Larger earthquakes, such as the 1872 earthquake, are predicted to occur on a 200-year recurrence interval (Sherrod, Blakely and Weaver 2021).

11.2.5 Warning Time

There is no current reliable way to predict the day or month that an earthquake will occur at any given location, but immediate warning can be given when the earthquake occurs. The USGS has developed an earthquake early warning system for Washington, California, and Oregon. The system detects earthquakes immediately as they begin and takes only a few seconds for the warning to be sent out, providing warning before the ground movement occurs. The warning time is very short (10s of seconds, depending on the type of earthquake), but it could allow time for someone to get under a desk, step away from a hazardous material they are working with, or shut down a computer system. The data could also be used to take automatic actions, such as stopping elevators at the nearest floor, closing water reservoir valves to prevent loss of potable water, or activating backup generators.

In Washington, the early warning alerts are sent to all cell phones using the Wireless Emergency Alert System or the MyShake smartphone app. Cell phones on the Android system will receive the messages automatically (PNSN 2024).

11.2.6 Climate Change Impacts

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 or heavy precipitation 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.

11.2.7 Future Trends in Development

Land use in the planning area will be directed by comprehensive plans adopted under Washington's Growth Management Act. The information in this plan provides the participating partners a tool to ensure that there is no increase in exposure in areas of high seismic risk. Development in the planning area will be regulated through building standards and performance measures so that the degree of risk will be reduced. The geologic hazard portions of the planning area are regulated under each jurisdiction's critical areas ordinances. The most recently adopted building codes take liquefaction and soil mapping into account in their standards.

Areas targeted for future growth and development have been identified across the County. It is anticipated that the human exposure and vulnerability to earthquake impacts in newly developed areas will be similar to those that currently exist within the County. New development in areas with softer NEHRP soil classes, liquefaction and landslide-susceptible areas may be more vulnerable to the earthquake hazard.

11.3 SECONDARY HAZARDS

Earthquakes can cause disastrous landslides. River valleys are vulnerable to slope failure, often as a result of loss of cohesion in clay-rich soils. Earthen dams and levees are highly susceptible to seismic events, and the impacts of their eventual failures can be considered secondary risk exposure to earthquakes. Additionally, fires can result from gas lines or power lines that are broken or downed during the earthquake. It may be difficult to control a fire, particularly if the water lines feeding fire hydrants are also broken.

11.3.1 Seiche

A seiche is a standing wave in an enclosed or partly enclosed body of water, normally caused by earthquake activity or landslides flowing into waterbodies, though also possibly caused by other factors such as wind. The effect is caused by resonances in a body of water that has been disturbed. Vertical harmonic motion results, producing an impulse that travels the length of the basin at a velocity that depends on the depth of the water. The impulse is reflected back from the end of the basin, generating interference. Repeated reflections produce standing waves with one or more nodes, or points, that experience no vertical motion.

The waves in a seiche are stationary in the horizontal plane; they move up and down, but not forward like wind waves at sea. That is why these waves are called standing waves. The frequency of the oscillation is determined by the size of the basin, its depth and contours, and the water temperature.

Seiches can occur in harbors, bays, lakes, rivers and canals. They are often imperceptible to the naked eye, and observers in boats on the surface may not notice that a seiche is occurring due to the extremely long wavelengths. These events usually do not occur near the epicenter of a quake, but often hundreds of miles away. This is due to the fact that earthquake shock waves close to the epicenter consist of high-frequency vibrations, while those at much greater distances are of lower frequency, which can enhance the rhythmic movement in a body of water. The biggest seiches develop when the period of the ground shaking matches the frequency of oscillation of the water body.

Researchers believe local amplification of seismic waves could make other urban areas above sedimentary basins in the region particularly vulnerable to seiches or water waves during large earthquakes on the Seattle

Fault or the Cascadia Subduction Zone. With Lake Chelan, other reservoirs and the Columbia River a risk of seismic events within the planning area, there is potential for seiches to occur in Chelan County. The degree of vulnerability to this hazard is difficult to gage without hazard mapping that illustrates extent, location and potential severity of probabilistic events.

11.4 VULNERABILITY

11.4.1 People

The entire planning area population of 79,997 is potentially vulnerable to some degree to direct damage from earthquakes or indirect impacts such as business interruption, road closures, and loss of function of utilities. A breakdown of this estimate by jurisdiction is provided in Appendix C.

11.4.2 Structures

There are estimated to be 46,438 buildings in the planning area, with a total value of $25.10 billion. All are vulnerable to the earthquake hazard. Most of these buildings (79%) are residential. A breakdown of these estimates by jurisdiction is provided in Appendix C.

Since the entire planning area is vulnerable to the earthquake hazard, all 455 inventoried critical facilities and community lifelines are vulnerable. The breakdown of the numbers and types of facilities is presented in Table 11-4.

Table 11-4. Critical Facilities Vulnerable to Earthquake

Category	# of Critical Facilities
Communications	52
Energy	9
Food, Hydration, Shelter	26
Hazardous Materials	8
Health and Medical	35
Safety and Security	86
Transportation	225
Government Facilities	14
Total	**455**

11.4.3 Systems

All systems, networks, and capabilities within Chelan County are vulnerable to the earthquake hazard.

11.4.4 Natural, Historic, and Cultural Resources

The entire planning area is vulnerable to the earthquake hazard, including all natural resources, habitat, wildlife, and historic and cultural resources.

11.4.5 Activities That Have Value to the Community

All activities that have value to the community are vulnerable to the earthquake hazard.

11.4.6 Agriculture

All agriculture structures and systems within the planning area are potentially vulnerable to the earthquake hazard.

11.5 IMPACTS

Earthquake impact data was generated using a Hazus analysis. Two USGS event scenarios were modeled:

- A Magnitude-7.2 event on the Chelan Fault with an epicenter approximately 5.6 miles east-southeast of the City of Chelan (see Figure 11-8)
- A Magnitude-9.0 event on the Cascadia Fault with an epicenter approximately 250 miles southwest of Wenatchee (see Figure 11-9).

The analysis results are summarized in the sections below. Appendix C presents results for each jurisdiction. The results of this analysis are likely to underestimate risk, due to limitations in the modeling parameters:

- All community lifelines are assumed to have been built to high code standards. This may not be the case, especially for older facilities.
- The Hazus model does not consider the extreme duration of shaking expected during a Cascadia Subduction Zone event. Some models estimate that ground shaking will occur for up to five minutes.

11.5.1 People

Residents of High-Risk Areas

The degree of impact is dependent on many factors, including the age and construction type of the structures people live in, the soil type their homes are constructed on, their proximity to fault location, etc. People can be injured or killed from an earthquake. Injury can be sustained from falling bookshelves in their homes, facades falling onto city streets, or car accidents due to fissures forming in roads. After an earthquake, people may experience health concerns caused by lack of clean water, poor sanitation, or hospitals operating at lower capacities. Many people may be impacted financially – most homeowners insurance does not cover earthquake damage. A separate earthquake policy is required.

Susceptible Population Groups

Two groups are particularly vulnerable to impacts from earthquake hazards:

- Population Below Poverty Level—Households below the poverty level may lack the financial resources to improve their homes to prevent or mitigate earthquake damage or repair their homes after the earthquake. Economically disadvantaged residents are also less likely to have insurance to compensate for losses incurred during earthquakes.
- Population Over 65 Years Old—Population group over 65 years old are vulnerable because they are more likely to need special medical attention, which may not be available due to isolation caused by earthquakes. Elderly residents also have more difficulty leaving their homes during earthquake events and could be stranded in dangerous situations.

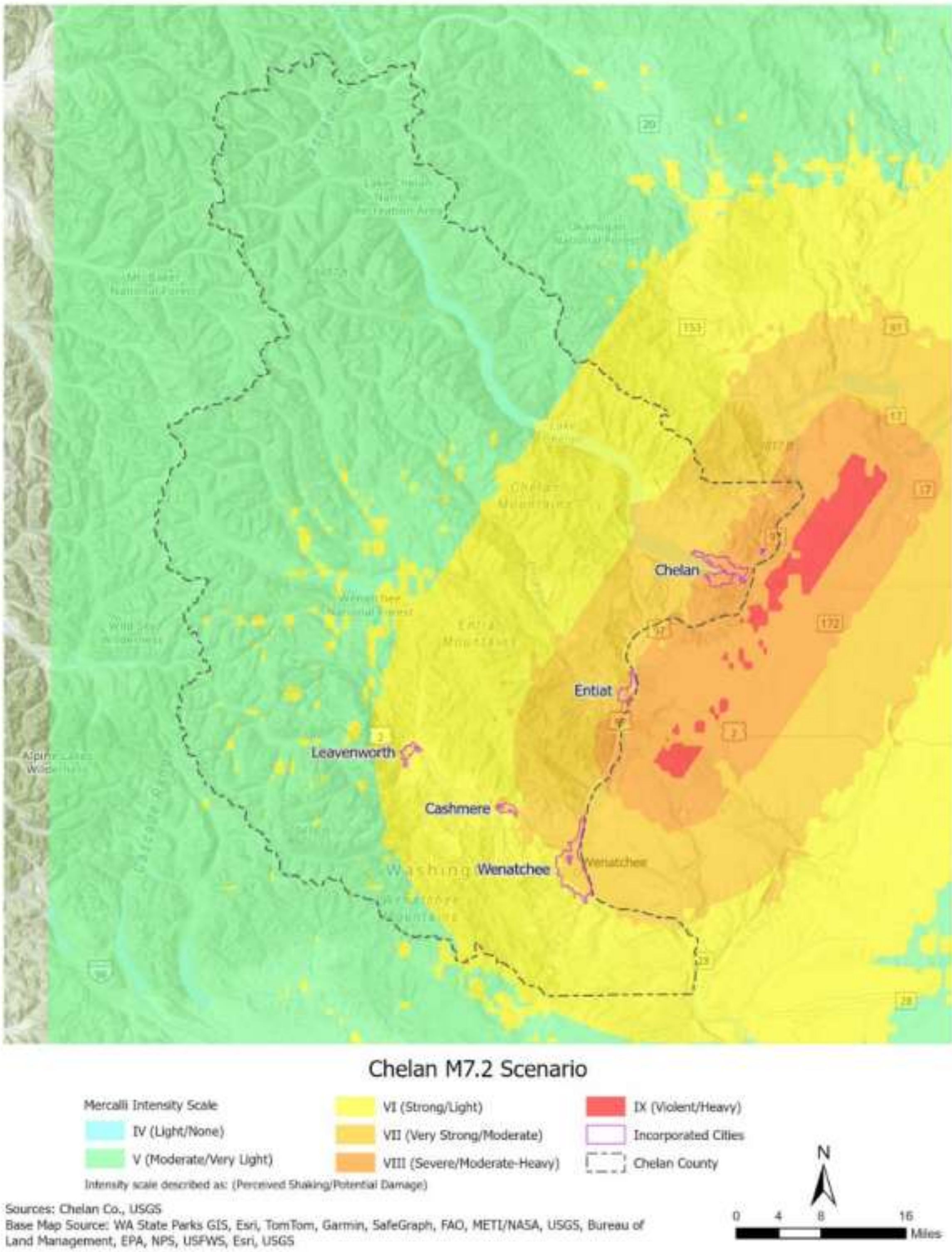


Figure 11-8. Chelan M7.2 ShakeMap Scenario

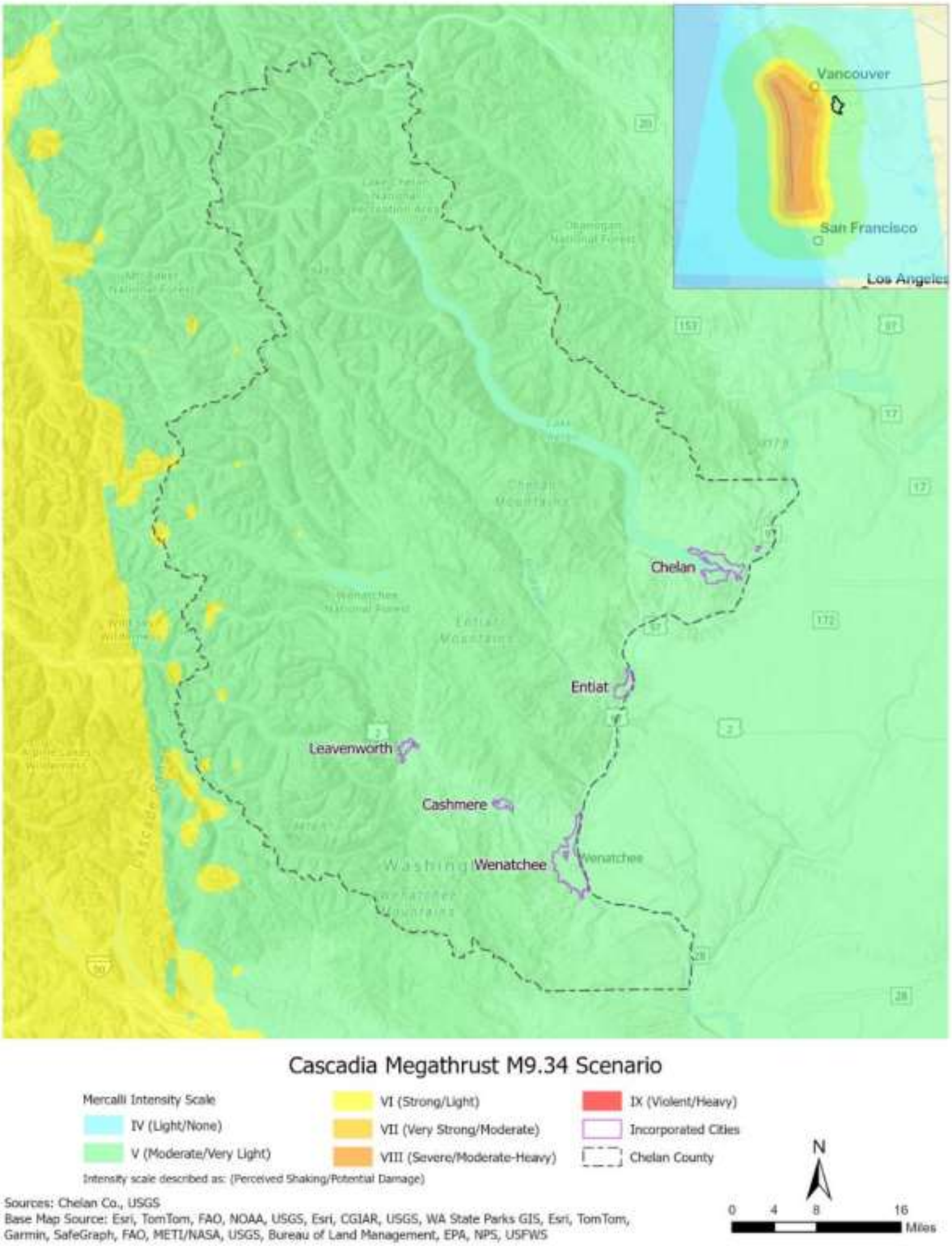


Figure 11-9. Cascadia M9.0 ShakeMap Scenario

Estimated Impacts on Persons and Households

Hazus estimated impacts on persons and households in the planning area for the two selected earthquake scenarios as summarized in Table 11-5.

Table 11-5. Estimated Earthquake Impact on Persons

Scenario	Displaced Households		Persons Requiring Short-Term Shelter	
	Number	% of Total	Number	% of Total
Chelan M7.2	9	Les than 0.1%	4	Less than 0.1%
Cascadia M9.34	None	N/A	None	N/A

11.5.2 Structures

A Hazus analysis was conducted on structures and critical facilities and community lifelines in the planning area for the two scenarios. Damage from the Cascadia scenario was minimal; therefore, only results from the Chelan scenario are provided.

Level of Damage to Critical Facilities

Hazus classifies the impacts of community lifelines to earthquake damage in five categories: no damage, slight damage, moderate damage, extensive damage, or complete damage. The model was used to assign a probability of each damage state to every community lifeline in the planning area. The results of the Cascadia Subduction Zone events indicated that no damage was expected to any community lifeline. The results for the Chelan Fault M7.2 scenario event are summarized in Table .

Table 11-6. Estimated damage to critical facilities from M7.2 Chelan fault zone scenario

Category	# of Critical Facilities	Number of Buildings with 50% or Greater Probability of Achieving Damage Level				
		None	Slight	Moderate	Extensive	Complete
Communications	52	43	3	3	3	0
Energy	9	6	0	1	2	0
Food, Hydration, Shelter	26	25	1	0	0	0
Hazardous Materials	8	8	0	0	0	0
Health and Medical	35	25	5	5	0	0
Safety and Security	86	68	9	7	2	0
Transportation	225	224	0	1	0	0
Government Facilities	14	11	0	0	3	0
Total	**455**	**410**	**18**	**17**	**10**	**0**

Hazardous Materials

Hazardous material releases from fixed facilities and transportation-related releases can occur during an earthquake event. Vital transit corridors such as State Highways 2, 97, 150, 207, 285, and 971 can be disrupted during an earthquake, which can result in the release of hazardous materials that are being transported along these corridors to the surrounding environment. Facilities holding hazardous materials are of particular concern because of possible isolation of populations surrounding them. There are at least eight known facilities in the planning area that handle materials considered to be hazardous. During an earthquake event, structures storing these materials could rupture and leak into the surrounding area, or river, having a disastrous effect on the environment.

Roads

There are many roads that cross earthquake-prone soils in the planning area. These soils have the potential to be significantly damaged during an earthquake event. Access to major roads is crucial to life and safety after a disaster event as well as to response and recovery operations. The following major roads in the planning area pass through NEHRP D soils areas:

- State Highway 2
- State Highway 97
- State Highway 285
- State Highway 150
- State Highway 207
- State Highway 971

Bridges

Earthquake events can significantly impact bridges. Bridges are important because they often provide the only access to some neighborhoods. Bridges often follow floodplain boundaries, which typically have soft or liquefiable soils, and thus, if not constructed to seismic standards may be impacted by earthquakes. A key factor in the degree of impact is the age of the facility and the type of construction, which help indicate the standards to which the facility was built.

Water and Sewer Infrastructure

Water and sewer infrastructure would likely suffer considerable damage in the event of an earthquake. This is hard to analyze due to the amount of infrastructure and the fact that water and sewer infrastructure are usually linear easements, which are not modeled in Hazus. Without further analysis of individual components of the system, it should be assumed that these systems are exposed to potential breakage and failure.

Damage to Structures

Damage to structures will vary depending on a number of factors described below. Table 11-7 provides the estimated damage value for structures within Chelan County.

Table 11-7. Estimated Impact of Earthquake Scenario Events in the Planning Area

	Damage to Buildings	
Earthquake Scenario Event	**Structure + Contents Damage**	**% of Total Value**
Chelan M7.2	$729 Million	2.9%
Cascadia Subduction Zone M9.34	$18.1 Million	0.1

Building Age

Table 11-8 identifies significant milestones in building and seismic code requirements that directly affect the structural integrity of development. Using these time periods, the planning team used Chelan County assessor's data to identify the number of structures in the planning area by date of construction. The number of structures does not reflect the number of total housing units, as many multi-family units and attached housing units are reported as one structure. Approximately __ of the planning area's structures were constructed before there were state minimums regarding residential seismic construction standards. Approximately 16% were built after seismic Zone 3 standards were required.

Table 11-8. Age of Structures in Planning Area

	Number of Current Structures Built in Period[a]	Significance of Timeframe
Pre-1972		Adoption of building codes was at the discretion of individual cities and counties. There were no state minimums regarding residential construction, although newly constructed schools, hospitals and places of assembly were required to withstand a lateral force of 5% of the building weight.
1972-1993		Houses built after 1972 are compliant with the 1970 Uniform Building Code, which required that all structures be constructed to Zone 2 seismic standards.
1994-2003		Zone 3 standards of the Uniform Building Code went into effect in Western Washington in 1994, requiring all new construction to be capable of withstanding the effects of 0.3 times the force of gravity.
2004-2006		Adoption of new codes that became effective in July of 2004 brought Washington State's building codes to the highest level nationwide addressing the state's seismic hazard.
2007-present		Amendments to the International Building Code that took effect in July of 2007 included provisions for structural design for earthquake loads and flood hazards. The code applies to all building permits in the state of Washington. The codes are driven in part by soil and liquefaction maps prepared.
Total		

a. Year built information was collected from Chelan County tax assessor data. When year-built information was unavailable, it was estimated based on census block or county-wide average year-built dates.

Source: Western States Seismic Policy Council, 2016

Location

Structures located closer to the earthquake epicenter or on liquefiable or softer soils are more at risk of damage. Liquefiable soils act like quicksand while the ground is shaking. Anything built on top of the soils that is not anchored to the bedrock is at risk of shifting, tipping, or sinking. Soft soils may not be able to support the structure during movement. And structures near the epicenter will experience more severe shaking than structures at a greater distance. Structures may be knocked off their foundation or suffer structural damage.

Loss Potential and Estimated Debris

Table 11-9 summarizes Hazus estimates of earthquake damage in the planning area for the two earthquake scenarios. The debris estimate includes only structural debris; it does not include additional debris that may accumulate, such as from trees. In addition, these estimates do not include losses that would occur from any local fires stemming from an earthquake.

Table 11-9. Estimated Impact of Earthquake Scenario Events in the Planning Area

	Structure Debris	
Earthquake Scenario Event	**Tons**	**Truckloads**
Chelan M7.2	52,870	3,524
Cascadia Subduction Zone M9.34	7,100	473

11.5.3 Systems

During an earthquake event, networks and capabilities that are essential for emergency services (including first responders and public works) and economic stability can be severely impacted. Emergency services and public works may face challenges adequately responding to the event due to collapsed buildings, blocked roads, and reduced capacity. In addition, planning and permitting departments may face challenges during the recovery phase following an earthquake event due to the scale of damage and the number of inspections and permits that will be required.

After a large-scale earthquake event, the economy may suffer business closures, disrupted supply chains, and higher unemployment. Many homeowners do not have earthquake coverage as part of the homeowners insurance and may be liable for all costs to repair damaged structures. A 2018 report by the Washington State Office of the Insurance Commissioner found that approximately only 3.4% of polices have earthquake coverage in Chelan County (Kreidler 2018). These economic impacts may be devastating and take years to recover.

11.5.4 Natural, Historic, and Cultural Resources

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

Structures on historic registers were constructed to less stringent or even no earthquake building standards. If structures have not been retrofitted, they may be impacted during an earthquake. Buildings made of unreinforced masonry will be most impacted. Historic structures may be destroyed by earthquake.

11.5.5 Activities that Have Value to the Community

Earthquakes can greatly impact on activities that have value to the community, depending on the location and severity of the event. Residential life, business operations, and recreational pursuits may be disrupted by an earthquake. Schools may become unsafe, disrupting student learning and after school activities such as sports, clubs, and other community events. Other activities that have value to the community such as local parks, sports facilities, and trails may suffer damage and be closed to public use until repaired due to safety.

11.5.6 Agriculture

Earthquake impacts on agriculture would depend on the severity of the event, and proximity of the planning area to the source. The direct impacts are likely to be nominal, associated with damage to structures and facilities used for process and production of agriculture production. The indirect impacts associated with damages to transportation corridors, irrigation systems and loss of power are likely to be far greater than the direct impacts. Disruption of transportation corridors would likely impact distribution of agricultural products and the loss of power would interrupt processing operations. The loss of irrigation systems may be devastating to a crop, especially if the loss occurred during the hot growing season.

11.5.7 National Risk Index

According to the National Risk Index (NRI), Chelan County has a "Relatively High" risk index for the earthquake hazard. Table 11-10 provides the risk factor breakdown. See Section 7.2 for a description of the components of the NRI.

Table 11-10. NRI Scoring for Earthquake in Chelan County

Expected Annual Loss	Risk Index Rating	Community Resilience	Social Vulnerability	Risk Value	Risk Index Score
$2,545,923	Relatively High	Relatively Moderate	Relatively High	$3,317,320	90

11.6 SCENARIO

Any seismic activity of M6 or greater on faults within the planning area's general region would have significant impacts throughout the planning area. An earthquake on the Chelan Fault could have disastrous consequences for the entire state and the region. The USGS warning systems could give a few seconds' notice that a major earthquake is about to occur. This would not provide adequate time for preparation.

Large magnitude earthquakes in the region could lead to massive structural failure of property on liquefiable soils. Structural failure may be intensified if the earthquake occurs during winter when soils are saturated. Heavy damage would also occur in areas with poor site conditions, older construction, or construction especially vulnerable to long duration, long period ground motions. Dams, levees and revetments built on poor soils would likely fail, representing a loss of critical infrastructure. Access to and from the County would be challenging, given the likelihood that bridges and major transportation routes may be impassable. These events could cause secondary hazards, including landslides and mudslides that would further damage structures.

11.7 ISSUES

Important issues associated with an earthquake include the following:

- After a major seismic event, Chelan County would likely experience disruptions in the flow of goods and services due to the destruction of major transportation infrastructure across the broader region.
- Critical facility owners should be encouraged to create or enhance continuity of operations plans using the information on risk and vulnerability contained in this plan.
- Damage to road systems in the planning area after an earthquake has the potential to significantly disrupt response and recovery efforts and lead to isolation of populations.
- Due to limitations in current modeling abilities, the risk to critical facilities and infrastructure in the planning area from the earthquake hazard is likely understated. A more thorough review of the age of critical facilities, codes they were built to, and location on liquefiable soils should be conducted.
- Earthquakes can cause conflagration of wooden homes and collapse of essential buildings such as fire stations.
- Earthquakes could trigger other natural hazard events such as dam failures, levee failures and landslides, which could severely impact the planning area or regional critical facilities.
- Geotechnical standards should be established that consider the probable impacts from earthquakes in the design and construction of new or enhanced facilities.

- Major arterials in the planning area cross liquefiable soils and could be impassable after an event.
- Model estimates indicate that debris removal from earthquake events would require over 4,000 truckloads, depending on the event scenario.
- Natural hazards have a devastating impact on businesses. Of all businesses that close following a disaster, more than 43% never reopen, and an additional 29% close for good within the next two years. The Institute of Business and Home Safety has developed "Open for Business," which is a disaster planning toolkit to help guide businesses in preparing for and dealing with the adverse effects of natural hazards. The kit integrates protection from natural disasters into companies' risk reduction measures to safeguard employees, customers, and the investment itself. The guide helps businesses secure human and physical resources during disasters and helps to develop strategies to maintain business continuity before, during, and after a disaster occurs.
- Over __% of the planning area's building stock was built prior to 1994, when Zone 3 seismic standards were incorporated into the building code.
- Residents are expected to be self-sufficient up to two weeks following a major earthquake without government response agencies, utilities, private sector services and infrastructure components. Education programs are currently in place to facilitate the development of individual, family, neighborhood and business earthquake preparedness. Government alone can never make this region fully prepared. It takes individuals, families, and communities working in concert with one another to truly be prepared for disaster.
- There are likely additional faults in or around Chelan County that have not yet been discovered.

11.8 MITIGATING THE HAZARD

Table 11-11 presents a range of potential opportunities for mitigating the earthquake hazard.

Table 11-11. Potential Opportunities to Mitigate the Earthquake Hazard

Community Scale	Organizational Scale	Government Scale
	Manipulate the Hazard	
None	None	None
	Reduce Vulnerability and Impacts	
• Locate outside of hazard area (off soft soils) • Retrofit structure (anchor house structure to foundation) • Secure household items that can cause injury or damage (such as water heaters, bookcases, and other appliances) • Build to higher design	• Locate or relocate critical functions outside hazard area where possible • Build redundancy for critical functions and facilities • Retrofit critical buildings and areas housing critical functions	• Locate community lifelines or functions outside hazard area where possible • Harden infrastructure • Provide redundancy for critical functions • Adopt higher regulatory standards • Perform seismic retrofits for vulnerable critical buildings and areas

Community Scale	Organizational Scale	Government Scale
Build Local Capacity		
• Practice “drop, cover, and hold” • Develop household mitigation plan, such as creating a retrofit savings account, communication capability with outside, 72-hour self-sufficiency during an event • Keep cash reserves for reconstruction • Become informed on the hazard and risk reduction alternatives available • Develop a post-disaster action plan for your household	• Adopt higher standard for new construction; consider “performance-based design” when building new structures • Keep cash reserves for reconstruction • Inform your employees on the possible impacts of earthquake and how to deal with them at your work facility. • Develop a continuity of operations plan	• Provide better hazard maps • Provide technical information and guidance • Enact tools to help manage development in hazard areas (e.g., tax incentives, information) • Include retrofitting and replacement of critical system elements in capital improvement plan • Develop strategy to take advantage of post-disaster opportunities • Warehouse critical infrastructure components such as pipe, power line, and road repair materials • Develop and adopt a continuity of operations plan • Initiate triggers guiding improvements (such as <50% substantial damage or improvements) • Further enhance seismic risk assessment to target high hazard buildings for mitigation opportunities • Develop a post-disaster action plan that includes grant funding and debris removal components
Nature-Based Opportunities		
None identified		

12. FLOOD

12.1 GENERAL BACKGROUND

Flooding is defined as a significant rise in water level due to increased surface water run-off or groundwater saturation that results in an increase in surface water levels beyond what is typically expected and that can cause damage to man-made structures.

A floodplain is the area adjacent to a flood source such as a river, creek, alluvial fan, 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.

When floodwaters recede after a flood event, they leave behind layers of rock and mud. These gradually build up to create a new floor of the floodplain. Floodplains generally contain unconsolidated sediments (accumulations of sand, gravel, loam, silt, and/or clay), often extending below the bed of the stream. These sediments provide a natural filtering system, with water percolating back into the ground and replenishing groundwater. These are often important aquifers, the water drawn from them being filtered compared to the water in the stream. Fertile, flat reclaimed floodplain lands are commonly used for agriculture, commerce and residential development.

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 altered or significantly reduced.

12.1.1 Measuring Floods and Floodplains

The frequency and severity of flooding are measured using a discharge probability, which is the probability that a certain river discharge (flow) level will be equaled or exceeded in a given year. Flood studies use historical records to determine the probability of occurrence for the different discharge levels. The flood frequency equals 100 divided by the discharge probability. For example, the 100-year discharge has a 1% chance of being equaled or exceeded in any given year. The “annual flood” is the greatest flood event expected to occur in a typical year. These measurements reflect statistical averages only; it is possible for two or more floods with a 100-year or higher recurrence interval to occur in a short time period. The same flood can have different recurrence intervals at different points on a river.

The extent of flooding associated with a 1% 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 (SFHA), 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.

12.1.2 Floodplain Ecosystems

Floodplains can support ecosystems that are rich in plant and animal species. A floodplain can contain 100 or even 1,000 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, but the surge of new growth endures for some time. 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.

12.1.3 Effects of Human Activities

Because they border water bodies, floodplains have historically been popular sites to establish settlements. Human activities tend to concentrate in floodplains for several 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. Human activities can interface effectively with a floodplain as long as steps are taken to mitigate the activities' adverse impacts on floodplain functions.

12.1.4 Types of Floodplains in the Planning Area

Stage, flash and post-fire flooding are three types of flooding common in Chelan County. Stage flooding occurs during periods of heavy rains, especially falling on existing snowpack during early winter and late spring. Stage flooding can last several days after the storm. Flash floods are most likely to occur during the summer thunderstorm season and are usually associated with cloudburst-type rainstorms. Winter flash flooding events, when they occur, are typically caused by ice or debris dams. Due to the County's topography and climate, stage and flash flooding are a continuing threat in most parts of the county After a significant wildfire, vegetation is lost, and soils can harden to repel rather than absorb water. This can result in mud/silt or debris flows that impact public and private property (county roads, private homes/cabins, etc.). It also reduces flow conveyance, increasing the potential for flood damage.

12.1.5 Stage Flooding

Stage floods occur because of prolonged heavy rainfall, a rapidly melting snow pack or a combination of these. Stage flooding problem areas can occur countywide; some of the most susceptible areas are the area where Icicle Creek and the Wenatchee River meet in Leavenworth, the Wenatchee River between Cashmere and Wenatchee, the headwaters of the Wenatchee River, and the confluence area of the Wenatchee and Columbia Rivers. The following sections describe the watersheds in the planning area that are sources of stage flooding.

12.1.6 Flash Flooding

Flash flooding is flooding characterized by a quick rise and fall of water level. Flash floods generally result from intense storms dropping large amounts of rain within a short period of time onto watersheds that cannot absorb or slow the flow.

Historically, Chelan County has had regular occurrences of flash flooding. Reoccurring problem areas for flash flooding include Slide Ridge in the Chelan area and Number 1 and Number 2 Canyons and Dry Gulch in the Wenatchee area. The primary cause of flash flooding, which can occur in any county drainage area, is high-intensity rainfall.

Depending upon the characteristics of a particular watershed, peak flows may be reached from less than one hour to several hours after rain begins. The debris dams and mudslides accompanying rapid runoff conditions make narrow canyons and alluvial fans at the mouth of the canyons extremely hazardous areas.

12.1.7 Post-Fire Flooding

Wildfires dramatically change landscape and ground conditions, which can lead to increased risk of flooding due to heavy rains, flash flooding, and mudflows. The threat of flash flooding is increased in an area that has suffered from a major wildfire. Not only is there a greater amount of loose debris, but most of the ground cover also has been burnt away. Without ground cover, more soil and debris can flow, increasing the chance of debris dams. In addition, post-wildfire soils may become hydrophobic. Hydrophobic soils repel water, causing reduced water infiltration, and increased runoff, erosion, and sedimentation (Brooks n.d.). When rain falls on unprotected earth, or on hydrophobic soils, as in a burn area, soils on moderate to steep slopes can become unstable. The reduced water infiltration caused by post-wildfire affects can increase runoff and cause erosion which may trigger devastating floods and mudflows that may flow into populated area.

Post-fire flooding is a concern in Chelan County. Chelan County has experienced significant wildfire activity. In 2015 the Chelan Complex Fire burned approximately 88,985 acres (Chelan County 2015). Six years later, in 2021, the burn scar in the Antoine Creek Basin led to increased surface water flows, causing severe spring runoff, flooding, and damage to roadways. The County has taken steps to mitigate these issues, including receiving a grant from FEMA to upgrade culverts and reduce the risk of future post-fire flooding (Chelan County 2021).

Number 1 and Number 2 Canyons near Wenatchee have previously experienced flash flooding and mud and debris flows. In 2022, Chelan County received a $1 million grant from FEMA to fund construction of a debris basin in Number 1 Canyon to mitigate the flood risk. The construction of the debris basins was completed in April of 2023 (Chelan County 2023). See >> for a photo of the completed debris basin.

Much of these areas are steep canyons or areas that contribute to drainages that feed the floodplains of Chelan County. Post-fire flooding can be the worst type of flooding in that there is usually large sediment loads associated with these types events. This sediment transport can lead to channel deposition and migration, which can lead to public safety issues, lack of early warning, and costly cleanup for public agencies and private residents.

In 1972, an area-wide flood event resulted from a large frontal storm combined with the late melt of a record snow pack. The Preston Creek debris torrent that occurred during this event originated from lands burned in 1970. The Crum/Ringsted/Byrd Canyon floods of 1977, the Dinkelman/Mills/Roaring flood of 1989, and the

Potato Creek and Oklahoma Gulch floods of 1997 were all post-fire responses triggered by short duration, high intensity convective storms (Chelan County Conservation District 2004).

Source: (Chelan County 2023)

Figure 12-1. Number 1 Canyon Debris Basin

12.2 NFIP AND CRS PARTICIPATION

Local Plan Requirement C2—44 CFR Part 201.6(c)(3)(ii)

The plan must address the jurisdiction's participation in the NFIP, and continued compliance with NFIP requirements, as appropriate.

Chelan County and the cities of Cashmere, Chelan, Leavenworth, Wenatchee, and Entiat participate in the NFIP. All have adopted regulations that meet the NFIP requirements. Table 12-1 summarizes participation dates for these communities.

Table 12-1. NFIP Participation by Chelan County and Municipalities

ID	Community Name	Initial Flood Hazard Boundary Map	Initial Flood Insurance Rate Map	Current Effective Map Date	Program Entry Date
530016	City of Cashmere	04/05/74	12/1/77	09/30/04	12/1/77
530015	Chelan County	01/12/73	02/04/81	09/30/04	02/04/81
530017	City of Chelan	06/25/76	01/05/78	01/05/78	01/05/78
530019	City of Leavenworth	05/24/74	01/05/78	07/02/02	01/05/78
530020	City of Wenatchee	02/01/74	11/2/77	01/06/94	02/04/81

ID	Community Name	Initial Flood Hazard Boundary Map	Initial Flood Insurance Rate Map	Current Effective Map Date	Program Entry Date
530018	City of Entiat	11/01/74	N/A	NSFHA[a]	08/03/84

a. NSFHA = No Special Flood Hazard Area. This indicates an area that is in a moderate- to low-risk flood zone. An NSFHA is not in any immediate danger from flooding caused by overflowing rivers or hard rains, although structures are still at risk. In fact, more than 20% of all flood insurance claims come from outside mapped high-risk flood areas.
Source: FEMA, 2018a

Chelan County established eligibility in the NFIP's Emergency Program on October 30, 1974, after receiving its Flood Hazard Boundary Map on February 1, 1974. The County's first Flood Insurance Rate Maps (FIRM) were issued on February 4, 1981, which is also the date the County was converted to the NFIP's Regular Program. FIRMs were updated on June 5, 1989, July 2, 2002, and September 30, 2004. In September 2004, digital FIRMs (DFIRMs) were developed for a portion of the Wenatchee River, from just downstream of Leavenworth to just downstream of Cashmere, including Mission Creek. In 2023, FEMA released draft workmaps showing the results of a county-wide physical map revision process. In 2024, FEMA released updated draft floodplains. In 2026, the FIRMs are anticipated to become effective, creating county-wide DFIRM coverage. The Draft DFIRMs form the basis for this chapter's risk assessment.

Chelan County's Flood Chapter 3.20 is fully compliant with NFIP and State floodplain management regulations. This chapter exceeds the FEMA and state requirements in the following ways:

- New residences in the floodplain must be elevated three feet above the base flood elevation; non-residential buildings must be one foot above the base flood elevation.
- No fill, grading, or excavation that unduly affects the efficiency or capacity of the channel or floodway, or decreases flood storage, is permitted. Fills must be protected against erosion.
- Critical facilities must be located outside the floodplain to the extent possible, or must be elevated at least three feet above the base flood elevation.
- Where base flood elevation data has not been provided by FEMA, applicants must develop such data for subdivision proposals and other proposed developments (exceeds FEMA's 50 lot-5 acre criteria).

Currently, the County is in good standing with the NFIP. A FEMA Community Assistance Visit is still ongoing.

12.2.1 Insurance Summary

Table 12-2 lists flood insurance statistics that help identify vulnerability in the planning area. Six planning area communities participate in the NFIP, with 735 flood insurance policies providing $185.3 million in coverage. According to FEMA statistics, 147 flood insurance claims were paid between January 1, 1978, and September 30, 2018, for a total of $1.1 million, an average of $7,540 per claim. Not all structures within the special flood hazard area are covered by flood insurance; according to FEMA, fewer than 25% of structures at risk nationally are covered by flood insurance.

Table 12-2. Flood Insurance Statistics for Chelan County

Jurisdiction	Date of Entry Initial FIRM Effective Date	# of Flood Insurance Policies as of 7/22/2024	Insurance In Force	Total Annual Premium	Claims, 11/1978 to 7/22/2024	Value of Claims paid, 11/1978 to 7/22/2024
Cashmere	12/1/1977	22	$5,141,000	$25,767	6	$7,976

City of Chelan	01/05/1978	5	$1,925,000	$5,482	0	0
Chelan County	02/04/1981	317	$90,042,000	$330,160	110	$1,037,815
Entiat	08/03/1984	0	$0	$0	0	0
Leavenworth	01/05/1978	3	$1,010,000	$2,682	5	$87,000
Wenatchee	11/2/1977	221	$57,807,000	$217,942	35	$42,973
Total		**568**	$155,925,000	$582,033	**156**	**$1,175,764.00**

a. Values reflected have not been converted to current dollar values. Amounts reflect damages covered under the standard flood insurance policy and do not reflect exclusions such as basement flooding or non-structural damages.
Source: FEMA, 2024

Properties constructed after FIRMs were adopted may be less impacted by flooding because they were constructed after regulations and codes were adopted to decrease impacts. Structures built before a FIRM is adopted are generally more impacted by flooding because they do not meet current codes or are located in hazardous areas. The first FIRMs in the planning area were available in 1977.

12.3 HAZARD PROFILE

12.3.1 Watersheds

The Washington Department of Ecology has divided Washington into Water Resource Inventory Areas to delineate the state’s major watersheds. The following sections describe the WRIAs that make up Chelan County.

WRIA 45, Wenatchee River Watershed

Surface Waters

The Wenatchee Watershed (WRIA 45) is approximately 1,370 square miles, including some areas that drain directly into the Columbia River. This area includes 230 miles of major streams and rivers and associated aquatic habitat. The headwaters of WRIA 45 are the Little Wenatchee and White Rivers in the Cascade Mountain range. These rivers flow into Lake Wenatchee, the source of the Wenatchee River. The Wenatchee River discharges into the Columbia River in the City of Wenatchee. The following tributaries enter the Wenatchee River downstream of the lake, adding significant volume to the river.

- Nason Creek—Confluence at Wenatchee River Mile (RM) 53.6
- Chiwawa River—Confluence at RM 48.6
- Chiwaukum Creek—Confluence at RM 35.6
- Icicle Creek—Confluence at RM 25.6
- Chumstick Creek—Confluence at RM 23.5
- Peshastin Creek—Confluence at RM 17.9
- Mission Creek—Confluence at RM 10.4.

The Chiwawa, White and Little Wenatchee Rivers, and Nason and Icicle Creeks are the source of over 90% of the surface water in the watershed (Wentachee River Watershed Steering Committee 1996).

Climate and Stream Flows

The Wenatchee Watershed extends from snowfields, glaciers and steep, forested Cascade Mountains in the northwest, through orchards in the Wenatchee River Valley, to the shrub-steppe of the eastern watershed at the confluence of the Wenatchee and Columbia Rivers. Average annual precipitation over this drainage area varies from over 150 inches at the Cascade Crest to eight inches in Wenatchee. The climate in the watershed is hot and dry in the summer, especially in the lower elevations. The higher elevations receive, on average, between 10 and 20 feet of snow in the winter (Wentachee River Steering Committee 1998).Snowmelt is a primary source of late summer and fall stream flow. Variability in winter precipitation results in highly variable stream flow, especially in the more arid lower watershed. The different climatic zones within the watershed are important because the largest irrigation and domestic water demands occur in the drier, lower valley near Wenatchee, where stream flow can be limited some years.

Topography and Soils

The main topographic features of the Wenatchee River watershed are as follows (Chelan County, 2011):

- All or part of the Wenatchee River, Chumstick Creek, Peshastin Creek, and Icicle Creek Valleys
- Ollala, Hay, Nahahum, Warner, Warm Springs, Brender, Brisky, Tripp, Yaksum, and Fairview Canyons

The topography of the west and north is a direct result of large mountain glaciers that formed in the Icicle, Tumwater, and Chumstick Canyons. Glacial action was responsible for deepening and smoothing the valley floors. These glaciers probably terminated along the Mountain Home Road, to the southeast of Leavenworth, where there is evidence of a terminal moraine (Chelan County, 2011).

Throughout much of the area, the soil is underlain with alluvial deposits and glacial drift. Volcanic pumice and ash from the Glacier Peak region have added substantially to the depth and character of the soil in many areas. The mountainous terrain, with characteristically steep slopes and high elevations, consists largely of rock outcroppings and shallow soils (Chelan County, 2011).

Fish

The Wenatchee River and its tributaries have some of the healthiest anadromous fish runs in the Columbia River drainage and contain salmonid habitat that is important to the entire Columbia River region. However, spring Chinook in the Wenatchee Watershed have been federally listed as endangered and bull trout and steelhead have been listed as threatened under the Endangered Species Act (ESA) (listings occurred in 1998, 1999, and 2006, respectively). Core populations of sockeye salmon, steelhead, bull trout, and spring and summer Chinook salmon in the upper Wenatchee are relatively strong compared to other populations in the Columbia River basin. Anadromous salmonid populations in the Wenatchee watershed must negotiate a 468-mile journey from the mouth of the Wenatchee River to the Pacific Ocean, once as smolts and again as adults. Within the watershed, human alterations are reducing habitat quality and quantity (Andonaegui 2001).

<u>WRIA 46, Entiat River Watershed</u>

Surface Waters

The Entiat River is the major surface water source in this 418-square-mile watershed. Dozens of small creeks and streams are tributary to the river. The higher elevations in the northwest portion of the watershed receive about 90 inches of precipitation annually, most of which occurs as snow. The lowest elevations, near the town of Entiat, receive about 10 inches of precipitation. Meltwater from the snowpack supplies most of the stream flow in spring and early summer. Nearly all of the precipitation runoff and snowmelt occurs from April through July (Washington Department of Ecology 1995).

The watershed is shaped like a triangle with the Columbia River at the base and the valley rising between the Chelan and Entiat Mountains. The Entiat River begins at the terminus of the Entiat Glacier on Mt. Maude and flows approximately 50 miles into the Columbia River at the south end of the City of Entiat. The drainage is generally long and narrow, with numerous small tributaries flowing into the main river. The north fork of the Entiat River and the Mad River are the largest tributaries. These bodies of water and their tributaries provide the main source of drinking water for the area and are also important for irrigation and recreation (Chelan County, 2011).

There are no reservoirs in the Entiat watershed, although the lowest 0.5 miles of the Entiat River and floodplain is influenced by backwater effects from Lake Entiat, which is the pool for the Rocky Reach Dam Hydroelectric Facility on the Columbia River. No artificial ponds have been identified (Andonaegui 2001).

Climate and Stream Flow

Mean annual precipitation varies from 90 inches in the headwater areas near the Cascade crest to less than 10 inches along the Columbia River. Approximately 75% of the mean annual precipitation falls from October through March. Most winter precipitation falls as snow; however, rain is not unusual at some mid- and lower elevations. Cumulative snow depths range from less than 24 inches in lower elevations to nearly 400 inches in the mountains. Precipitation in July and August, the two driest months, is 5 to 10% of the annual mean. High flows in the Entiat watershed commonly result from rapid spring snowmelt, large storms (including warm rain-on-snow events), or high-intensity convective storms. High-intensity, short-duration thunderstorms in summer can result in brief but heavy downpours that occasionally produce flash floods.

Topography and Soils

Elevations in the Entiat River watershed range from just over 700 feet above sea level along the Columbia River to 9,249 feet at the summit of Mt. Fernow. Many of the soils in the area become unstable or erosive as slopes increase. Throughout much of the area, the soil is underlain with alluvial deposits and glacial drift. The geology of the Entiat area is igneous bedrock with granite and diorite predominating (Chelan County, 2011).

Most of the large-scale topographic features are the result of alpine glaciation, which significantly affected the upper half of the watershed. During the neo-glaciation period, a valley glacier nearly 25 miles long extended from its source at the headwall of the Entiat watershed to just below Potato Creek, which is marked by a terminal moraine indicating the furthest downstream influence of the glacier on channel geomorphology and bed material. Above the terminal moraine, the Entiat valley has a characteristic U-shaped appearance and is covered with glacial till. Glaciation resulted in hanging valleys and a moderately broad floodplain in the mid Entiat River that contains water-stratified silt, sand, gravel and cobbles (Chelan County Conservation District 2004)

<u>WRIA 47, Lake Chelan Watershed</u>

Surface Waters

The main surface water feature of this 1,047-square-mile watershed is Lake Chelan, the largest and deepest lake in Washington. The lake consists of two basins: the Wapato basin at the lower end of the lake is about 12 miles long and has a maximum depth of about 400 feet; the upper Lucerne basin is 38 miles long and has a maximum depth of nearly 1,500 feet. Lake Chelan is the third deepest freshwater lake in the US, even deeper than the Great Lakes (Washington State Department of Natural Resources n.d.). A shallow sill, about 130 feet deep, separates the two basins at a restriction of the lake known as The Narrows. The lake's average width is about 1.5 miles (Kendra and Singleton 1987). Lake Chelan and the Columbia River provide the main source of drinking water for the area. They are also important for irrigation and recreation (Washington Department of Ecology, 1995c; Chelan County, 2011).

Roughly 75% of the inflow to Lake Chelan comes from the Stehekin River and Railroad Creek. Smaller tributaries to the lake include Fish, Prince, Gold, First, Safety Harbor, and Twenty-Five Mile Creeks. The lake discharges to the Chelan River, which in turn discharges to the Columbia River. The outfall is controlled through a hydroelectric dam and a penstock system to the Columbia River.

There are two reservoirs in WRIA 47 with volumes of 10 acre-feet or greater. Wapato Lake, at 2,000 acre-feet, and Antilon Lake, at 1,920 acre-feet, were constructed in natural, in-channel basins enlarged to enhance irrigation storage. These reservoirs cover 338 acres.

About 10% of WRIA 47 consists of sub-basins that drain directly to the Columbia River; less than 5% of total WRIA 47 stream flow discharges from these sub-basins. Approximately 2% of WRIA 47 lies within Okanogan County,

Average annual precipitation in the Chelan watershed ranges from 150 inches per year at the crest of the Cascade Mountains to 11 inches per year in the city of Chelan. Most of the annual precipitation falls in winter as snow. As the snowpack melts in spring and early summer, it supplies most of the stream flow. In addition, some melting snow infiltrates into the soil to become groundwater, which then slowly discharges to rivers and tributary streams, providing a relatively low but constant flow the rest of the year. Precipitation that is not lost to evapotranspiration runs off steep slopes into stream channels and minor tributaries of the Stehekin River and Railroad Creek, and into minor tributaries of Lake Chelan, where they ultimately discharge out of Lake Chelan into Chelan River and finally the Columbia River.

Topography and Soils

Elevations in the Lake Chelan Watershed range from just over 700 feet above sea level along the Columbia River to 9,511 feet at the summit of Bonanza Peak, the highest point in Chelan County. Approximately 70% of WRIA 47 is above an elevation of 3,000 feet, and 47% is above 5,000 feet. The mountainous terrain, with characteristically steep slopes and high elevations, consists largely of rock outcroppings and shallow soils. The geology is characterized by underlying rock formations covered by a shallow mantle of soils in the valleys (Chelan County, 2011).

The Soil Conservation Service has classified 84% of the Lake Chelan watershed ground cover as forest. Lands below the forest level consist of grasses, sagebrush and shrubs, with the more level areas developed as crop land (Chelan County, 2011).

Many of the soils in the area become unstable or erosive as slopes increase. Throughout much of the area, the soil is underlain with alluvial deposits and glacial drift. Volcanic pumice and ash from the Glacier Peak region have added substantially to the depth and character of the soil in many areas (Chelan County, 2011).

Landforms consist of the classic U-shaped glacially-carved valleys of Lake Chelan, the Stehekin River and smaller tributaries in the higher elevation sub-basins, which are surrounded by high ridges and steep cliffs. The Stehekin Valley is a U-shaped, glacially-carved canyon above Lake Chelan that is nearly 6,000 feet deep, and a mile or less wide as it extends 25 miles from Lake Chelan to the Cascade Crest. Lower elevation sub-basins are narrower incised valleys that are tributaries to Lake Chelan and the Columbia River, bounded by rolling hills near the lake's terminus at the City of Chelan, and gravel terraces along the Columbia River.

WRIA 40, Alkali-Squilchuck (Malaga-Stemilt-Squilchuck Area)

Surface Waters

In addition to the three primary watersheds making up Chelan County, a small portion of WRIA 40 (Alkali-Squilchuck) extends into the southeastern corner of the county around Malaga. The portion of WRIA 40 in Chelan County includes the Squilchuck Creek, Stemilt Creek, and Cummings Canyon Creek watersheds. The rest of the watershed extends into Kittitas, Yakima, and Benton Counties, and includes other small creeks primarily draining directly to the Columbia River.

Squilchuck and Stemilt Creeks are tributaries to the Columbia River. The Squilchuck/Stemilt Watershed (WRIA 40A) covers 76.6 square miles, bounded by the Columbia River to the north, sub-basins of the Wenatchee and Columbia Rivers to the west, Naneum Ridge to the south, and Jump-off Ridge to the east. About 8% of WRIA 40A is in Kittitas County and the remainder is in Chelan County. This area consists of four sub-basins: Stemilt (21,430 acres); Squilchuck (17,600 acres); Malaga (8,490 acres); and Wenatchee Heights (2,200 acres).

Squilchuck Creek is 10.6 miles long with three perennial tributaries: Miners Run Creek, Lake Creek and Upper Squilchuck Creek. Numerous intermittent tributaries flow during periods of snowmelt and during high-intensity thunderstorms (USFS, 1998). About 27% of the Squilchuck Creek watershed is in public ownership ((RH2 2007).

Stemilt Creek is 12.4 miles long with four perennial tributaries: Orr Creek (also called Westerly Northwest Branch); Middle Creek (also called Easterly Northwest Branch); Little Stemilt Creek (also called Southeast Branch); and Big Stemilt Creek (also called Easterly Southeast Branch). A few springs discharge into lower Stemilt Creek. About 58% of the Stemilt Creek watershed is in public ownership (RH2 2007).

There are approximately 35 reservoirs in WRIA 40A with volumes of 10 acre-feet or greater. They cover 195 acres and provide storage of approximately 3,500 acre-feet. Eight are inactive, and all but one were constructed in natural, off-channel basins enlarged to enhance irrigation storage. Water levels in these reservoirs are largely sustained by diversions from Squilchuck and Stemilt Creeks.

Climate and Stream Flow

Average annual precipitation in WRIA 40A—ranging from eight inches in the lower elevations to 32 inches in the highest elevations—promotes shrub-steppe and sub-alpine forest vegetation, respectively. Winters are moderately cold, with snow at all elevations. Most precipitation above 3,000 feet is from snow (USFS, 1998). Summers are hot and dry. Approximately 65% of annual water flow in Squilchuck and Stemilt Creeks derives from snowmelt during April to July. Springs in the upper reaches support base flow in the creeks (RH2, 2007).

Topography and Soils

The southeast corner of Chelan County includes Pitcher Canyon, Halverson Canyon, Mission Peak, Wenatchee Heights, Jumpoff Ridge, the Malaga and Three Lakes Communities, Rock Island Dam and vicinity, and the drainage basins of Squilchuck Creek, Stemilt Creek, and Colockum Creek. The area is bordered by the Columbia River to the north and east, and by the Kittitas County boundary to the south (Chelan County, 2011).

Elevation in WRIA 40A ranges from 605 feet at the Columbia River to 6,887 feet at Mission Peak. Dominant landforms consist of high ridges and steep slopes that surround large basins, knobs and depressions, deeply incised channels, gravel terraces, and the Wenatchee Heights mesa.

12.3.2 Location

Chelan County has significant floodplains along the Columbia, Wenatchee, White, Entiat, Chiwawa, and Stehekin Rivers, and Nason, Chumstick, Icicle, Peshastin, Mission, and Squilchuck Creeks. There are other unmapped flood hazard areas throughout the County. The hazard areas range from urban settings around the cities of Wenatchee, Cashmere, and Leavenworth to rural areas along the White River and smaller streams.

No. 1 Canyon, No. 2 Canyon, and Dry Gulch are each located on the western edge of the City of Wenatchee. The upper basins of these drainages are largely undeveloped and remain vegetated with native plant species. Development has occurred along the eastern fringes where the canyons discharge runoff into the city. These interface zones have experienced flash flooding problems in recent years due to a variety of issues, such as lack of appropriately sized drainage channels, the alteration of drainage channels, development adjacent to the channels, and wildfires. As drainage flows from the county through the city and ultimately is discharged into the Columbia River, new channels can be cut by the flows when current conveyance capacities are exceeded. Outside of those areas immediately adjacent to the city, conveyance systems within the county predominantly consist of open ditches and culverts (Chelan County, 2011).

Flooding is one of the most common natural hazards in Chelan County. Steep drainage areas and populated low-lying areas typical of the County present a geography that will continually be subject to flooding problems. Historically, Chelan County has had regular occurrences of flash flooding. Due to the County's topography and climate, stage and flash flooding will continue to be a threat in most parts of the county.

The Columbia River, Wenatchee River, Entiat River, Stehekin River, and other perennial streams in Chelan County follow an annual cycle with peak streamflow in April and May and low streamflow in August and September. Normally, streamflow in many of the smaller drainages are intermittent seasonally, while drainages in lower elevations are often dry. Hazardous areas found along stream courses for most types of residential or recreational development include those areas within the floodplain (100-year flood event) and floodway boundaries. Reoccurring problem areas for flash flooding include Slide Ridge in the Chelan area and No. 1 and No. 2 Canyons in the Wenatchee area. Stage flooding problem areas are in Mission Creek, the area where the Icicle and Wenatchee Rivers meet in Leavenworth, the headwaters of the Wenatchee River, and the confluence area of the Wenatchee River.

The threat of flash flooding is increased in an area that has suffered from a major wildfire. Not only is there a greater amount of loose debris, most of the ground cover has been burnt away. Without ground cover, more soil and debris will be allowed to flow, increasing the chance of debris dams. Major wildfires have occurred recently in Chelan County, and flash floods and mud flows have occurred following these events.

Figure 12-2. FEMA Floodplain Boundaries

12.3.3 Extent

The principal factors affecting flood damage are flood depth and velocity. The deeper and faster flood flows become, the more damage they 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; Table 12-3 lists peak flows used by FEMA to map the floodplains of the planning area.

Flash flooding has caused deaths in the area and is a threat to populated areas. For example, the City of Wenatchee, with a population nearing 30,000, is located on an alluvial fan below the mouths of three canyons (No. 1 Canyon, No. 2 Canyon, and Dry Gulch). A severe thunderstorm or rapid snowmelt can quickly lead to extensive damage and possible fatalities.

Table 12-3. Summary of Peak Discharges (Anticipated Velocity) Within the Planning Area

	Drainage	Discharge (cubic feet/second)			
Source/Location	**Area (sq. mi.)**	**10-Year**	**50-Year**	**100-Year**	**500-Year**
Wenatchee River					
At Monitor Gage	1,301	26,500	38,500	48,700	82,000
At Dryden Gage	1,155	25,700	36,863	46,372	78,289
At Peshastin Gage	1,000	24,300	34,000	42,300	71,800
At South Line S34, T26N, R17E	606	17,600	21,500	23,000	26,000
At Plain Gage	591	17,500	26,500	34,100	62,800
At Lake Gage	273	10,000	12,100	13,000	14,800
Mission Creek[a]					
At southern city limits of Cashmere	93	513	854	1025	1495
Peshastin Creek					
At Mouth	143	1,980	3,210	3,790	5,130
Icicle Creek					
At Mouth	213	7,930	11,000	12,360	15,650
Chumstick Creek					
At Mouth	82	900	1,430	1,720	2,810
At Eagle Creek Road	50	560	900	1,200	1,820
At Cross Section AP	41	470	760	930	1,520
At Sunistich Canyon Road	30	400	640	770	1,250
Chiwawa River					
At Mouth	190	4,900	6,500	7,200	8,800
Nason Creek					
At Kahler Creek Bridge	98.6	4,270	5,860	6,590	8,250
Above Kahler Creek Confluence	91.2	3,990	5,490	6,170	7,720
Below Butcher Creek Confluence	87.5	3,850	5,290	5,960	7,460
Below Roaring Creek Confluence	76.3	3,430	4,720	5,320	6,670
Above Gill Creek Confluence	70.8	3,220	4,440	5,000	6,260

At Merritt	67.5	3,090	4,270	4,810	6,020
At Burlington Northern Railroad Bridge	64.2	2,960	4,090	4,610	5,780
Entiat River					
At Mouth	419	6,000	8,000	8,900	11,000
At Fish Hatcher Road	343	5,600	7,500	8,300	10,500
At Mad River Road	251	5,100	6,700	7,400	9,200
At Cross Section CJ	203	4,700	6,200	6,900	8,400
Mad River[a]					
At Mouth	91	932	1135	1215	1388
Stehekin River					
At Mouth	344	14,400	17,900	19,200	22,100
At Cross Section J	308	13,200	16,500	17,700	20,300
At Cross Section U	277	12,200	15,200	16,300	18,800
Squilchuck Creek[a]					
At Mouth	28	307	696	922	1640
Mid-Creek	18	200	696	922	1640
Upper Creek	14	153	297	372	592
No. 1 Canyon[a]					
At Mouth	8	260	1060	1700	4500
No. 2 Canyon[a]					
At Mouth	10	340	1360	2200	5800
Dry Gulch[a]					
At Mouth	2	60	250	410	1100

[a] Updated data used to develop April 2024 draft maps used for the risk assessment.
Data Source: FEMA Flood Insurance Study for Chelan County, WA; September 30, 2004 Hydrology Report

12.3.4 Previous Occurrences

Presidential disaster declarations are typically issued for hazard events that cause more damage than state and local 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 and public entities. Some of the programs are matched by state programs. Chelan County has experienced eight flood events and 32 fire events since 1972 for which presidential disaster declarations were issued, as summarized in Table 12-4. The fire events are relevant to flood history in relation to post-fire flooding, as described in Section 12.1.7. Review of these events helps identify targets for risk reduction and ways to increase a community's capability to avoid large-scale future events. Still, many flood events do not trigger federal disaster declarations, but have significant impacts on the communities impacted. These events are also important to consider in establishing recurrence intervals for flooding. The following sections provide an overview of some of the more significant floods in the county.

Table 12-4. History of Chelan County Flood and Fire Events with Presidential Disaster Declarations

Disaster #	Event Dates	Declaration Date	Description
DR-4650-WA	12/26/2021-1/15/2022	3/29/2022	Severe winter storms, snowstorms, straight-line winds, flooding
DR-4249	11/12/2015 – 11/21/2015	1/15/2016	Severe storms, straight-line winds, flooding, landslides, mudslides
DR-1817-WA	1/6/2009 – 1/16/2009	1/30/2009	Severe winter storm, landslides, mudslides, and flooding
DR-1671-WA	11/2/2006 – 11/11/2006	12/12/2006	Severe storms, flooding, landslides, and mudslides
DR-1499-WA	10/15/2003 – 10/23/2003	11/7/2003	Severe storms and flooding
DR-1159-WA	12/26/1996 – 2/10/1997	1/17/1997	Severe winter storms, land and mudslides, flooding
DR-1079-WA	11/7/1995 – 12/18/1995	1/3/1996	Severe storms, high wind, and flooding
DR-883-WA	11/9/1990 – 12/20/1990	11/26/1990	Severe storms and flooding
DR-334-WA	6/10/1972	6/10/1972	Severe storms and flooding

Source: (FEMA 2024)

Historical Stage Flooding Events

Stage flooding events have been the most common type of recorded flood events to occur within the County in the past 25 years. Episodes in 1990 and 1995 far exceeded the predicted 100-year flood events. These floods have caused extensive damage along the Wenatchee River and Icicle Creek drainages; however, no fatalities have been recorded as a result of stage flooding in Chelan County. In October 2003, substantial flooding occurred in the Stehekin River, destroying public and private property and infrastructure. The following are notable stage flooding events in Chelan County (Chelan County, 2011):

- May/June 1948—Snowmelt flooding broke lake and river records countywide.
- May/June 1972—Snowmelt flooding combined with heavy rains affected rivers countywide, particularly the Entiat River.
- November 1990—Severe storms and flooding occurred during Veteran's Day and Thanksgiving weekend countywide, particularly along the Wenatchee River.
- November/December 1995—Extensive rains caused record-setting flood stages countywide, particularly in the Wenatchee River.
- December 1996/January 1997—Saturated ground combined with snow, freezing rain, rain, rapid warming and high winds within a five-day period combined to cause flooding.
- October 2003—A rain-on-snow event in the upper Cascades caused a flood-of-record in the Stehekin River.
- May 2006—Rapid spring thaw caused flooding in the Entiat River, Chatter Creek and Icicle Creek.
- November 2006—A rain-on-snow event caused extensive flooding in the Stehekin River and limited flooding in Icicle Creek.

- January 2009—A rain-on-snow event caused limited flooding in the Mad River, Mill Creek, and Icicle Creek, particularly in the Leavenworth area.

Historical Flash Flooding Events

The following flash flood events in Chelan County have resulted in fatalities:

- 1925, Squilchuck Creek—16 fatalities
- 1942, Tenas Gorge—8 fatalities
- 1972, Preston Creek/Entiat River—4 fatalities.

Disaster and Emergency Declarations

The following summarizes disaster declarations or emergency proclamations related to the flood hazard.

- Federal DR or EM Declaration, 1953-2023: 7 events classified as flood

12.3.5 Overall Probability

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% 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 an event over a large area.

The Columbia River, Wenatchee River, Entiat River, Stehekin River, and other perennial streams in Chelan County follow an annual cycle, with peak flow in April and May and low flow in August and September. Normally, flow in many of the smaller drainages is seasonally intermittent, with drainages in lower elevations often dry. Primary flood seasons in Chelan County are during the spring snowmelt (March to June) and from November to February, when rain-on-snow events have produced historic floods (Chelan County, 2011). Flash flooding can also occur in summer following severe thunder storms and intense rainfall.

Recent history has shown that Chelan County can expect an average of one episode of minor river flooding each winter. Large, damaging floods typically occur every two to five years. Urban portions of the county annually experience nuisance flooding related to drainage issues.

Primary flood season in Chelan County occurs during the spring snowmelt (March to June) and again November to February when rain-on-snow events have produced historic floods. Windstorm season is typically October through March, and snow season runs October through March, although higher elevations will see snow ten months of the year.

The primary cause of flash flooding which can occur in any drainage area in the county is high intensity rainfall. Although infrequent, and usually of short duration, high intensity rain fall has been seen in all seasons in the past and particularly in July and August. Based on historic frequency and future conditions, the probability of future flood occurrences is one flood event each year.

12.3.6 Warning Time

Flood Timing With Rainfall Events

Due to the sequential pattern of meteorological conditions needed to cause serious flooding, it is unusual for a flood to occur without warning. Warning times for riverine 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.

A hydrograph, which is a graph or chart illustrating stream flow in relation to time (see Figure 12-3), is a useful tool for examining a stream's response to rainfall. Once rain starts falling over a watershed, runoff begins and the stream begins to rise. Water depth in the stream (stage of flow) will continue to rise in response to runoff even after rainfall ends. Eventually, the runoff will reach a peak and the stage of flow will crest. The stream stage will remain the most stable at this point, exhibiting little change over time until it begins to fall and eventually subsides to a level below flooding stage.

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 Recognition Systems

The Chelan County flood threat recognition system consists, in part, of precipitation and U.S. Geological Survey stream gages at strategic locations in the county that constantly monitor and report rainfall and stream levels. To assess the flood threat along the major rivers in the county, the stream gage information is fed into a National Weather Service (NWS) river forecasting program. See Figure 12-3 for the Wenatchee River at Peshastin hydrograph. This program creates a forecast of the amount of flow expected in the stream for the next 10 days (measured in cubic feet per second), which can then be compared to the flood stages at those locations. For locations that do not have stream gages or river forecasts, the NWS also provides Doppler radar data and weather/flood forecast information that can determine other types of flood risk across the county, such as flash flooding, small stream flooding, etc. All of this information is analyzed to evaluate the flood threat and possible evacuation needs.

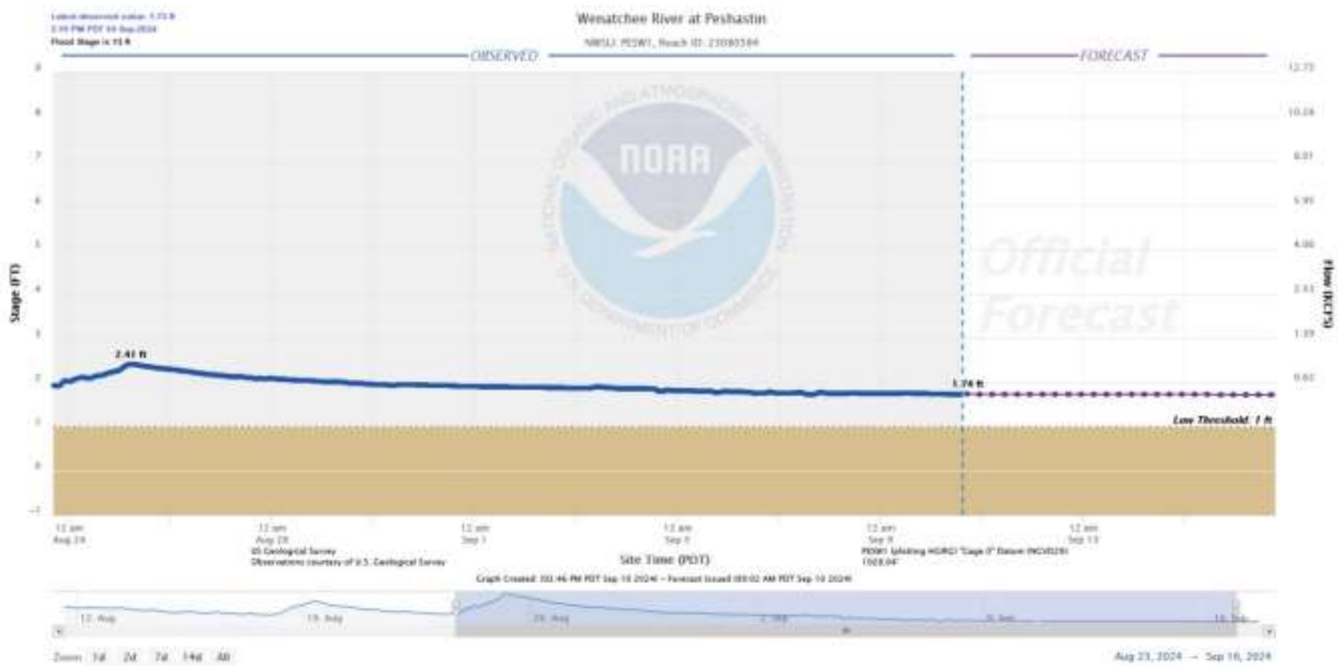


Figure 12-3. Wenatchee River Hydrograph at Peshastin

Flood Watches and Warnings

The NWS issues flood watches and warnings when forecasts indicate rivers may approach bank-full levels or when other types of localized flooding are possible. When a flood watch is issued, the public should prepare for the possibility of a flood. When a flood 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 flood warning means a flood is imminent, generally within 12 hours, or is occurring. Local media typically broadcast NWS watches and warnings; they can also be found online. If a flash flood warning is issued, which indicates that sudden or violent flooding is imminent or occurring, the Emergency Alert Service will alarm on NOAA weather radios and cut into local media broadcasts. Flash flood warnings will also trigger wireless emergency alerts on smart phones. Official thresholds for flood warnings have been established on the major rivers within Chelan County as follows:

- Wenatchee River—Action phase at 12 feet, flood stage at 13 feet at Peshastin.
- Entiat River—Action phase at 6 feet, flood Stage at 7.5 feet at Ardenvoir.
- Stehekin River— Action Phase at 22 feet, flood stage at 23 feet at Stehekin.

There are several more stream gages across the county for areas that do not currently have river forecasts or predetermined flood stages. These gages are monitored for situational awareness during flood events.

Rain Gages

Chelan County Flood Control Zone District has purchased and installed a series of rain gages, in cooperation with the county’s Natural Resource Department, the U.S. Forest Service, the U.S. Geologic Service, the Natural Resource Conservation Service and the Cascadia Conservation District. These rain gages collect and measure precipitation to provide an early alert system to the community when a potentially high-intensity storm is in the area. Selection of rain gage locations was based upon factors such as historical flooding, high-burn-severity areas and population centers. Seven rain gages are located along ridgelines throughout Chelan County in order to transmit precipitation data to the NWS between from April through November. When a gage receives heavy rainfall over a 10-minute period, the NWS begins to monitor the gage. If warranted, the NWS will issue a watch or warning based on the precipitation information received.

Doppler Radar Gap

The NWS uses five active Doppler radars (Spokane, Pendleton, Langley Hill (Grays Harbor), Camano Island (Seattle), and Portland) to monitor real-time weather conditions in Washington, identify hazardous weather conditions, and predict weather. None of the five radars have coverage of weather conditions below 10,000 feet on the northeastern slopes of the Cascades, leaving a gap in coverage along the eastern slopes of the Cascades and part of the Columbia Basin from the Canadian border in Okanogan County to around Yakima (see Figure 12-4). This gap in coverage creates a less reliable weather prediction system for the area, thus creating a vulnerability or uncertainty for local residents, businesses, and industries.

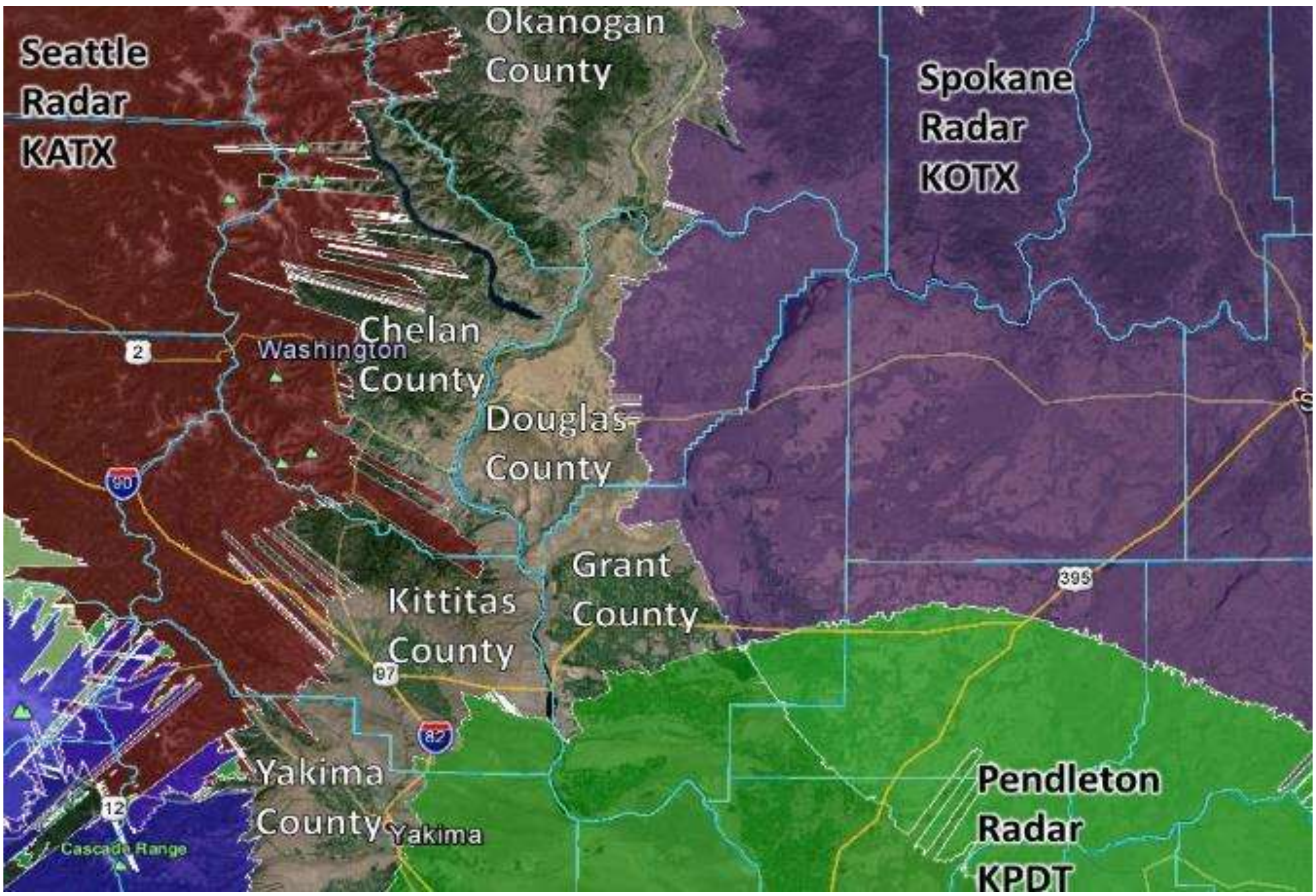


Figure 12-4. Doppler Radar Gap for East Cascades

12.3.7 Climate Change Impacts

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. Scientists project greater storm intensity with climate change, resulting in more direct runoff and flooding. High frequency flood events in particular will likely increase with a changing climate. What is currently considered a 1%-annual-chance also may strike more often, leaving many communities at greater risk. Going forward, model calibration 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 areas to contribute to peak storm runoff. 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.

12.3.8 Future Trends in Development

A growing population may increase the number of people and infrastructure exposed to flood risks, leading to potential health hazards, displacement, and in rare cases, loss of life. Changes in land use may harm ecosystems that help regulate flooding, such as wetlands. As areas in Chelan County continue to develop, there is an increase in impervious surfaces such as roads, buildings, and pavement which reduce natural infiltration and increase runoff, leading to a higher flood risk during heavy rainfall events. In addition, development in the floodplain may also reduce natural water storage areas and impact ecosystems that play a vital role in absorbing and storing excess water during heavy rainfall. However, through effective planning, resilient infrastructure, and updated floodplain management, the adverse impacts of flooding can be minimized.

The County’s and cities’ comprehensive plans have adopted goals, objectives, policies, and actions with regards to frequently flooded areas. These plan components strive to steer future trends in development away from increasing flood risks in Chelan County. The County and cities critical areas regulations regulate how development and redevelopment can safely occur on lands that contain critical areas. Additionally, Chelan County and its cities participate in the NFIP and have adopted flood damage prevention ordinances in response to its requirements. Chelan County has committed to maintaining its good standing under the NFIP through actions identified in this plan.

12.4 SECONDARY HAZARDS

The most problematic secondary hazard for stage flooding is bank erosion, which in some cases can be more harmful than actual flooding. This is especially true in the upper courses of rivers with steep gradients, where floodwaters may pass quickly and without much damage, but scour the banks, edging properties closer to flood hazard areas or causing them to fall in. Flooding is also responsible for hazards such as landslides when high flows over-saturate soils on steep slopes, causing them to fail. Hazardous materials spills are also a secondary hazard of flooding if storage tanks rupture and spill into streams, rivers, or storm sewers.

Within the planning area, the potential for erosion is most concerning following wildfires. Runoff from steep slopes that have been baked and denatured by wildfires increases velocities in channels. This accelerates erosion rates and results in large volumes of sediment being carried downstream. As stream velocities deaccelerate, the sediments fall out and decrease the carrying capacities of the channel, which causes overbank flows and can lead to channel migration. Channel migration is especially a concern for the numerous, developed alluvial fans within the planning area. Additionally, this sediment can be conveyed over land and deposited on developed lands such as roads and public/private property.

12.5 VULNERABILITY

The Level 2 (user-defined) Hazus protocol was used to assess vulnerability to flooding in the planning area. The model used census data at the block level, FEMA floodplain data, and FEMA developed depth grids. The 100-year and 500-year floodplain areas used for the risk assessment are based upon the FEMA's 2024 Draft Maps, released in April 2024.

12.5.1 People

Population counts of those living in the 100- and 500-year floodplains were generated by analyzing structures in the floodplain. The total planning area population was multiplied by the ratio of the number of residential structures in each floodplain to the total number of residential structures.

Using this approach, the populations in each floodplain were estimated as follows:

- 100-year floodplain—3,246 (4.0% of the planning area population)
- 500-year floodplain—25,826 (31.7% of the planning area population)

12.5.2 Structures

Buildings and Facilities

An estimated 3.6% ($904.5 million) of the total replacement value of the planning area is in the 100-year floodplain and 26.6% ($6.6 billion) is located in the 500-year floodplain. The significant increase between 100-year and 500-year is because most of the City of Wenatchee is in the 500-year floodplain. Table 12-5 show the percentage and count, by occupancy type, of vulnerable planning area structures. Roughly 50% of the vulnerable buildings and facilities are in Wenatchee. The distribution of unincorporated land area in the floodplains by land use category is shown in Table 12-6.

Table 12-5. Structures in the 100- and 500-Year Floodplain, by Occupancy Type

Structure Occupancy Types	100-Year Floodplain	500-Year Floodplain	Total Structures in Floodplain
Commercial	427	1,917	1917
Industrial	10	53	63
Agriculture	9	36	45
Religion	4	23	27

Residential	1,165	6,920	8,085
Government	10	42	52
Education	0	34	34
TOTAL	1,625	8,598	10,223

Table 12-6. Acres in the 100- and 500-Year Floodplain, by Zoning Category

Unincorporated Zoning	100-Year(acres)	500-Year (additional acres)
Commercial	121	38
Industrial	284	35
Public	424	30
Resource	4,417	170
Rural Residential	19,683	1,177
Urban Residential	344	327

Community Lifelines, Critical Facilities, and Infrastructure

Critical facilities and community lifelines vulnerable to the flood hazard represent 11% (52 facilities) of the total community lifelines in the planning area for the 100-year floodplain and 25% (117 facilities) for the 500-year floodplain. The breakdown of exposure by facility type is shown in Table 12-7.

Hazardous Material Facilities

Hazardous material facilities are those that use or store materials that can harm the environment if damaged by a flood. For this assessment, such facilities were identified through the EPA's Toxic Release Inventory (TRI) and other facilities identified by the planning team. One business in the 500-year floodplain has been identified as TRI reporting facilities or other known hazardous material containing facilities. During a flood event, containers holding these materials can rupture and leak into the surrounding area, having a disastrous effect on the environment as well as residents.

Table 12-7. Critical Facilities and Infrastructure in Mapped Flood Hazard Areas

	100-Year Floodplain	500-Year Floodplain	Floodplain Total	Planning Area Total
Communications	1	16	17	53
Energy	2	1	3	9
Food Hydration, Shelter	0	7	7	26
Hazardous Materials	0	1	1	8
Health and Medical	4	11	15	35
Safety and Security	2	24	26	86
Transportation	36	5	41	225
Water Systems	7	0	7	14

12.5.3 Systems

Essential systems, networks, and capabilities such as emergency response systems, economic stability, and planning capabilities are vulnerable to the flooding hazards. Roads or railroads that are blocked or damaged can isolate residents and can prevent access throughout the planning area. Preserving access is particularly important for emergency service providers needing to get to vulnerable populations or to make repairs. Bridges washed out or blocked by floods or debris also can cause isolation. Underground utilities can be damaged. Dikes and levees can fail or be overtopped, inundating the land that they protect.

The following major roads in the planning area pass through the 100-year and/or 500-year floodplain and thus are exposed to flooding. Some of these roads are built above the flood level, and others function as levees to keep the rivers and creeks within their channels. Still, in severe flood events these roads can be blocked or damaged, preventing access to some areas:

- U.S. Highway 2
- U.S. Highway 97
- U.S. Highway 97 Alternate
- State Route 150
- State Route 207
- State Route 285
- State Route 971

Flooding events can also significantly impact bridges, which provide the only ingress and egress to some neighborhoods. There are 36 bridges that are in or cross over the 100-year floodplain and 40 bridges that are in or cross over the 500-year floodplain in the planning area.

Water and sewer systems can be affected by flooding. Floodwaters can back up drainage systems, causing localized flooding. Culverts can be blocked by debris from flood events, also causing localized urban flooding. Floodwaters can get into drinking water supplies, causing contamination. Sewer systems can be backed up, causing wastewater to spill into homes, neighborhoods, rivers, and streams.

12.5.4 Natural, Historic, and Cultural Resources

Natural, historic, and cultural resources that are in areas with flood risk and very vulnerable to flooding. Many species of mammals, birds, reptiles, amphibians, and fish live in Chelan County in floodplain ecosystems. Watercourses and water bodies in Chelan County have historic and cultural significance. They supported villages of the many bands of the Wenatchi people, whose main focus was fishing, and provided transportation routes for trading, hunting, and gathering. Summer and winter villages were located throughout Chelan County. One of the largest summer villages was at the mouth of the Icicle Creek. This village could support several thousand people during the peak salmon fishing season.

12.5.5 Activities that Have Value to the Community

Much of Chelan's recreation industry and economy is focused on water, attracting water users to the many recreational opportunities, including boating, fishing, rafting, swimming, water sports, hiking, camping, and viewing. All water-based recreation is vulnerable to flooding.

12.5.6 Agriculture

Floodplains are often well suited for agricultural production because of the quality and fertility of the soil's floodplains can provide. Agricultural uses of floodplains are encouraged because it limits the density of development exposed to the flood risk. Therefore, much of the agriculture land near watercourses or in river valleys is vulnerable to flooding.

12.6 IMPACTS

Many areas vulnerable to flooding may not experience serious flooding or flood damage impacts. Vulnerability can be defined as: the extent of harm, which can be expected under certain conditions of exposure, susceptibility and resilience (UNESCO-IHE, 2016). Defining impacts can help flood hazard managers understand the best ways to reduce it. The main objective in assessing impacts is to inform decision-makers or specific stakeholders about options for adapting to the impact of flooding hazards. This section summarizes impacts in terms of people, structures, systems, natural, historic, and cultural resources, activities that have value to the community, and agriculture. Detailed risk assessment results are provided in Appendix C.

12.6.1 People

Displaced Persons and Vulnerable Populations

The Hazus analysis of impacts on persons and households in the planning area estimated that 805 people in the 100-year floodplain and 18,419 people in the 500-year floodplain could be displaced by flood events. Those who have trouble evacuating, especially if waters rise suddenly without much warning, are most vulnerable. This includes those with access and functional needs, the elderly, and the very young.

In addition, economically disadvantaged populations whose houses are impacted by flood events may not have the means to make repairs, especially if they do not have homeowners or renters flood insurance. A geographic analysis of demographics using the Hazus model identified populations vulnerable to the flood hazard as follows:

- **Economically Disadvantaged Populations**—An estimated 16.3% of the people within the households in the census blocks that intersect the 100-year floodplain are economically disadvantaged, defined as having annual household incomes of $20,000 or less.
- **Population over 65 Years of Age**—An estimated 20.5% of the population in the census blocks that intersect the 100-year floodplain are over 65 years of age. Approximately 28% of the over-65 population in the floodplain also have incomes considered to be economically disadvantaged and are considered to be extremely vulnerable.
- **Population under 16 Years of Age**—An estimated 23.1% of the population within census blocks that intersect the 100-year floodplain are under 16 years of age.

In addition, persons with disabilities or others with access and functional needs are more likely to have difficulty responding to a flood or other hazard event than the general population. Local government is the first level of response to assist these individuals. Coordination of efforts to meet their access and functional needs is paramount to life safety efforts. It is important for emergency managers to distinguish between functional and medical needs in order to plan for incidents that require evacuation and sheltering. Knowing the percentage of population with a disability allows emergency management personnel and first responders to have personnel available who can provide services needed by those with access and functional needs. According to Social Vulnerability Index (SVI) estimates, there are 14,033 individuals in Chelan County with some form of disability, representing 17.9% of the county population (Social Vulnerability Index (SVI) 2022).

In addition, approximately 10.9% (15,729 individuals) are over the age of 65 and 3.1% of households do not have a vehicle (Social Vulnerability Index (SVI) 2022).).

Public Health and Safety

Floods present threats to public health and safety. Floodwater is frequently contaminated by pollutants such as sewage, human and animal feces, pesticides and insecticides, fertilizers, oil, asbestos, and rusting building materials. The following health and safety risks are commonly associated with flood events:

- **Unsafe food**—Floodwaters contain disease-causing bacteria, dirt, oil, human and animal waste, and farm and industrial chemicals. Their contact with food items, including food crops in agricultural lands, can make that food unsafe to eat. Refrigerated and frozen foods are affected during power outages caused by flooding. Foods in cardboard, plastic bags, jars, bottles, and paper packaging may be unhygienic with mold contamination.
- **Contaminated drinking and washing water and poor sanitation**—Flooding impairs clean water sources with pollutants. The pollutants also saturate into the groundwater. Flooded wastewater treatment plants can be overloaded, resulting in backflows of raw sewage. Private wells can be contaminated by floodwaters. Private sewage disposal systems can become a cause of infection if they or overflow.
- **Mosquitoes and animals**—Floods provide new breeding grounds for mosquitoes in wet areas and stagnant pools. The public should dispose of dead animals that can carry viruses and diseases only in accordance with guidelines issued by local animal control authorities. Leptospirosis—a bacterial disease associated predominantly with rats—often accompanies floods in developing countries, although the risk is low in industrialized regions unless cuts or wounds have direct contact with disease-contaminated floodwaters or animals.
- **Mold and mildew**—Excessive exposure to mold and mildew can cause flood victims—especially those with allergies and asthma—to contract upper respiratory diseases, triggering cold-like symptoms. Molds grow in as short a period as 24 to 48 hours in wet and damp areas of buildings and homes that have not been cleaned after flooding, such as water-infiltrated walls, floors, carpets, toilets and bathrooms. Very small mold spores can be easily inhaled by human bodies and, in large enough quantities, cause allergic reactions, asthma episodes, and other respiratory problems. Infants, children, elderly people, and pregnant women are considered most vulnerable to mold-induced health problems.
- **Carbon monoxide poisoning**—In the event of power outages following floods, some people use alternative fuels for heating or cooking in enclosed or partly enclosed spaces, such as small gasoline engines, stoves, generators, lanterns, gas ranges, charcoal or wood. Built-up carbon monoxide from these sources can poison people and animals.
- **Hazards when reentering and cleaning flooded homes and buildings**—Flooded buildings can pose significant health hazards to people entering them. Electrical power systems can become hazardous. Gas leaks can trigger fire and explosion. Flood debris—such as broken bottles, wood, stones and walls—may cause injuries to those cleaning damaged buildings. Containers of hazardous chemicals may be buried under flood debris. Hazardous dust and mold can circulate through a building and be inhaled by those engaged in cleanup and restoration.
- **Mental stress and fatigue**—People who live through a devastating flood can experience long-term psychological impact. The expense and effort required to repair flood-damaged homes places severe financial and psychological burdens on the people affected. Post-flood recovery can cause, anxiety, anger, depression, lethargy, hyperactivity, and sleeplessness. There is also a long-term concern among the affected that their homes can be flooded again in the future.

Current loss estimation models such as Hazus are not equipped to measure public health impacts. The best level of mitigation for these impacts is to be aware that they can occur, educate the public on prevention, and be prepared to deal with these vulnerabilities in responding to flood events.

12.6.2 Structures

Loss Estimates

Table 12-8 summarizes Hazus estimates of flood damage in the planning area. The debris estimate includes only structural debris and building finishes; it does not include additional debris that may result from a flood event, such as from trees, sediment, building contents, bridges, or utility lines. The 15,000 tons of estimated debris from a 1%-annual-chance flood event is enough to fill 600 25-ton trucks.

Table 12-8. Estimated Impact of a Flood Event in the Planning Area

Damage Type	100-Year Flood	500-Year Flood
Structure Debris (Tons)	2,622	26,477
Buildings Impacted	560	3,636
Total Value (Structure + Contents) Damaged	$41 million	$626 million
Damage as % of Total Value	0.2%	2.5%

Repetitive Loss Properties

A repetitive loss property is defined by FEMA as an NFIP-insured property that has experienced any of the following since 1978, regardless of any changes in ownership:

- Four or more paid losses in excess of $1,000
- Two paid losses in excess of $1,000 within any rolling 10-year period
- Three or more paid losses that equal or exceed the current value of the insured property.

Repetitive loss properties make up only 1 to 2% of flood insurance policies in force nationally, yet they account for 40% of the nation's flood insurance claim payments. In 1998, FEMA reported that the NFIP's 75,000 repetitive loss structures had already cost $2.8 billion in flood insurance payments and that numerous other flood-prone structures remain in the floodplain at high risk. The government has instituted programs encouraging communities to identify and mitigate the causes of repetitive losses. A report on repetitive losses by the National Wildlife Federation (1998) found that 20% of these properties are located outside of the mapped 100-year floodplain. The key identifiers for repetitive loss properties are the existence of flood insurance policies and claims paid by the policies.

FEMA-sponsored programs, such as the CRS, require participating communities to identify repetitive loss areas. A repetitive loss area is the portion of a floodplain holding structures that FEMA has identified as meeting the definition of repetitive loss. Identifying repetitive loss areas helps to identify structures that are at risk but are not on FEMA's list of repetitive loss structures because no flood insurance policy was in force at the time of loss. FEMA's list of repetitive loss properties identifies six such properties in the planning area as of December 31, 2015. The breakdown of the properties by jurisdiction is shown in Table 12-9Table .

Table 12-9. Repetitive Loss Properties in Chelan County

	Total Repetitive Loss Properties	Properties That Have Been Mitigated	Unmitigated Residential	Unmitigated Non-residential	SFHA	Zone X

Wenatchee	2	1	1	0	1	0
Leavenworth	0	0	0	0	0	0
Entiat	0	0	0	0	0	0
Cashmere	0	0	0	0	0	0
Chelan	0	0	0	0	0	0
Unincorporated County	7	2	4	1	4	2
Total	**8**	**2**	**5**	**1**	**5**	**1**

Based on FEMA Report of Repetitive Losses, 7/24/2023

A further review of the repetitive loss data found that all dates of repetitive losses coincide with dates of known flooding in the County. Additionally, almost all of the identified properties are within a FEMA designated special flood hazard area (SFHA). This indicates that the overall cause of repetitive flooding is the same as has been profiled in this plan and is covered by available mapping. With the potential for flood events every two to five years, Chelan County considers all of the mapped floodplain areas as susceptible to repetitive flooding. These areas are subject to provisions of flood damage prevention ordinances in effect within Chelan County.

There are six repetitive loss properties in Chelan County that have had 11 losses (there may have been more but the six are the ones listed by FEMA as not having been mitigated, i.e., if there are others, they were mitigated and are no longer repetitive loss properties).

- Single-family residence in Monitor area (lower Wenatchee River). Losses occurred 11/27/95 and 11/22/90. Total losses for both floods were just over $29,600 for the building.
- Single-family residence near Chelan. Losses occurred 12/1/95 and 11/25/90. Total losses for both floods were just over $23,725 for the building.
- Single-family residence near Lake Wenatchee (Nason Creek). Losses occurred 11/30/95 and 11/24/90. Total losses for both floods were about $59,700 for building and $3,290 for contents.
- Nonresidential structure near Cashmere. Losses occurred 2/9/96 and 5/28/93. Total losses for both floods were about $32,270 for building and $56,300 for contents.
- Single-family residence near Leavenworth (Icicle Creek). Losses occurred 11/11/06, 5/18/06, and 11/29/95. Total losses for the three floods were about $22,400 for building and $35,560 for contents.
- Single-family residence in Stehekin. Losses occurred 5/15/2001, 7/16/99, 6/10/97, and 6/11/96. Total losses for the four floods were about $40,844 for building and $9,142 for contents.

There are no severe repetitive loss properties in Chelan County.

Critical Facilities and Community Lifelines

Hazus assesses the potential damage to community lifelines from flooding using depth/damage function curves. Based on historical averages, these curves indicate potential damage amounts as a percentage of the value of structures or contents. Actual damage to facilities may be less than these conservative estimates. For critical buildings, Hazus also estimates functional down-time, which is the time it might take to restore a facility to 100% of its functionality after flood damage occurs. Results for the 100-year and 500-year flood events are summarized in Table 12-10 and Table 12-11.

Table 12-10. Estimated Damage to Community Lifelines from 100-Year Flood

	Number of Facilities Affected	% of Total Value Damaged (Each Facility)
Energy	2	18%
Safety and Security	1	6%
Water Systems	7	.07%-65%

Table 12-11. Estimated Damage to Community Lifelines from 500-Year Event

	Number of Facilities Affected	% of Total Value Damaged (Each Facility)
Communications	6	11%-31%
Energy	2	15%-21%
Food Hydration, Shelter	3	12%-29%
Health and Medical	5	.9%-42%
Safety and Security	15	.05%-12%
Transportation	3	31%
Water Systems	6	.05%-65%

12.6.3 Systems

Systems, networks, and capabilities can be impacted by flooding in Chelan County in a variety of ways. An extreme flood event may stress emergency response, public works, and other government services with high demands for response and recovery. Floods block access routes and delay rescue or medical aide access to impacted areas. Flooding can impact local economy through flood damage and closure of businesses, which will directly impact employment in the community.

Significant financial resources are often needed to recover from flood events. Applying for, receiving, and managing the necessary public assistance and grant funding to effectively recover will require a greater capacity from local government, including public works. In addition, the planning and permitting departments in Chelan County may be impacted in their ability to function if records, personnel, or offices are impacted by the flood event. Permitting staff may also be stressed by the needs to perform post-disaster inspections, identify substantially damaged structures, and issue permits for repairs.

12.6.4 Natural, Historic, and Cultural Resources

Flooding is a natural event and floodplains provide natural and beneficial functions. Still, flooding can impact the natural environment in negative ways, especially when compounded with impacts from human development. Migrating fish can wash into roads or into flooded fields. Pollution from roads, such as oil, and hazardous materials can wash into rivers and streams. During floods these pollutants 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.

Many species of mammals, birds, reptiles, amphibians, and fish live in Chelan County in ecosystems that are dependent upon streams, wetlands and floodplains. Changes in hydrologic conditions can result in a change in the biodiversity of the ecosystem. Wildlife and fish are impacted when plant communities are eliminated or fundamentally altered to reduce suitable habitat. Wildlife populations are limited by shelter, space, food, and water. Since water supply is a major limiting factor for many animals, riparian communities are of special importance. Riparian areas are the zones along the edge of a river or stream that are influenced by or are an influence upon the water body. Human disturbance to riparian areas can limit wildlife's access to water, remove breeding or nesting sites, and eliminate suitable areas for rearing young. Wildlife relies on riparian areas and are associated with the flood hazard in the following ways:

- Mammals depend upon a supply of water for their existence. Riparian communities have a greater diversity and structure of vegetation than other upland areas. Beavers and muskrats are now recolonizing streams, wetlands and fallow farm fields, which are converted wetlands. As residences are built in rural areas, there is an increasing concern of beaver dams causing flooding of low-lying areas and abandoned farm ditches being filled leading to localized flooding.
- A great number of birds are associated with riparian areas. They swim, dive, and feed along the shoreline, or snatch food from above. Chelan County rivers, lakes and wetlands are important feeding and resting areas for migratory and resident waterfowl. Other threatened or endangered species (such as the bald eagle or the peregrine falcon) eat prey from these riparian areas.
- Fish habitat throughout the county varies widely based on natural conditions and human influence. Many ditches were dug throughout the county to make low, wet ground better for farming. As the water drained away and the wetlands were converted to farm fields, natural stream conditions were altered throughout the county. Agriculture along many rivers extends to the water's edge and smaller side channels have been tiled to drain better. Within developing areas, small streams were placed in pipes and wetland filled in to support urban development.

Protection of these biological resources within the floodplains of the planning area is very important to Chelan County. Equipped with planning tools such as WRIA planning, comprehensive planning, critical areas ordinances, and open space planning, Chelan County has been able to establish a diverse inventory of preserve areas that maintain the natural and beneficial functions of the floodplain. Habitat complexity project areas that promote the natural and beneficial functions of floodplains include the following:

- The Peshastin Fishway (Chelan County Natural Resources Department, 2019a)
- Cashmere Pond (Chelan County Natural Resources Department, 2019b)
- The Nason Creek Oxbow (Chelan County Natural Resources Department, 2019c)
- The Wenatchee River Irwin property (Chelan County Natural Resources Department, 2019d)
- The Entiat National Fish hatchery
- Icicle Creek (Chelan County Natural Resources Department, 2019e)

12.6.5 Activities that Have Value to the Community

Flooding can impact the water recreation industry in Chelan County, causing erosion damage to water courses, damaging habitat areas, increasing turbidity. Although these may be short-term impacts, flooding can also damage boat launches, docks, campgrounds, hotels, and other infrastructure that supports water recreation.

12.6.6 Agriculture

Flooding can adversely impact agricultural production by causing delays in and reduction of crop harvest. If soil is too wet it can result in poor conditions for the crops to grow; wet soils may deprive plants the oxygen, nutrients and trace elements needed to flourish.

Flooded soils create significant challenges for agricultural lands. The floods have many direct impacts, the most prominent being:

- Deposition of sand and debris on productive lands
- Erosion of agricultural soils
- Flooded soil syndrome—loss of beneficial fungi which mobilize soil-based plant nutrients

As a result of these effects after floods, farmers are challenged by yield losses and devastation of arable land. Subsequently, producers need to plan for the slow recovery of their arable soils.

12.6.7 National Risk Index

According to the National Risk Index (NRI), Chelan County has a “Relatively Low” risk index for the flood hazard. Table 12-12 provides the risk factor breakdown. See Section 7.2 for a description of the components of the NRI.

Table 12-12. NRI Scoring for Flood in Chelan County

Expected Annual Loss	Risk Index Rating	Community Resilience	Social Vulnerability	Risk Value	Risk Index Score
$741,322	Relatively Low	Relatively Moderate	Relatively High	$916,348	64.9

12.7 SCENARIO

The primary water courses in the planning area have the potential to flood at regular intervals (two to five years on average), generally in response to a succession of intense winter storms. Storm patterns of warm, moist air usually occur between early November and late March. The worst-case scenario is a series of storms in a short time that flood numerous drainage basins that have been burned over by wildfire. This could overwhelm response and flood hazard management capabilities in the planning area. Major roads could be blocked, preventing critical access for many residents and responders. High flows could cause water course scouring, possibly washing out roads and creating additional isolation issues. In a multi-basin flood event, resources would be stretched thin resulting in delays in repairing and restoring critical facilities and infrastructure. The mapped and identified floodplains in the County are where most impacts from flooding would be concentrated; however, groundwater flooding issues typical for the planning area would be significantly enhanced as the ground reaches saturation.

12.8 ISSUES

The planning team has identified challenges, data gaps and issues associated with full identification and understanding of flood hazards in the planning area. These are, include but not limited to the following:

- The currently effective flood hazard mapping for the County does not accurately reflect the true flood risk.

- There needs to be a sustained effort to gather historical damage data, such as high water marks on structures and damage reports, to measure the cost-effectiveness of potential mitigation projects.
- Ongoing flood hazard mitigation will require funding from multiple sources.
- Existing floodplain-compatible uses such as agricultural and open space need to be maintained. During times of moderate to high growth there is pressure to convert these areas to more intensive uses.
- There needs to be a coordinated flood hazard mitigation effort among county jurisdictions affected by flood hazards.
- Education for residents in flood hazard areas about flood preparedness and the resources available during and after floods should continue.
- There is a lack of consistency in regional flood hazard management policy in the planning area.
- As the planning area continues to grow, there will be increased pressures for development in areas subject to flood risk.
- The potential impact of climate change on flood conditions in the planning area is unknown and needs to be monitored.
- Wildfires will likely continue to impact the planning area. Post-fire best management practices will need to be investigated and, if implemented, maintained to limit the impacts of these fires on flooding. The County should continue to coordinate with the U.S. Forest Service.
- The capability for prediction forecast modeling needs to be enhanced.
- There are significant gaps in the flood threat recognition capabilities within the planning area (i.e.: the Doppler radar gap)
- Flood warning capability should be tied to flood phases.
- Enhanced modeling is needed to better understand the true flood risk.
- Floodplain restoration/reconnection opportunities should be identified as a means to reduce flood risk.
- Post-flood disaster response and recovery actions need to be clearly identified.
- Current or greater staff capacity is required to maintain the existing level of flood hazard management within the planning area.
- Flood hazard management actions require interagency coordination.
- Predetermined flood stages and corresponding actions are need for those stream gages within the County that currently do not have flood forecasting capabilities.

12.9 MITIGATING THE HAZARD

Table 12-13 presents a range of potential opportunities for mitigating the flood hazard.

Table 12-13. Potential Opportunities to Mitigate the Flood Hazard

Community Scale	Organizational Scale	Government Scale
Manipulate the Hazard		
• Clear storm drains and culverts • Use low-impact development techniques	• Clear storm drains and culverts • Use low-impact development techniques	• Maintain drainage systems • Institute low-impact development techniques on property • Structural flood control, levees, channelization, or revetments • Stormwater management regulations and master planning • Acquire vacant land or promote open space uses in developing watersheds to control increases in runoff • Dredging, levee construction, and providing regional retention areas

Community Scale	Organizational Scale	Government Scale
Reduce Vulnerability and Impacts		
• Locate outside of hazard area • Elevate utilities above base flood elevation • Use low-impact development techniques • Raise structures above base flood elevation • Elevate items within house above base flood elevation • Build new homes above base flood elevation • Flood-proof structures	• Locate outside of hazard area • Use low-impact development techniques • Build critical function redundancy or retrofit critical buildings • Provide floodproofing when new critical infrastructure must be located in floodplains	• Locate or relocate critical facilities outside of hazard area • Acquire or relocate identified repetitive loss properties • Promote open space uses in identified high hazard areas via techniques such as: planned unit developments, easements, setbacks, greenways, sensitive area tracks • Adopt land development criteria such as planned unit developments, density transfers, clustering Institute low impact development techniques on property • Acquire vacant land or promote open space uses in developing watersheds to control increases in runoff • Institute low impact development techniques on property • Preserve undeveloped and vulnerable shoreline • Restore existing flood control and riparian corridors • Harden infrastructure, bridge replacement program • Provide redundancy for critical functions and infrastructure • Adopt regulatory standards such as freeboard standards, cumulative substantial improvement or damage, lower substantial damage threshold, compensatory storage, non-conversion deed restrictions • Stormwater management regulations and master planning • Adopt “no-adverse impact” floodplain management policies that strive to not increase the flood risk on downstream communities • Improve unpaved roads to reduce their likelihood to fail due to flooding • Harden infrastructure, bridge replacement program • Facilitate managed retreat from, or upgrade of, the most at-risk areas

Community Scale	Organizational Scale	Government Scale
Build Local Capacity		
• Buy flood insurance • Develop household plan, such as retrofit savings, communication with outside, 72- hour self-sufficiency during and after an event	• Keep cash reserves for reconstruction • Support and implement hazard disclosure for sale of property in risk zones. • Solicit cost-sharing through partnerships on projects with multiple benefits.	• Produce better hazard maps • Provide technical information and guidance • Enact tools to help manage development in hazard areas (stronger controls, tax incentives, and information) • Incorporate retrofitting or replacement of critical system elements in capital improvement plan • Develop strategy to take advantage of post-disaster opportunities • Warehouse critical infrastructure components • Develop and adopt a continuity of operations plan • Consider participation in the Community Rating System • Maintain and collect data to define risks and vulnerability • Train emergency responders • Create an elevation inventory of structures in the floodplain • Develop and implement a public information strategy • Charge a hazard mitigation fee • Integrate floodplain management policies into other planning mechanisms within the planning area. • Consider impacts of climate change on the risk associated with the flood hazard • Consider the residual risk associated with structural flood control in future land use decisions • Enforce National Flood Insurance Program • Adopt a Stormwater Management Master Plan
Nature-Based Opportunities		
• Restore and reconnect floodplains that have been degraded by development and structural flood control • Use soft approaches for stream bank restoration and hardening • Set back levees on systems that rely on levee protection to allow the channel to meander, which reduces erosion and scour potential • Preserve floodplain storage capacity by limiting or prohibiting the use of fill in the floodplain • Incorporated green infrastructure into stormwater management facilities • Protect and/or restore riparian buffers		

13. LANDSLIDE

13.1 GENERAL BACKGROUND

13.1.1 Landslide Types

Landslides are commonly categorized by the type of initial ground failure. Common types of slides are shown on Figure 13-1 through Figure 13-4. The most common is the shallow colluvial slide, occurring particularly in response to intense, short-duration storms. The largest and most destructive are deep-seated slides, which are less common than other types.

Source: Washington Department of Ecology, 2014

Figure 13-1. Deep Seated Slide

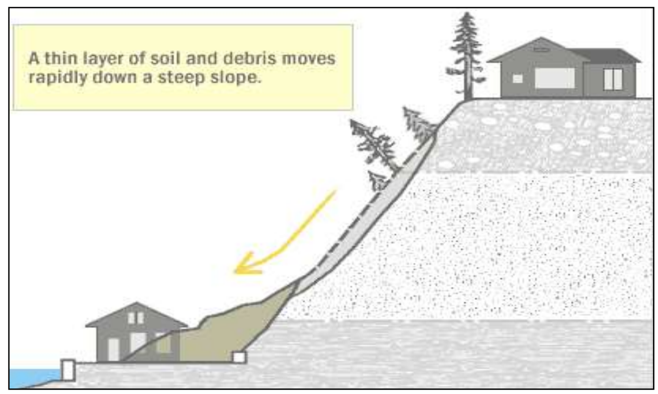


Figure 13-2. Shallow Colluvial Slide

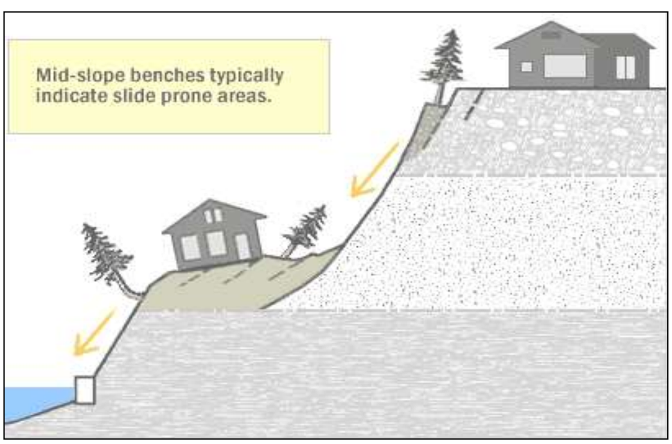


Figure 13-3. Bench Slide

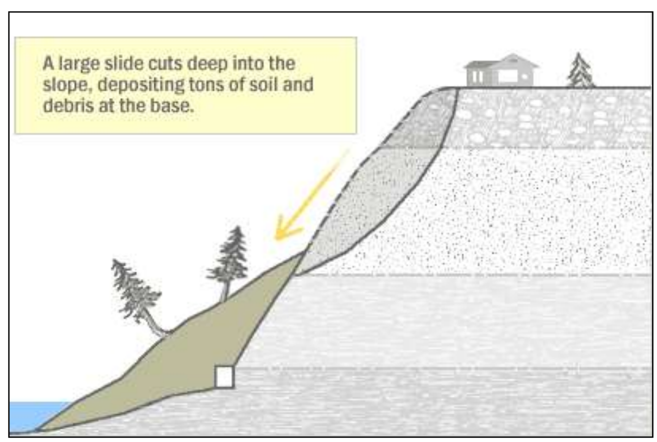


Figure 13-4. Large Slide

Other landslide types also include the following:

- Block slides—Blocks of rock that slide along a slip plane as a unit down a slope.
- Creep—A slow-moving landslide often only noticed through crooked trees and disturbed structures.

- Debris avalanche—A debris flow that travels faster than about 10 miles per hour (mph). Speeds in excess of 20 mph are not uncommon, and speeds in excess of 100 mph, although rare, can occur. The slurry can travel miles from its source, growing as it descends, picking up trees, boulders, cars, and anything else in its path.
- Earth flows—Fine-grained sediments that flow downhill and typically form a fan structure.
- Mudslides or Debris Flows—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.
- Rock falls—Blocks of rock that fall away from a bedrock unit without a rotational component.
- Rock topples—Blocks of rock that fall away from a bedrock unit with a rotational component.
- Rotational slumps—Blocks of fine-grained sediment that rotate and move down slope.
- Transitional slides—Sediments that move along a flat surface without a rotational component.

13.1.2 Landslide Causes

Landslides are caused by a combination of geological and climate conditions, as well as encroaching urbanization. Vulnerable areas are affected by residential, agricultural, commercial, and industrial development and the infrastructure that supports it. The following human activities have particular influence on the landslide hazard:

- **Construction Earthwork—**Excavation, grading and fill during construction of buildings or roads on sloping terrain can steepen the terrain and increase weight loads on slopes, potentially increasing the landslide hazard.
- **Drainage and Groundwater Alterations—**Activities that increase the amount of water flowing into landslide-prone slopes can increase the landslide hazard. This can include broken or leaking water or sewer lines, water retention facilities that direct water onto slopes, lawn irrigation, minor alterations to small streams, and ineffective stormwater management measures. Development that increases impervious surface may redirect surface water to other areas. Road and driveway drains, gutters, downspouts, and other constructed drainage facilities can concentrate and accelerate flow.
- **Changes in Vegetation—**Removal of vegetation from very steep slopes, by wildfire or land clearing, can increase landslide hazards. In addition, woody debris in stream channels (both natural and man-made) may cause the impacts from debris flows to be more severe.

Other factors that can contribute to landslide include the following:

- 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
- Removing or changing the type of vegetation covering slopes.
- Erosion by rivers, glaciers, or ocean waves that create over-steepened slopes

13.1.3 Landslide Management

While small landslides are often a result of human activity, the largest landslides are often naturally occurring phenomena with little or no human contribution. The sites of large landslides are typically areas of previous landslide movement that are periodically reactivated by significant precipitation or seismic events. Such naturally occurring landslides can disrupt roadways and other infrastructure lifelines, destroy private property, and cause flooding, bank erosion and rapid channel migration. Landslides can create immediate, critical threats to public safety, and engineering solutions to protect structures from large active landslides are often prohibitively expensive.

In spite of their destructive potential, landslides can serve beneficial functions to the natural environment. They supply sediment and large wood to a stream network, contributing to complexity and dynamic channel behavior critical for aquatic and riparian ecological diversity. Effective landslide management should include the following elements:

- Continuing investigation to identify natural landslides, understand their mechanics, assess their risk to public health and welfare, and understand their role in ecological systems
- Regulation of development in or near existing landslides or areas of natural instability.
- Preparation for emergency response to landslides to facilitate rapid, coordinated action among local government and state and federal agencies, and to provide emergency assistance to affected or at-risk residents.
- Evaluation of options including landslide stabilization or structure relocation where landslides are identified that threaten critical public structures or infrastructure.

Critical area ordinances at the local level reduce the impacts of human alterations on critical areas, which include geologically hazardous areas such as areas prone to landslide, erosion, mass-wasting, debris flows and rock falls. The designation of critical areas, including geologically hazardous areas, is a requirement of the Washington State Growth Management Act (WAC 365-190-080(4).

13.2 HAZARD PROFILE

13.2.1 Location

Slides can occur in urban and rural areas throughout the County. 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: (Washington State Legislature 2023)

- Areas of historical failures
- Areas delineated by the USDA Natural Resources Conservation Service as having limitation for building site development
- Areas designated as quaternary slumps, earthflows, mudflows, lahars, or landslides on maps published by the USGS Survey or Washington Department of Natural Resources
- Areas with all three of the following characteristics:
    - Slopes steeper than 15%
    - Hillsides intersecting geologic contacts with a relatively permeable sediment overlying a relatively impermeable sediment or bedrock
    - Springs or groundwater seepage

- Areas that have shown movement within the last 10,000 years or that are underlain or covered by mass wastage debris of that time period
- Slopes that are parallel or subparallel to planes of weakness (such as bedding planes, joint systems, and fault planes) in subsurface materials
- Slopes with gradients steeper than 80% subject to rock-fall during seismic shaking
- Areas potentially unstable as a result of rapid stream incision, stream bank erosion, and undercutting by wave action
- Areas that show evidence of, or that are at risk from snow avalanches
- Areas in a canyon or on an active alluvial fan, presently or potentially subject to inundation by debris flows or catastrophic flooding
- Any area with a slope of 40% or steeper and with a vertical relief of 10 or more feet, except areas composed of consolidated rock.

The Washington State Hazard Mitigation Plan defines six major landslide provinces. Chelan County is in the Columbia River Basin province, which largely consists of thick lava flows known as Columbia River Basalts. Landslides in this province include slope failures in bedrock along soil interbeds and in overlying catastrophic flood sediments. Bedrock slope failures are often large deep-seated translational landslides, slumps or earth flows, triggered by over-steepening of a slope or removal of the toe of a slope. Figure 13-5 shows historical landslides in Chelan County.

13.2.2 Extent

Landslides of all intensities have occurred in Chelan County, from the largest landslide in Washington State, the Stemilt landslide that occurred approximately 20,000 years ago, covers about 46 square miles, and is 1,500 feet deep, to the annual rock falls and debris flows that block roads.

Landslides can be classified as either shallow landslides or deep-seated landslides. Shallow landslides are generally less intense and affect a smaller area. Shallow landslides include debris flows, rock falls, and rock topples. Deep seated landslides are rooted in bedrock are generally much more intense than shallow landslides. They cover larger areas and are more destructive to infrastructure and structures. Deep seated landslides include translational slides, rotational slides, and large block slides (DNR 2017).

Landslides of all intensities destroy property and infrastructure and can take the lives of people. Even small landslides have the potential of destabilizing the foundation of structures, which may result in monetary loss for residents. Landslides are estimated to cost billions of dollars in damage annually and result in multiple deaths (USGS n.d.) Landslides can pose a serious hazard to properties on or below hillsides. They can cause block access to roads, which can isolate residents and businesses and delay commercial, public and private transportation. This can result in economic losses for businesses. Vegetation or poles on slopes can be knocked over, resulting in possible losses to power and communication lines. Landslides also can damage rivers or streams, potentially harming water quality, fisheries and spawning habitat.

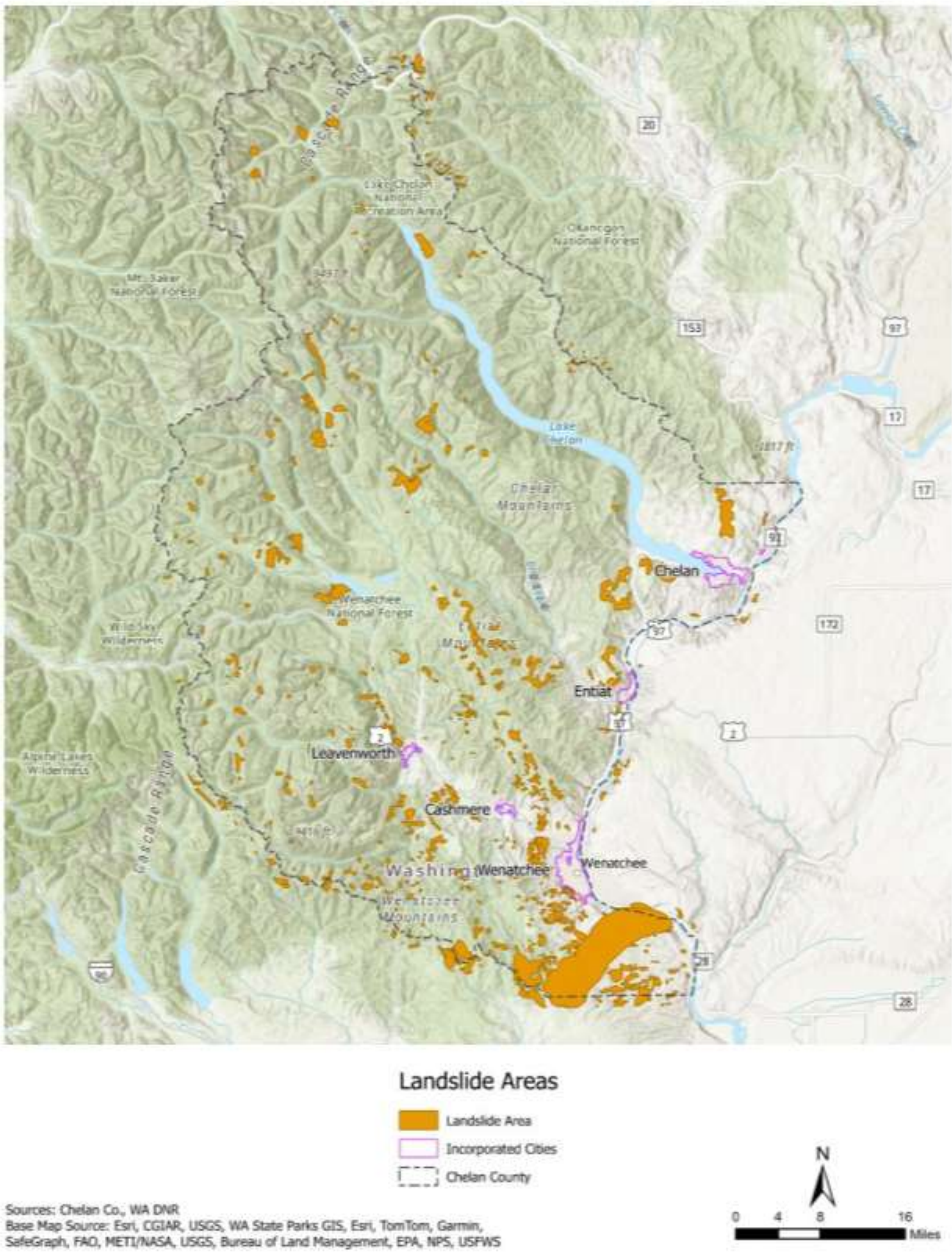


Figure 13-5. Historical Landslides

The State Road 530 landslide that occurred in Oso, Washington, showed the devastating damage that can be caused by landslides. On March 22, 2014, the slide traveled over 60 mph, covering over a square mile of land and depositing a thickness of 15 to 75 feet in some areas. The slide caused 43 fatalities and 12 injuries, destroyed 37 homes, and destroyed State Route 530 for over a mile. The debris blocked the North Fork Stillaguamish River for over 24 hours, backing up a pool of water that flooded the valley about two miles upstream and reached approximately 20 feet deep, inundating an additional six homes. Total property damage was estimated at $60 million (NOAA 2014). Although Oso is west of the Cascades and Chelan County is to the east, the magnitude of this event as well as its occurrence in the same state have heightened the awareness of the severity of this hazard in the planning area.

13.2.3 Previous Occurrences

Some damaging slides have occurred in and near to Chelan County. On December 14, 1872, a slide triggered by an earthquake caused a massive rock slide, which cut off the flow of the Columbia River. This slide occurred a few miles north of the present location of the town of Entiat. A handful of small-scale landslides have occurred in Chelan County over the years, usually the result of significant precipitation. Some significant landslides that have occurred between 2007 and 2024 include:

- In January 2007, a landslide occurred at Dirty Face Mountain and closed the Lake Wenatchee Highway temporarily.
- In February 2008, a landslide destroyed one home in the Kahler Glen development at Lake Wenatchee.
- In March of 2016, a landslide threatened Whispering Ridge neighborhood near Wenatchee, causing 26 homes to evacuate. Two of the homes were declared unsafe to live in (Kostanich 2016). Whispering Ridge is currently being monitored.
- In August 2019, a debris flow from Squilchuck Creek inundated the Boodry Street area. Three homes were determined to be uninhabitable.
- In October of 2021, about 8,100 cubic yards of mud and debris needed to be removed from the Slide Ridge area after a landslide occurred.

Some landslide events have resulted in fatalities, as noted in Table 13-1.

Table 13-1. Landslide Deaths in Chelan County

Year	Location	Type	Fatalities
1942	Tenas George	Mud	8
1965	Leavenworth	Mud	1
1973	Preston Creek	Mud	4
1995	SR 97A	Rock	2

The Washington Department of Natural Resources, Washington Geologic Survey tracks landslides. Recent landslides are shown on a web mapping platform called Reported Landslides in Washington State. According to the map, the County has experienced at least one reported landslide every year for the past nine years (Washington Geological Survey 2024). Most of the reported landslides were associated with rock fall or debris flows that affected roadways. The number of reported landslides is shown in Table 13-2 and Figure 13-6.

Table 13-2. Reported Landslides Each Year (2015-2024)

Water Year	Number	Water Year	Number
2015-2016	4	**2020-2021**	2
2016-2017	2	**2021-2022**	3
2017-2018	1	**2022-2023**	6
2018-2019	4	**2023-2024**	1
2019-2020	1		

Disaster and Emergency Declarations

The following summarizes disaster declarations or emergency proclamations related to the landslide hazard.

- Federal DR or EM Declaration, 1953-2024: 0 events for landslide, debris flow, mud flows within Chelan County

13.2.4 Overall Probability

Landslides occur every year in Chelan County. However, severe landslides that affect a large area are relatively uncommon in Chelan County even though over 85% of the county is in steeply sloped areas of the Cascade Range Landslide Province as identified in the Washington State Hazard Assessment (Draft). Much of the underlying earthen material is bedrock and therefore less susceptible to landslides.

Chelan County is vulnerable to landslides. Slides often occur on steep slopes after severe storms, wildfires, earthquakes or construction activity in slide prone areas. Because of the steep topography and narrow valleys of Chelan County, the potential for slides is high all year round. Under the right conditions any steep sloped area of Chelan County may be classified as a potential hazard area.

According to DNR landslide tracking, over the past nine years there has been at least one reported landslide each year and 24 total reported landslides. Based on historic frequency and future conditions, the probability of future landslide occurrences is high, with a chance of at least one landslide occurring every year.

13.2.5 Warning Time

Mass movements can occur suddenly or slowly. The velocity of movement may range from inches per year to many feet per second, depending on slope angle, material and water content. Generally accepted warning signs for landslide activity include the following:

- 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 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.

Some methods used to monitor mass movements can provide an idea of the type of movement and the amount of time prior to failure. Assessing the geology, vegetation and amount of predicted precipitation for an area can help in predictions of what areas are generally at risk. Currently, there is no practical warning system for individual landslides. The standard operating procedure is to monitor situations on a case-by-case basis and respond after an event has occurred.

13.2.6 Climate Change Impacts

Climate change may impact storm patterns, increasing the probability of more frequent, intense storms with varying duration. More intense rainfall, caused by climate change, may saturate the soil and trigger landslides.

Increase in global temperature is likely to affect the snowpack and its ability to hold and store water. In a warming climate, precipitation that previously would have fallen as snow, is now rain. Rain falling on an existing snowpack may cause rapid melting and increased runoff. This may lead to a greater risk of landslides (USGS 2019). The CMRW tool estimates that Chelan County will experience a 5% increase in heavy precipitation magnitude from 2020-2049 (Climate Mapping for a Resilient Washington 2024).

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. Chelan County has an anticipated 37% increase in wildfire likelihood from 2020-2049, with some areas in the County having an increase of as much as 97% (Climate Mapping for a Resilient Washington 2024). Wildfires destroy vegetation and may alter soil properties to be hydrophobic (repel water). The soils will not be able to absorb water, leading to downslope water flow, which may accumulate volume and collect debris, causing a dangerous debris flow (USGS n.d.). All of these factors would increase the probability for landslide occurrences.

13.2.7 Future Trends in Development

The ever-increasing pressure for development in or near the mountains and narrow valleys bring added exposure to people and their structures. Increasingly, more and more people are recreating, working and building in potentially hazardous areas with little caution or preparation. Development pressure in rural areas and at recreation sites in the mountains brings added exposure to people and their structures. Slide effects on individual or public organizations include partial damage or destruction of significant portions of highways and railroads, utility lines, and private and public property. Other major effects involve the loss of natural resources and the cost of debris removal.

Source: (Washington Geological Survey 2024)

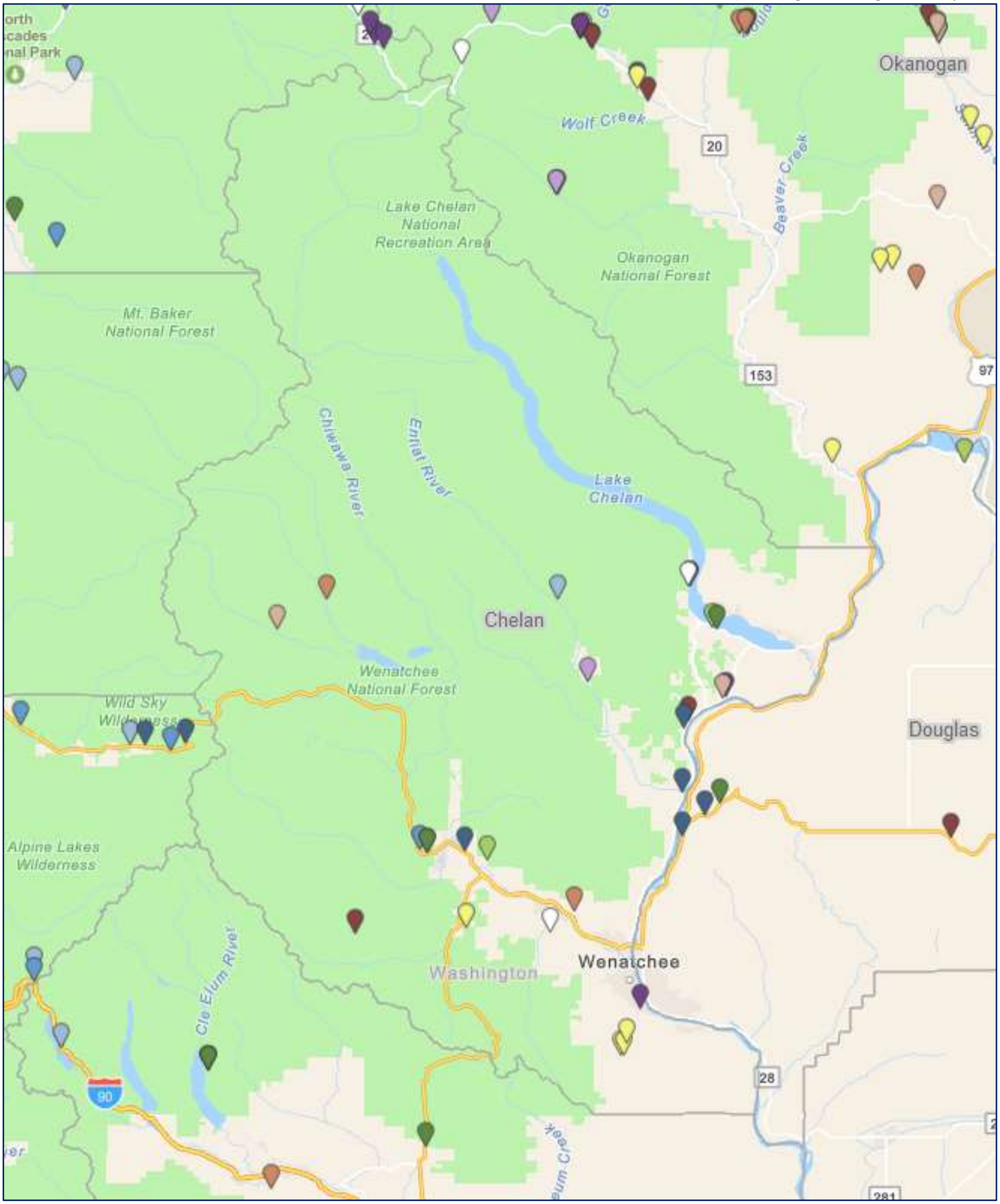


Figure 13-6. Recently Reported Landslides (2015-2024) Source: (Washington Geological Survey 2024)

The State of Washington has adopted the International Building Code by reference in its Washington Building Standards Code. The International Building Code includes provisions for geotechnical analyses in steep slope areas that have soil types considered susceptible to landslide hazards. These provisions ensure that new construction is built to standards that reduce vulnerability to the landslide risk. In addition, all municipal planning partners have comprehensive plans that define landslide hazard areas as critical areas and have adopted critical areas ordinances that regulate development in landslide-prone areas. This will facilitate wise land use decisions as future growth impacts landslide hazard areas. It is anticipated that some new development will be exposed to landslide risk, as runout models do not yet exist and it is likely that not all landslide hazard areas have been identified.

13.3 SECONDARY HAZARDS

Most landslides do not result in secondary hazards. Landslides are often secondary hazards of other event types, such as earthquakes, severe weather or wildfires. However, landslides occurring near water bodies may create flooding. For example, a landslide may block a creek or river, causing water to back up behind the landslide and potentially a flash flood when the debris dam fails. A landslide that falls into a water body, such as Lake Chelan or along the Columbia River, may cause a seiche that could damage marinas, docks, and other structures near the shoreline.

13.4 VULNERABILITY AND IMPACTS

Impact and vulnerability estimates for the landslide hazard are described qualitatively. No loss estimation of these facilities was performed because damage functions have not been established for the landslide hazard. Modeling based on identified landslide hazard areas would overestimate potential losses because it is unlikely that all areas susceptible to landslides would experience landslides at the same time. Population and structures vulnerable to hazards was based on the DNR Landslide Compilation data, a database of historic landslides.

13.4.1 People

Population vulnerable to the hazard was estimated using the residential building count in landslide hazard areas and multiplying by the 2023 Washington Office of Financial Management estimated average population per household. Using this approach, the estimated population living in mapped landslide hazard areas is 3.7% of the total planning area population (3,032 people). In addition to these resident populations, motorists driving on landslide prone roadways, workers employed in the commercial, industrial, and agricultural buildings, and those engaged in recreation activities such as hiking or camping are vulnerable to the landslide hazard.

All people in the landslide hazard area could potentially be impacted. People can be killed or injured by landslides, and their property and possessions destroyed. Road closures may affect people’s ability to travel. Vulnerable populations face the same impacts but may be more affected by the hazard. Populations with access and functional needs as well as elderly populations and the very young are more likely to be impact by landslide hazards as they may not be able to evacuate quickly enough to avoid the impacts of a landslide. The low-income population may not have the funds to repair damage, remove debris, or replace possessions damage by landslides.

13.4.2 Structures

Table 13-3 shows the count of planning area structures within the landslide hazard area. About 65% of the structures are residential (1,566).

Structure Occupancy Types	Structures in Landslide Hazard Area
Commercial	720
Industrial	19
Agriculture	90
Religion	1
Residential	1,566
Government	4
Education	0
TOTAL	2,400

Table 13-3. Vulnerable Structures

The total replacement value of structures and contents in the mapped landslide hazard area is $893 million.

Community lifelines, critical facilities, and infrastructure vulnerable to the landslide hazard represent 3% of the total critical infrastructure and facilities in the planning area. Linear infrastructure is also vulnerable to damage from landslides including roads, power and phone lines.

Any structure in the path of a landslide is likely to be impacted. Depending on the size, intensity, and speed of the landslide, a structure could be destroyed, knocked off its foundation, or suffer partial damage.

Landslides can have a range of impacts on the following infrastructure:

- **Roads**—Landslides can block or damage roads, isolating neighborhoods and causing problems for public and private transportation. This can result in economic losses for businesses and delayed emergency response.
- **Bridges**—Landslides can significantly impact road bridges. They can knock out bridge abutments or significantly weaken the soil supporting them, 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 underneath a tower or a landslide could flow into 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 and may generate significant communication issues.

13.4.3 Systems

Systems within Chelan County that are vulnerable to the landslide hazard include emergency response capabilities and economic systems.

A large landslide that results in tons of debris may hinder emergency services ability to conduct search and rescue operations. In addition, the unstable terrain created after a landslide can complicate rescue efforts, putting first responders and victims at risk.

The Malaga LAMIRD is vulnerable to landslide due to its location on the historic Stemilt landslide. This area provides important industrial lands for businesses to operate and could face direct impacts due to a landslide. If tons of debris block the distribution of goods and transportation routes for employees, the local economy may face indirect consequences.

13.4.4 Natural, Historic, and Cultural Resources

The County's resources are vulnerable to landslides. Natural resources can be negatively affected due to the damage caused by the landslide, such as damage to vegetation and fish habitat. Landslides can block streams and rivers and create water quality issues. Historic and cultural resources could be buried or damaged in the landslide. Cultural sites and gathering areas could become inaccessible.

13.4.5 Activities that Have Value to the Community

Recreation, tourism, and local economy is vulnerable to landslides. They can be impacted by the landslide hazard due to closed roads, delay in transportation of good, and recreation areas that may be closed or inaccessible. Landslides that flow into water bodies could affect recreation due to changes in the water depth or damage to marinas, docks, and boat launches from seiches. Recreationists can be injured from rock fall while hiking or driving along steep cliffs.

13.4.6 Agriculture

Most agricultural production is located on the flat valley floors. The steep slopes and soil types that are susceptible to landslides are not typically ideally suited for agricultural production. Therefore, the vulnerability of agriculture is minimal. Agriculture located at the bottom of steep slopes is most vulnerable.

The direct impacts from landslides to agriculture is considered to be minimal. However, there are indirect impacts from landslides that could have some significant impacts on agricultural productions such as:

- In situations like Oso, WA where there is a significant amount of "runout" of the slide, agricultural production areas could be impacted by that runout.
- Key transportation corridors could be disrupted, thus impacts the distribution of agricultural products.
- Landslides could impact communication and power utilities
- Landslides could impact water supplies by relocating river channels or diverting flows, which could impact availability of irrigation water

13.4.7 National Risk Index

According to the National Risk Index (NRI), Chelan County has a "Very High" risk index for the landslide hazard. Table 13-4 provides the risk factor breakdown. See Section 7.2 for a description of the components of the NRI.

Table 13-4. NRI Scoring for Landslide in Chelan County

Expected Annual Loss	Risk Index Rating	Community Resilience	Social Vulnerability	Risk Value	Risk Index Score
$1,894,834	Very High	Relatively Moderate	Relatively High	$2,275,278	99.8

13.5 SCENARIO

Major landslides in Chelan County occur as a result of soil conditions that have been affected by wildfire, severe storms, groundwater or human development. Landslides are most likely during late winter when the water table is high. After heavy rains, 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. The worst-case scenario for landslide hazards in the planning area would generally correspond to repeated severe storms with heavy rain and flooding in areas ravaged by wildfire.

13.6 ISSUES

Important issues associated with landslides in the planning area include the following:

- Landslide activity within the planning area is frequent and can be severe
- Although known landslide hazard areas and steep slopes are subject to regulation under critical area ordinances, continued development pressures could lead to more homes in landslide risk areas. Furthermore, landslides may occur that threaten people and property outside of the mapped risk areas.
- An accurate picture of where landslides occurred during previous storms is vital in making intelligent land use planning and mitigation decisions. In the past, many landslide losses may have gone unrecorded because insurance companies do not cover such damage. Transportation network damage has often been repaired under the general category of "maintenance."
- An estimated 3.6% of the replacement value of the planning area ($893 million) is in mapped landslide hazard areas; 98% of this is in unincorporated areas of the county.
- Areas with significant landslide risk should be monitored, to the extent possible, immediately following a possible triggering event. Officials may need to focus the majority of attention on emergency response; however, the possibility for a secondary event should not be disregarded.
- Current maps show areas that might be unstable, but do not offer a complete picture of areas at risk, as they do not indicate runout (where a landslide might go). Mapping and assessment of landslide hazards are constantly evolving. As new data and science become available, assessments of landslide risk should be reevaluated.
- Facilities that contain hazardous materials located in landslide hazard areas may present additional risks.
- It is estimated that 3,032 people (3.7% of the population) are vulnerable to landslide risk. This does not include residences that may be in landslide runout areas or areas where there are no historic mapped landslides.
- Landslides in the County often impact transportation corridors limiting ingress and egress and creating issues of isolation.
- Landslides may cause negative environmental consequences, including water quality degradation.
- Landslides may result in isolation of the entire county (worst case) or neighborhoods and communities, due to the fact that large portions of the transportation infrastructure are in areas of high and moderate

slope instability. Isolation may result in food shortages, loss of power, and severely reduced economic productivity.

- Landslides may result in loss of water quality to the environment and for drinking purposes, due to increased sediment delivery into surface waterways.
- The impact of climate change on landslides is uncertain. Climate change impacts that alter vegetation patterns, increase the occurrence of wildfires, or alter precipitation patterns may increase exposure to landslide risks.
- The risk associated with the landslide hazard overlaps the risk associated with other hazards such as earthquake, flood and wildfire. This provides an opportunity to seek mitigation alternatives with multiple objectives that can reduce risk for multiple hazards.
- There are 14 critical facilities located in mapped landslide hazard areas in the planning area. Most of these facilities are transportation facilities in the unincorporated County areas. However, all transportation routes adjacent to steep hillsides and rock walls should be considered to be in a landslide hazard area. Rock falls occur annually on transportation routes throughout the County but are not included in the mapped hazard areas.
- There are critical facilities in areas of unstable slopes that could result in interruption to utility services, particularly water and power. This creates a need for mitigation and for continuity of operations planning to develop procedures for providing services without access to essential facilities.
- There are existing homes in landslide hazard areas throughout the planning area. The degree of vulnerability of these structures depends on the codes and standards the structures were constructed to. Information to this level of detail is not currently available.
- There are 2,400 structures vulnerable to landslides in mapped landslide hazard areas. About 65% of them are residential.

13.7 MITIGATING THE HAZARD

Table 13-5 presents a range of potential opportunities for mitigating the landslide hazard.

Table 13-5. Potential Opportunities to Mitigate the Landslide Hazard

Community Scale	Organizational Scale	Government Scale
	Manipulate the Hazard	
• Stabilize slope (dewater, armor toe) • Reduce weight on top of slope • Minimize vegetation removal and the addition of impervious surfaces	• Stabilize slope (dewater, armor toe) • Reduce weight on top of slope	• Stabilize slope (dewater, armor toe) • Reduce weight on top of slope • Install rock curtains on steep slopes along transportation routes
	Reduce Exposure and Vulnerability	
• Locate structures outside of hazard area (off unstable land and away from slide-run out area) • Retrofit home	• Locate structures outside of hazard area (off unstable land and away from slide-run out area) • Retrofit at-risk facilities	• Adopt land use policies that prohibit the placement of habitable structures in high-risk landslide areas. • Adopt higher regulatory standards for new development within unstable slope areas • Armor/retrofit critical infrastructure against the impact of landslides • Acquire properties in high-risk landslide areas.

Build Local Capacity		
• Subscribe to warning systems, and develop evacuation plan • Keep cash reserves for reconstruction • Educate yourself on risk reduction techniques for landslide hazards	• Institute warning system, and develop evacuation plan • Keep cash reserves for reconstruction • Develop a continuity of operations plan • Educate employees on the potential exposure to landslide hazards and emergency response protocol	• Produce better hazard maps • Provide technical information and guidance • Enact tools to help manage development in hazard areas: better land controls, tax incentives, information • Develop strategy to take advantage of post-disaster opportunities • Warehouse critical infrastructure components • Develop and adopt a continuity of operations plan • Educate the public on the landslide hazard and appropriate risk reduction alternatives • Consider the probable impacts of climate change on the risk associated with the landslide hazard
Nature-Based Opportunities		
• Replace or restore native vegetation known to stabilize steep slopes • Hybrid solutions that combine engineering with a nature-based approach using appropriate vegetation		

14. SEVERE WEATHER

14.1 GENERAL BACKGROUND

Severe weather refers to any dangerous meteorological event with the potential to cause damage, serious social disruption, or loss of human life. The most common severe weather events to impact the planning area are winter storms, severe thunderstorms, high winds and extreme temperatures. For this risk assessment, any use of the term “severe weather” refers to these four event types in aggregate. They are assessed as a single hazard for the following reasons:

- Records indicate that each of these weather event types has impacted the planning area to some degree, and all have similar frequencies of occurrence.
- These weather event types have no clearly defined extent or location. Therefore, no quantitative, geospatial analysis is available to support exposure or vulnerability analysis; the analyses for this hazard are qualitative.

Severe local storms occur when the interior of British Columbia is under the influence of high barometric pressure, and a deep low-pressure center from over the Pacific approaches the Washington coast. At this latitude, severe storms normally approach Chelan County from the south or southeast.

14.1.1 Winter Storms

A winter storm is defined for this plan as a storm with significant snowfall, ice, and/or freezing rain; the quantity of precipitation varies by elevation. Heavy snowfall is fou4 inches or more in a 12-hour period, or six or more inches in a 24-hour period in non-mountainous areas; and 12 inches or more in a 12-hour period or 18 inches or more in a 24-hour period in mountainous areas. Severe winter storms occur when there is significant precipitation and the temperature is low enough that the precipitation completely or partially freezes. Figure 14-1 shows the general circumstances that result in different winter precipitation events. The type of precipitation experienced during a winter storm can depend on location. Winter precipitation may fall as snow at higher altitudes but rain at lower elevations, with freezing rain or sleet at elevations in between.

Extreme cold occurs when temperatures are in dangerous ranges that may cause frostbite or hypothermia to people who are exposed. Extreme cold can occur as a result of low temperatures or a combination of low temperatures with wind chill. Figure 14-2 shows how wind can make temperatures feel colder than they really are. Extreme cold events often occur during severe winter storms.

14.1.2 Thunderstorms

NOAA classifies a thunderstorm as a storm with lightning and thunder, usually with gusty winds, heavy rain, and sometimes hail. Thunderstorms are usually short (seldom more than two hours). In the summer, dry thunderstorms occur, with lightning strikes but no rain (dry lightning). A severe thunderstorm is defined for this plan as a thunderstorm with heavy precipitation, dry lightning, or large hail.

Hail occurs when updrafts in thunderstorms carry raindrops upward into extremely cold areas of the atmosphere where they freeze into ice. 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. Fortunately, storms with large damaging hail are infrequent.

Lightning associated with thunderstorms is an electrical discharge that results from the buildup of positive and negative charges within a thunderstorm. When the buildup becomes strong enough, lightning appears as a "bolt." This flash of light usually occurs within the clouds or between the clouds and the ground. A bolt of lightning instantaneously reaches temperatures approaching 50,000ºF. The rapid heating and cooling of air near the lightning causes thunder. Dry thunderstorms are a major cause of wildfire during the summer.

Source: NOAA, NWS, 2018b

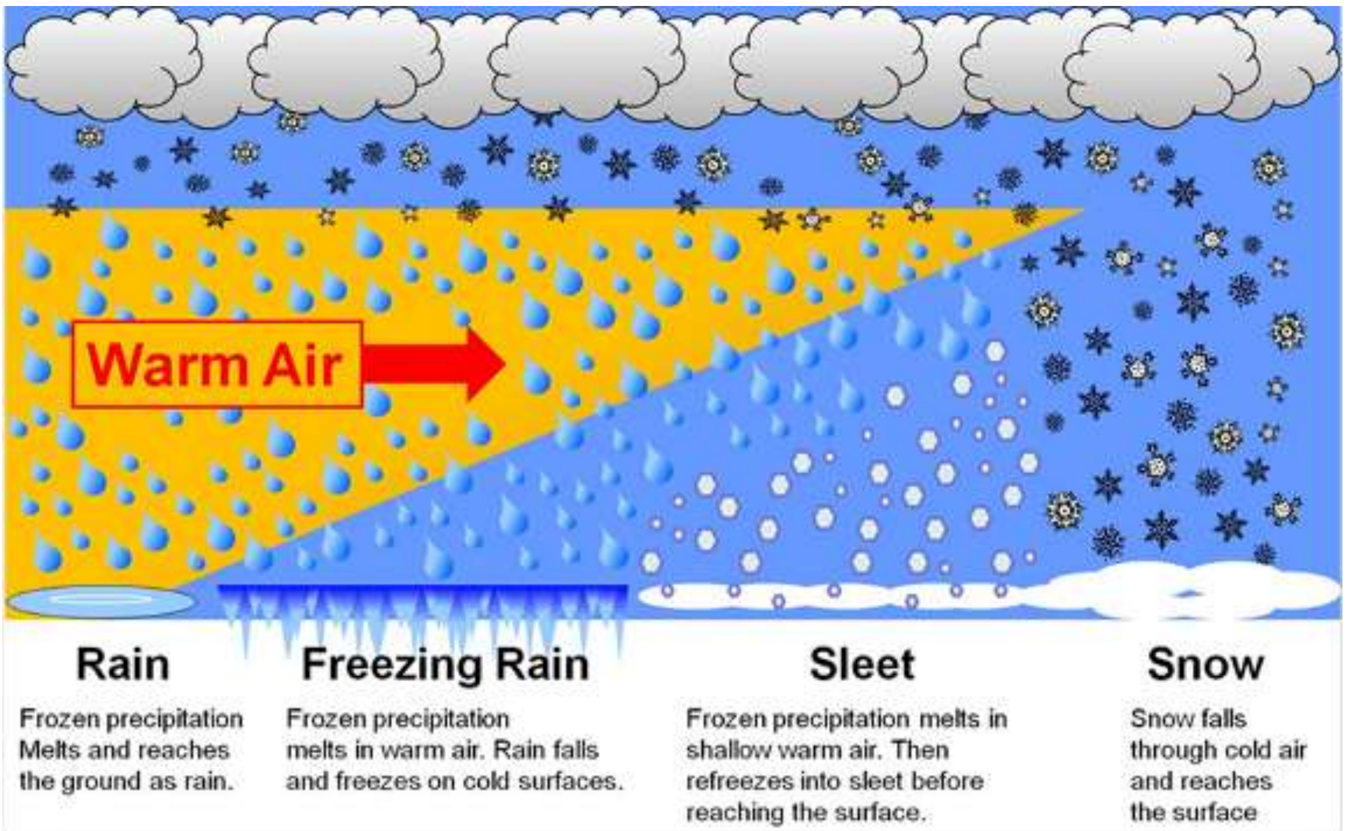
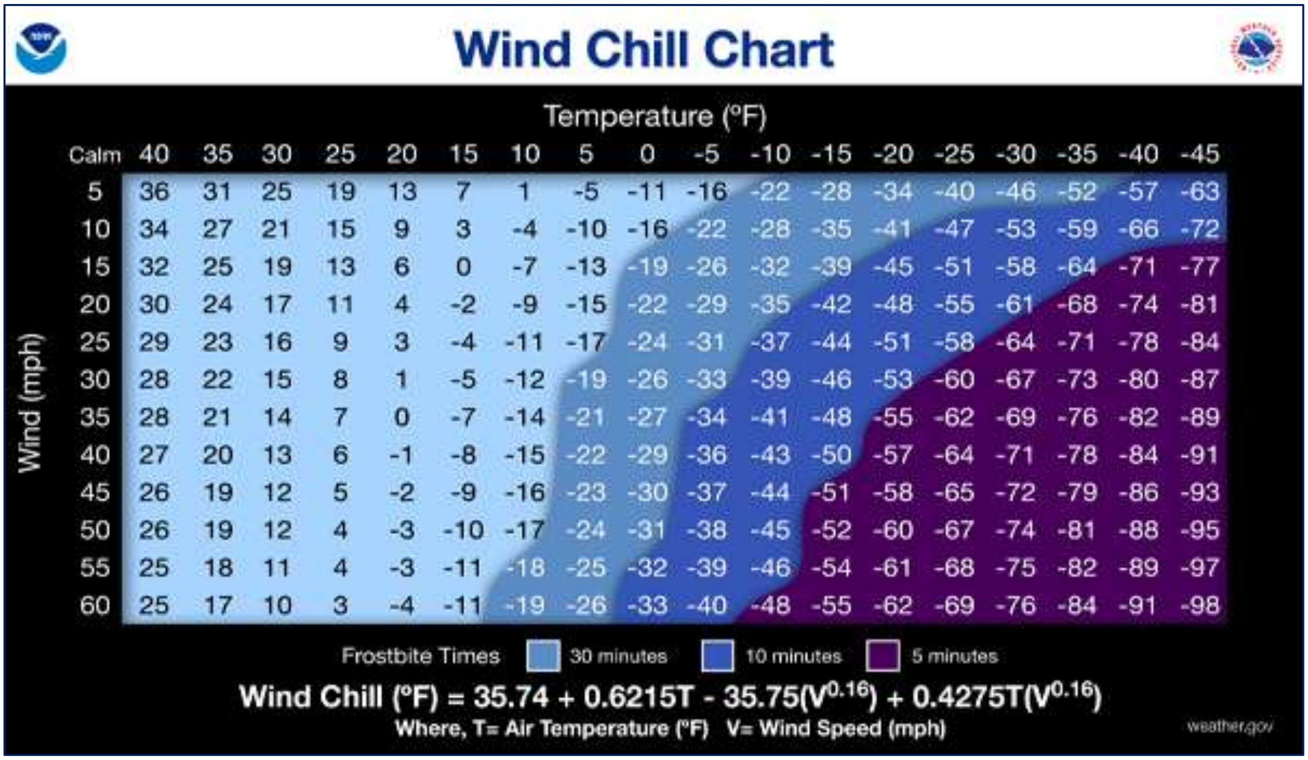


Figure 14-1. Effects of Air Temperature on Winter Precipitation Events

14.1.3 High Winds

High winds are defined for this plan as sustained winds of 40 mph or gusts of 58 mph or greater, not caused by thunderstorms, that are expected to last for an hour or more. The National Weather Service classifies wind from 38 to 55 mph as gale force winds; 56 to 74 mph as storm force winds and any winds over 75 mph as hurricane force winds. Destructive winds normally occur in the planning area between October and March.



Wind Chill Chart

Temperature (°F)

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

Wind Chill (°F) = $35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$

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

weather.gov

Figure 14-2. Wind Chill Chart

14.1.4 Extreme Temperatures

FEMA defines extreme weather as prolonged periods of excessively hot or cold weather, with temperatures above the average high (extreme heat) or below the average low (extreme cold). In Chelan County extreme cold means temperatures well below zero and extreme heat means temperatures above 100 degrees Fahrenheit. These types of extreme temperatures will pose significant risk to human health, agriculture, and infrastructure. Extreme heat often results in the highest annual number of deaths among all weather-related disasters (FEMA 2024). Extreme cold can cause frostbite, hypothermia and may even become life-threatening (National Oceanic and Atmospheric Administration n.d.)

14.2 HAZARD PROFILE

14.2.1 Location

All areas of Chelan County are vulnerable to the threat of severe storms and extreme temperatures. Due to topography and climatological conditions, the higher mountainous areas are often the most exposed to the effects of these storms. Normally the mountainous terrain and the north/south orientation of the Cascades tend to isolate severe storms into localized areas of the County, although individual storms can generate the force to impact the entire County at one time. Severe thunder, hail, wind and winter storms are common in all parts of Chelan County.

14.2.2 Extent

Winter Storms, Severe Thunderstorms, High Winds

The most common problems associated with severe storms are immobility and loss of utilities. Fatalities are uncommon but can occur. Roads may become impassable due to flooding, downed trees or a landslide. Power lines may be downed due to high winds or ice accumulation, and services such as water or phone may not be able to operate without power. Lightning can cause severe damage and injury. Physical damage to homes and facilities can be caused by wind or accumulation of snow or ice. Even a small accumulation of snow can cause havoc on transportation systems due to a lack of snow clearing equipment and experienced drivers and the hilly terrain.

Chelan County has been vulnerable to severe winter storms when significant snowfall has immobilized local and state transportation routes as well as utility systems. All areas of the County have been subject to these events, which appear to occur at least once every five to ten years. Primary effects normally vary with the intensity of the storm. In some cases, transportation accidents can occur from accumulation of snow, ice, hail or dust from accompanying winds. Physical damage to facilities can occur from accumulation of snow, ice, hail or dust and from accompanying winds.

Windstorms can be a frequent problem in the planning area and have been known to cause damage to utilities. The predicted wind speed given in wind warnings issued by the National Weather Service is for a one-minute average; gusts may be 25 to 30% higher. Lower wind speeds typical in the lower valleys are still high enough to knock down trees and power lines and cause other property damage. Mountainous sections of the County experience much higher winds under more varied conditions. Although the intensity of major storms has often been reduced by the Cascades, winds over exposed peaks can reach 100 mph, with peak gusts of 125 to 150 mph as the storm moves inland.

Ice storms accompanied by high winds can have especially destructive impacts, especially on trees, power lines, and utility services. While sleet and hail can create hazards for motorists when they accumulate, freezing rain can cause the most dangerous conditions within the planning area. Ice buildup can bring down trees, communication towers and wires, creating hazards for property owners, motorists and pedestrians. Rain can fall on frozen streets, cars, and other sub-freezing surfaces, creating dangerous conditions.

Lightning severity is typically investigated for both property damage and life safety (injuries and fatalities). The number of reported injuries from lightning is likely to be low. County infrastructure losses can be up to thousands of dollars each year.

Tornadoes are potentially the most dangerous of local storms, but they are not common in the planning area. If a major tornado were to strike within the populated areas of the county, damage could be widespread. Businesses could be forced to close for an extended period or permanently, fatalities could be high, many people could be homeless for an extended period, and routine services such as telephone or power could be disrupted. Buildings could be damaged or destroyed.

Extreme Temperatures

Extreme heat is one of the most deadly weather-related disasters, killing approximately 1,220 people in the United States each year (CDC 2024). Extreme heat generally occurs in Chelan County during the summer months. Extreme heat can impact the community in a variety of ways; high temperatures can lead to heat-related illnesses such as heat exhaustion and heat stroke. In addition, high temperatures can cause widespread impacts on the economy through heat stress in crops and damage to roads. In addition, due to high heat days, tourism may decline.

Extreme cold events occur in Chelan County during the winter months. These temperatures may lead to an increase in hypothermia and frostbite. In addition, if an extreme cold event occurs early or late in the growing season, crops can be damaged which may impact the harvest.

14.2.3 Previous Occurrences

Historically, Chelan County has been subject to many types of storms. These have varied in intensity from mild to severe. Common types of storms in this area include thunder, hail, wind, winter-related blizzards, etc. While not all of these have caused major long-term problems, they all have disrupted people's day-to-day activities and posed a burden, especially on the poor and elderly. Table 14-1 lists notable severe storms in Chelan County.

Table 14-1. Notable Recent Severe Storms in Chelan County

Date	Type	Description
January 1950	Snow	Eastern Washington received up to 50 inches of snow.
October 1950	Wind	Entire state, max. velocity 57 to 60 mph.
March 1956	Wind	Entire state, max. velocity 48 to 60 mph.
December 1968	Snow	Chelan County extensive snowfall. In Wenatchee, the record low temperature was set on December 30, 1968 at -19 degrees Fahrenheit. The same day, Leavenworth set their record low temperature at -36 degrees.
March 1972	Rain	Wenatchee area record rainfall for 24 hour period. Flash flood on 1970 burn scar.
June 1972	Hail	Wenatchee area, extensive soft fruit damage.
August 1979	Thunder	Entiat and Chelan area, ignited largest wildfires in the nation for 1970s.
January 1983	Wind	Wenatchee area, peak gusts 52+ mph.
March 1988	Wind	Entire county, unofficial gust 100+ in the Manson and Wenatchee areas.
January 1996	Snow	Several structures damaged due to snow loads.
January 1997	Snow	Passes closed two days due to heavy snow and avalanche danger.
December 2006	Wind	Widespread power outage in Lake Wenatchee and Entiat Valley .
January 2007	Snow	Power outages countywide.
January 2007	Wind	A strong lee side trough east of the Cascades led to strong damaging gravity wave winds. Where these gravity waves mixed down to the surface, extensive to catastrophic damages occurred causing over $10 million in property damages.
December 2012	Snow	Several rounds of heavy snow fell across the East Slopes of the Washington Cascades between December 16 and 24 causing $5.6 million in property damages within the region.
January 2018	Wind	The Wenatchee World Newspaper reported numerous trees downed by strong wind gusts in excess of 81 mph in and around Wenatchee between 3 pm and 5 pm. At least two large trees fell on houses in Wenatchee and East Wenatchee and numerous power lines were taken out by falling trees.
February 2019	Extreme Cold	The Wenatchee World Newspaper reported that severe cold snap brought temperatures well below freezing, leading to burst pipes and hazardous driving conditions. This event impacted the region's fruit trees, causing concerns about potential damage to the apple and cherry crops.

Date	Type	Description
October 2019	Wind	A strong cold front swept through eastern Washington. The strong wind gust (likely greater than 60-70 mph) topped a tree in Leavenworth, resulting in the damage of two homes and the injury of three people. The property damage is estimated $50,000.
January 2020	Winter Storm	After a series of winter storms, the region received 2 to 5 feet of snow. Highway 2 at Stevens Pass had to be closed due to numerous accidents. In addition, BSNF railroad company had to close the rail line across Stevens Pass for two days, due to hundreds of downed trees. This event caused $1,000,000 in damages.
December 2021	Wind	Sustained winds of 20-30 mph with gust reaching 55 mph caused 1,200 people in Chelan County to be without power.
June 2021	Extreme Heat	The regionwide heat dome killed an estimated 1,200 people in British Columbia, Oregon, and Washington. The ground temperatures in Wenatchee reached 145 degrees Fahrenheit, and air temperatures set records in Wenatchee at 113 degrees.
January 2022	Winter Storm	A severe snow storm set a daily record for snowfall in Leavenworth, with 34 inches received overnight. The storm closed all four mountain passes for several days, closed businesses, and caused roofs to collapse.
April 2022	Winter Storm	US Highway 2 and Steven Pass were closed due to snow accumulation reaching 23.5 inches, high winds, blowing snow, and poor visibility.
July 2022	Extreme Heat	A heat wave began on July 25, with temperatures reach above 100 degrees Fahrenheit. This event lead to the death of an elderly Wenatchee woman who ventured outside of the assisted living facility where she resided.
January 2024	Extreme Cold	The Wenatchee World Newspaper reported that Wenatchee received an unprecedented cold spell, with the temperature on January 13th reaching -10 degrees Fahrenheit.

Disaster and Emergency Declarations

The following summarizes disaster declarations or emergency proclamations related to the severe weather hazard.

- Federal DR or EM Declaration, 1953-2023: 7 events classified as severe storm

14.2.4 Overall Probability

Many of the recorded severe weather events for Chelan County have been related to high winds and severe winter weather. The planning area can expect to experience exposure to some type of severe weather event at least annually. According to records, in 55 years, the county has experienced 153 severe weather events, for an average of two to three events per year.

14.2.5 Warning Time

Meteorologists can often predict the likelihood of a severe weather event, such as extreme temperatures, windstorms, winter weather, or thunderstorms. This can give several days of warning time. However, meteorologists cannot predict the exact time of onset or severity of a storm. Some storms may come on quickly, with only a few hours of warning time. The Seattle and Spokane Offices of the National Weather Service (NWS) monitor weather stations and issue watches and warnings when appropriate. Watches and warnings are broadcast over NOAA weather radio and are forwarded to local media for re-transmission using the Emergency Alert System.

14.2.6 Climate Change Impacts

Climate change presents a challenge for risk management associated with severe weather. The science for linking the severity of specific severe weather events to climate change is still evolving; however, a number of trends provide some indication of how climate change may be impacting these events. The Intergovernmental Panel on Climate Change reports that heatwaves have become more frequent and severe over the past few decades. Global temperatures are anticipated to continue rising for decades, due to greenhouse gas emissions (IPCC 2021). Extreme heat days in the planning area are likely to increase; according to the CMRW, Chelan County can expect at least one more day over 100 degrees Fahrenheit, an average summertime temperature that increases by four degrees, and an average increase of seven additional 90 degree humidex days (Climate Mapping for a Resilient Washington 2024).

In addition, rising temperatures lead to more water vapor being evaporated in atmosphere. This, in turn, leads to more fuel for severe storms (USGS n.d.) With a warmer atmosphere, there is potential to hold more moisture, which may lead to more severe winter storms in areas where temperatures are cold enough for snow, like Chelan County (National Geographic 2020).

Climate change impacts on other severe weather events such as thunderstorms and high winds are still not well understood.

14.2.7 Future Trends in Development

Chelan County is anticipated to continue growing. A higher population density can lead to more people being affected by severe weather, increasing the potential for injuries, casualties, and strain on emergency services. In addition, evacuation and relief efforts may become more difficult with a larger population. All future development will be affected by severe weather. The ability to withstand impacts lies in sound land use practices and consistent enforcement of codes and regulations for new construction. The planning partners have adopted the International Building Code in response to Washington State mandates. This code is equipped to deal with the impacts of severe weather events through wind and snow load requirements, and the energy code. Land use policies identified in comprehensive plans within the planning area also address many of the secondary impacts (flood and landslide) of the severe weather hazard. To combat the effects of urban heat island effect, communities can implement design standards and urban planning principles that reduce the impacts of excessive heat events. With these tools, the planning partnership is well equipped to deal with future growth and the associated impacts of severe weather.

14.3 SECONDARY HAZARDS

Depending upon the time of year, additional hazards resulting from a severe storm or extreme temperatures can include wildfires, flash floods, avalanches or landslides. Secondary effects can include severe wind erosion of dry soils, overtaxing of electric utilities during severe weather conditions, crop damage from hail, agricultural losses resulting from inflated prices, and temporary shortages of necessities in a storm-impacted area.

14.4 VULNERABILITY AND IMPACTS

14.4.1 People

The entire Chelan County population is vulnerable to severe weather and may be impacted. The most common problems associated with severe weather events are immobility and loss of utilities. Populations living at higher elevations with large stands of trees or power lines may be more susceptible to wind damage and black out, while populations in low-lying areas are at risk for possible flooding. In general, populations who lack adequate shelter during severe weather events, those who are reliant on sustained sources of power in order to survive, and those who live in isolated areas with limited ingress and egress options are the most impacted. The most common impacts of specific weather event types on people are as follows:

- **Winter Storms**—Deaths and injuries from severe winter storms are generally the result of traffic accidents, heart attacks from shoveling snow, and frostbite or hypothermia from prolonged exposure to the cold. Death and injury may also result from flooding from severe winter storms. About 70% of snow and ice-related injuries occur in automobiles, and 25% result from exposure. Of those killed or injured, 50% are people over the age of 60; more than 75% are male; and 20% occur in the home (National Severe Storms Laboratory n.d.). Vulnerable populations, such as those with poor quality housing, the homeless, or those without access to a vehicle may be the most impacted. They may experience high heating bills, inability to travel to work, or even death due to lack of shelter.
- **Severe Thunderstorms**—Flash flooding caused from thunderstorms kills more people each year than hurricanes, tornadoes, or lightning (National Severe Storms Laboratory n.d.). Flash flooding often occurs in the canyons above Wenatchee, causing property damage. Dry thunderstorms accompanied by wind can cause fast moving fires. Those that are low-income may struggle to recover from flood damage, and those that are disabled, elderly, or young may be unable to evacuate on their own.
- **High Winds**—Damaging winds can cause injuries and fatalities in several ways. Downed trees may fall on homes or cars, killing or injuring those inside. Objects that are not secured can be picked up in wind events and become projectiles. Structures that collapse or blow over during damaging wind events, especially tornadoes, may kill or injure those seeking shelter inside. Vulnerable populations may be unable to recover from damage to their homes caused by high wind, which may require roof or structural repairs.
- **Extreme Temperatures**—During periods of extreme heat, residents of Chelan County can suffer from heat-related illnesses such as heat exhaustion or heat stroke. Cold waves may lead to an increased risk of hypothermia and frostbite. The individuals most vulnerable to extreme temperatures are the elderly, children, and those with pre-existing health conditions. Extreme heat can be deadly for people who do not have air conditioning, shelter, or who do not stay hydrated. Extreme cold can cause very high power bills, places a burden on the low-income population who do not live in energy efficient and well insulated homes.
- Severe weather often causes power outages. During winter storms and extreme temperatures, power outages can be deadly. During extreme heat, air conditioners and refrigerators stop working, which especially impacts the elderly and those with poor health or those that require refrigerated medicines, such as insulin. Power outages also limit communication capabilities, as most communication now occurs over the internet or cell service, which require electricity to operate.

14.4.2 Structures

All structures are vulnerable to severe weather and can potentially be impacted during severe weather events, but properties in poor condition or in particularly vulnerable locations may risk the most damage. Critical facilities are vulnerable during severe weather events, especially those that lack backup power generation capabilities. The most common impacts of specific weather event types on structures are as follows:

- **Winter Storms**—Damage from severe winter storms in the planning area is most likely to be related to secondary hazards, such as major or localized flooding or landslides. Damage could also be caused by tree fall, roof collapse, or other incidents caused by heavy snowfall. The transportation system is especially impacted by winter storms, and road closures, especially on mountain passes, is a frequent event in the winter.
- **Severe Thunderstorms**—Damage from thunderstorms in the planning area is most likely to be related to secondary hazards accompanying the event, such as flooding, wildfire, or damaging winds. If lightning directly strikes a building, it may cause substantial damage and may even set the structure on fire.
- **High Winds**—Mobile homes can be seriously damaged by wind gusts over 80 mph, even if they are anchored (National Severe Storms Laboratory n.d.). According to the SVI, there are about 3,633 mobile homes in the planning area, totaling 9.7% of all residential structures. Properties at higher elevations or on ridges may be more prone to wind damage. Falling trees can result in significant damage to structures. High wind can damage roofs by ripping of shingles. Roads and other transportation infrastructure could be blocked by downed trees or other debris.
- **Extreme Temperatures**— Extreme cold events may lead to pipes freezing, resulting in property damage. Extreme heat without air conditioning may cause a building to be uninhabitable due to temperatures.

All severe weather can cause impacts to communication and power facilities. If facilities supplying power to planning area land line telephone systems were disrupted due to severe weather, significant issues would arise with communication in the planning area. In addition, some facilities are particularly vulnerable to specific types of severe weather events.

14.4.3 Systems

Emergency response capabilities, economic systems, and government capabilities are vulnerable and may be impacted by severe weather. During severe weather events such as high winds and winter storms, power may be out, communication networks may be down and critical transportation routes may be impassible. Therefore, first responders may face difficulty responding effectively and coordinating efforts.

Severe storms often overwhelm agencies that are responsible for road maintenance.

Severe weather, including extreme heat and cold, may lead to business closures and economic losses. When transportation routes are closed or employees unable to travel to work, businesses suffer.

14.4.4 Natural, Historic, and Cultural Resources

Natural resources are highly vulnerable to severe weather events. Natural habitats such as streams and trees are vulnerable to the elements during severe weather risk major damage and destruction. Prolonged rains can saturate soil and lead to slope failure. Flood events caused by severe weather or snowmelt can produce river channel migration or damage riparian habitat. Climate change is a major driver impacting weather patterns and, in turn, the natural environment. For example, as there are fewer freezing days along the eastern Cascade slopes and fewer bark beetles are dying, severely stressing existing forests. Different species will fill this vacated niche. This, as with all adaption, will benefit some and adversely impact others.

Historic and cultural resources may be damaged by severe weather. Historic and cultural sites may be damaged from flooding or heavy snow. Extreme temperatures may affect events and the ability to gather.

14.4.5 Activities that Have Value to the Community

Activities that have value to the community are vulnerable to all severe weather events. Severe weather such as high winds, winter storms, severe thunderstorms and extreme temperatures may lead to cancellation of events, temporary closure of businesses, and disruptions in services.

14.4.6 Agriculture

All agriculture within Chelan County faces significant vulnerability and impacts from severe weather. Because of this, it is imperative that farmers have crop insurance, which protects against severe weather.

- **Winter Storms**—Heavy snow can be beneficial to agriculture, especially if it falls as mountain snowpack. On field crops, snow can help to insulate the ground and protect dormant crops from freezing. Melting snow also puts moisture back into the ground. However, snow may also cause damage in orchards by causing limbs to break. Snow in the late spring can be especially devastating to tree fruit by damaging flower buds.
- **Severe Thunderstorms**—Too much water can cause damage to a farm. Floods can postpone the planting of crops along with oxygen depletion after they are planted. Flooding enhances the possibility of disease and triggers nitrogen loss in crops. Different crops react differently to flooding but they all risk loss from too much water. The damage done by a hailstorm depends on the size of the hail and regularity of the storm. The larger the hail, the greater the damage. Hail can bruise fruits and vegetables or totally destroy a crop. Rain can wash away pollen grains from the flowers of fruit trees.
- **High Winds**—Windstorms can tear crops out of the ground or pound them flat. The wind can dry out plants, move soil, and cause erosion, as well as disperse weed seeds. High winds reduce pollinator activity.
- **Extreme Temperatures**— Extreme heat can lead to heat stress on crops and animals and a decreased crop yield (University of Washington 2024). During a prolonged period of extreme cold, livestock will need more feed to maintain body temperatures and health. This will increase feeding cost for farmers during the winter months. Cold temperatures can be devastating to tree fruit. It can reduce pollination activity and kill flower buds (Sallato and Whiting 2022).

14.4.7 National Risk Index

According to the National Risk Index (NRI), Chelan County has mostly low risk ratings for severe weather hazards, except for heat waves. Table 14-2 provides the risk factor breakdown. See Section 7.2 for a description of the components of the NRI.

Table 14-2. NRI Scoring for Severe Weather Hazards in Chelan County

Hazard Type	Expected Annual Loss	Risk Index Rating	Community Resilience	Social Vulnerability	Risk Value	Risk Index Score
Winter Storms	$53,689	Relatively Low	Relatively Moderate	Relatively High	$68,326	53.5
Ice Storms	$233	Very Low	Relatively Moderate	Relatively High	$306	0.8
Strong Winds	$54,846	Very Low	Relatively Moderate	Relatively High	$72,742	15.3
Lightening	$149,815	Relatively Low	Relatively Moderate	Relatively High	$199,355	69.2
Hail	$38,964	Very Low	Relatively Moderate	Relatively High	$52,722	34.3
Tornado	$44,583	Very Low	Relatively Moderate	Relatively High	$58,753	9.5
Cold Wave	$34	Very Low	Relatively Moderate	Relatively High	$4,082,471	29.1
Heat Wave	$3,024,138	Relatively High	Relatively Moderate	Relatively High	$49	97.1

14.5 SCENARIO

A worst-case severe-weather event would involve prolonged high winds during a winter storm with large amounts of precipitation after soils are already saturated. Such an event would have both short-term and long-term effects. Initially, schools and roads would be closed due to power outages caused by high winds and downed tree obstructions. Some areas of the county could experience limited ingress and egress. Prolonged rain could produce flooding, overtopped culverts with ponded water on roads, mud over roadways, and landslides on steep slopes. Floods and landslides could further obstruct roads and bridges, further isolating residents. If major landslides impact the two major highways in the planning area, significant transportation disruption could result.

14.6 ISSUES

Severe local storms are probably the most common widespread hazard. They affect large numbers of people in the planning area when they occur. Severe storms can quickly overwhelm city and county resources. Residents should be prepared for these types of storms: family plans should be developed, disaster kits should be put in homes, workplaces, schools and cars, and every family member should be taught how to shut off household utilities. Early dismissal from schools and businesses is an effective mitigation measure and should be encouraged.

Severe weather cannot be prevented, but measures can be taken to mitigate the effects. Critical infrastructure and utilities can be hardened to prevent damage during an event. The secondary effect of flooding can be addressed through decreasing runoff and water velocity. Important issues associated with severe weather in the planning area include the following:

- Dead or dying trees are more susceptible to falling during severe storm events.
- Debris management (downed trees, etc.) must be addressed, because debris can impact the severity of severe weather events, requires coordination efforts, and may require additional funding.
- Major transportation routes in the planning area are limited. If severe weather results in road closures, there could be cascading impacts on the county-wide transportation system, resulting in delays in response and recovery.

- Older building stock in the planning area is built to low code standards or none at all. These structures could be highly vulnerable to severe winter weather effects such as snow loads or high winds.
- Mobile homes are also vulnerable to damaging winds.
- Power outages that disrupt land line service could cause significant communication disruption.
- Priority snow removal routes should continue to be cleared first to ensure navigable routes through and between jurisdictions.
- Public education on dealing with the impacts of severe weather needs to continue so that residents can be better informed and prepared for severe weather events.
- Redundancy of power supply throughout the planning area must be evaluated to better understand what areas may be vulnerable.
- Street tree management programs should be evaluated to help reduce impacts from tree-related damages.
- The capacity for backup power generation is limited.
- The County has numerous isolated population centers.
- Vulnerable populations may live in poorly insulated structures, creating greater impacts from heat and cold events, or may not have air conditioning or efficient heating.
- Heat and cold can both stress agricultural commodities, especially tree fruit.

14.7 MITIGATING THE HAZARD

Table 14-3 presents a range of potential opportunities for mitigating the severe weather hazard.

Table 14-3. Potential Opportunities to Mitigate the Severe Weather Hazard

Community Scale	Organizational Scale	Government Scale
Manipulate the Hazard		
None	None	None
Reduce Vulnerability and Impacts		
• Insulate structures • Provide redundant heat and power • Plant appropriate trees near home and power lines (“Right tree, right place” National Arbor Day Foundation Program) • Trim or remove trees that could affect power lines	• Relocate critical infrastructure (such as power lines) underground • Reinforce or relocate critical infrastructure such as power lines to meet performance expectations • Install tree wire • Trim or remove trees that could affect power lines	• Harden infrastructure such as locating utilities underground • Trim or remove trees that could affect power lines • Designate snow routes and strengthen critical road sections and bridges

Build Local Capacity		
• Promote 72-hour self-sufficiency • Obtain a NOAA weather radio • Obtain an emergency generator	• Create redundancy • Equip facilities with a NOAA weather radio • Equip critical facilities with emergency power sources	• Support programs such as "Tree Watch" that proactively manage problem areas through use of selective removal of hazardous trees, tree replacement, etc. • Increase communication alternatives • Modify land use and environmental regulations to support vegetation management activities that improve reliability in utility corridors. • Modify landscape and other ordinances to encourage appropriate planting near overhead power, cable, and phone lines • Establish and enforce building codes that require all roofs to withstand snow loads • Consider the probable impacts of climate change on the risk associated with the severe weather hazard • Provide NOAA weather radios to the public
Nature-Based Opportunities		
None identified		

15. WILDFIRE AND WILDFIRE SMOKE

15.1 GENERAL BACKGROUND

15.1.1 Factors Affecting Wildfire Risk

A comprehensive discussion of fire mitigation requires a fundamental understanding of the key concepts that govern fire behavior. In the broadest sense, wildland fire behavior describes how fires burn, the manner in which fuels ignite, how flames develop, and how fire spreads across the landscape. The three major physical components that determine fire behavior are the fuels consumed by fire, the topography in which the fire is burning, and the weather and atmospheric conditions during a fire event.

At the landscape level, topography and weather—such as winds, temperature, humidity, and slope—are beyond our control. To influence how fires burn, we focus on manipulating the third component of the fire environment: the fuels that support the fire. By altering fuel loading and fuel continuity across the landscape, we have the best opportunity to control or affect how fires burn.

Topography

Fires burn differently under varying topographic conditions. Topography alters heat transfer and localized weather conditions, which in turn influences vegetative growth and resulting fuels. Changes in slope and aspect can have significant influences on how fires burn. North slopes tend to be cooler, wetter, more productive sites. This can lead to heavy fuel accumulations, with high fuel moistures, later curing of fuels, and lower rates of spread. In contrast, south and west slopes tend to receive more direct sun, and thus have the highest temperatures, lowest soil and fuel moistures, and lightest fuels. The combination of light fuels and dry sites leads to fires that typically display the highest rates of spread and means that these slopes are subject to active fire during more of the year than north and east-facing aspects. Prevailing westerly winds in this region often intensify fire activity on south and west-facing slopes.

Slope also plays a significant role in fire spread, by allowing preheating of fuels upslope of the burning fire. As slope increases, rate of spread and flame lengths tend to increase. Therefore, we can expect the fastest rates of spread on steep, warm south and west slopes with fuels that are exposed to the wind.

Fuels

Fuel is any material that can ignite and burn. This includes organic material, dead or alive, in the fire environment—grasses, brush, branches, down woody material, forest floor litter, conifer needles, and buildings. The characteristics of fuels, such as their physical properties, play a critical role in determining fire behavior. Fuel loading, size and shape, moisture content, and continuity and arrangement all affect fire behavior. Generally speaking, the smaller and finer the fuels, the faster the potential rate of fire spread. Small fuels such as grass, needle litter, and other fuels less than a quarter inch in diameter are most responsible for fire spread. In fact, “fine” fuels, with high surface-to-volume ratios, are considered the primary carriers of surface fire. Anyone who has observed grassfires can attest to their rapid spread.

As fuel size increases, the rate of spread tends to decrease due to a decrease in the surface-to-volume ratio. Fires in large fuels generally burn at a slower rate but release much more energy and burn with much greater intensity. This increased energy release, or intensity, makes these fires more difficult to control. Thus, it is much easier to control a fire burning in grass than to control a fire burning in timber.

When burning under a forest canopy, the increased intensities can lead to torching (single trees becoming completely involved) and potential development of crown fires. Fuels are found in combinations of types, amounts, sizes, shapes, and arrangements. It is the unique combination of these factors, along with the topography and weather, that determines how fires will burn.

The study of fire behavior recognizes that small changes in any component of fire behavior can dramatically and unpredictably alter how fires burn. It is impossible to speak in specific terms when predicting how a fire will burn under any given set of conditions. However, through countless observations and repeated research, some of the principles that govern fire behavior have been identified and are recognized.

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 capable of sudden changes in speed and direction, causing 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 most damaging firestorms are usually marked by high winds. The powerful and unpredictable influence of wind on fire behavior poses a major safety concern for firefighters. In a 1994 fire in Colorado, a sudden change in wind speed and direction led to a blowup that claimed the lives of 14 firefighters.

15.1.2 Factors Affecting Wildfire Smoke

As wildfires have increased in intensity and numbers each summer, wildfire smoke has become a greater concern due to the health impacts. Wildfire smoke is a mixture of gasses released by burning vegetation that include carbon monoxide, carbon dioxide, hydrocarbons, and particulate matter. The composition of wildfire smoke depends on many factors, including vegetation burned, fuel loads, fuel moisture, fire intensity. The dispersion of wildfire smoke depends on the weather. When smoke plumes rise into the atmosphere, they are caught by winds and transported to different regions. Chelan County is frequently impacted by smoke from wildfires in California, Oregon, and Canada.

15.1.3 Wildfire Types

Fire types are generally characterized based on the type of fuels they consume:

- **Ground fires** are fueled by roots and buried organic matter and can smolder or burn slowly for days or even months.
- **Crawling or surface fires** burn low-lying vegetation such as tree litter, grass, and shrubs.
- **Ladder fires** burn material between ground vegetation and tree canopies, such as small trees, downed logs and vines. Invasive plants that climb trees may encourage ladder fires.

- **Crown, canopy or aerial fires** burn suspended material at the canopy level, such as tall trees, vines and mosses. Crown fires ignite based on factors like the density of the suspended material, canopy height, canopy continuity, and the presence of surface and ladder fires to reach the tree crowns.

15.2 HAZARD PROFILE

15.2.1 Location

Wildfires, especially in the wildland-urban interface, are among Chelan County’s most significant natural hazards. Chelan County's dry summer climate, varied topography, extensive forests, and open grasslands, combined with heavy recreational use, make the county highly susceptible to wildfires. Several wildland-urban interface communities in the county are designated as high-risk by the State Forester, including the cities of Cashmere, Entiat, Leavenworth, and Wenatchee, as well as the rural communities of Stehekin, Peshastin, and Manson. Because wildfire smoke is often weather driven, all areas of the Chelan County are subject to wildfire smoke.

The Washington State Emergency Management Division maps significant fire hazard areas based on fire behavior potential, fire protection capacity, and risks to social, cultural, and community resources. Risk is determined by factors such as fire history, fuel type and density, extreme weather, topography, structure density, proximity to fuels, location of municipal watersheds, and potential loss of homes or businesses (Washington Emergency Management Division, 2014).

The upcoming 2025 update to the Chelan County Community Wildfire Protection Plan (CWPP) includes maps of burn probability (Figure 15-1), fire behavior class (Figure 15-2), structure exposure to embers and radiant heat (Figure 15-3), and critical infrastructure exposure (Figure 15-4). Each of these layers was used in this assessment to identify the extent and location of wildfire hazards in the planning area.

Burn Probability

Burn probability is the relative likelihood of any location burning due to a wildfire based on landscape characteristics including existing vegetation and surface fuels, terrain, climate, and fire history.

Burn probability from the 2023 Pacific Northwest Quantitative Wildfire Risk Assessment is displayed in Figure 15-1; the scale is relative to the county itself. The areas with the highest burn probabilities include the mountains from northeast of Lake Wenatchee down east of Chumstick and to the Wenatchee River by Cashmere, along the Icicle River and up into the Alpine Lakes Wilderness, and the area south of Leavenworth and Cashmere heading toward Blewett Pass. Other populated areas with higher burn probability include the Wenatchee National Forest land north of eastern Lake Chelan around Chelan and Manson, and the Wenatchee National Forest and Washington DNR land north and west of Entiat.

Fire Behavior Class

Fire behavior class was determined by combining predictions of flame length and crown fire activity following the Haul Chart (Figure 15-2). High to extreme fire behavior includes ember production that ignites additional fires away from the main fire and the movement of high-intensity fire from treetop to treetop. Such fires are extremely challenging if not impossible to control until winds die down and fuel moistures increase.

Many of the same areas that are exposed to high burn probabilities also are predicted to have high to extreme fire behavior – Along Icicle River, all around Lake Wenatchee and Leavenworth, east of Chumstick, and near

Blewett Pass. There are other areas that are predicted to have this intense fire behavior, including the center of the Entiat valley, north and south of the middle of Lake Chelan, and up valley from Stehekin.

Many of the valley bottoms and flat lands to the east of the county are predicted to have low fire behavior, which coincides with the most populated areas of the county.

Radiant Heat and Embercast

Flames and burning fuel produce significant amounts of heat that radiates from the combusting fuel outwards. This exposure to radiant heat is sometimes called direct exposure, as the fire itself is causing the home to ignite. Homes more often ignite due to embers – tiny pieces of coal that are small enough to fly up and away from the main fire and land elsewhere. This exposure can take place two miles away or more from the flaming front, which is why this is often referred to as indirect exposure.

Exposure is based on distance from long flame lengths and potential active crown fire assuming:

- Radiant heat can ignite homes when extreme fire behavior (flame lengths > 12 feet) occurs within 33 yards (30 meters) of structures.
- Embers can reach homes within about 550 yards (500 meters) of active crown fires.

These distance thresholds used by Beverly et al., (2010) are based on observations from actual wildfires.

Nearly the entire county is exposed to embers from burning vegetation, excluding a few communities on the eastern edge of the county (Wenatchee and Entiat). See Figure 15-3. The communities that are exposed to radiant heat include Lake Wenatchee, Leavenworth, Chumstick, Cashmere, and the rest of the communities along US Highway 2 from Berne to Monitor, the Entiat valley including Farris and Ardenvoir, much of the Chelan and Manson area, Stehekin, and the South Wenatchee and Malaga communities.

Critical Infrastructure Exposure

Radiant heat and embers not only affect homes but also the critical infrastructure that these communities rely on. Much of the infrastructure along the Columbia River is indirectly exposed to wildfire through embers, but the infrastructure that is in the mountains and along US Highway 2 are often exposed to radiant heat as well as embers. See Figure 15-4.

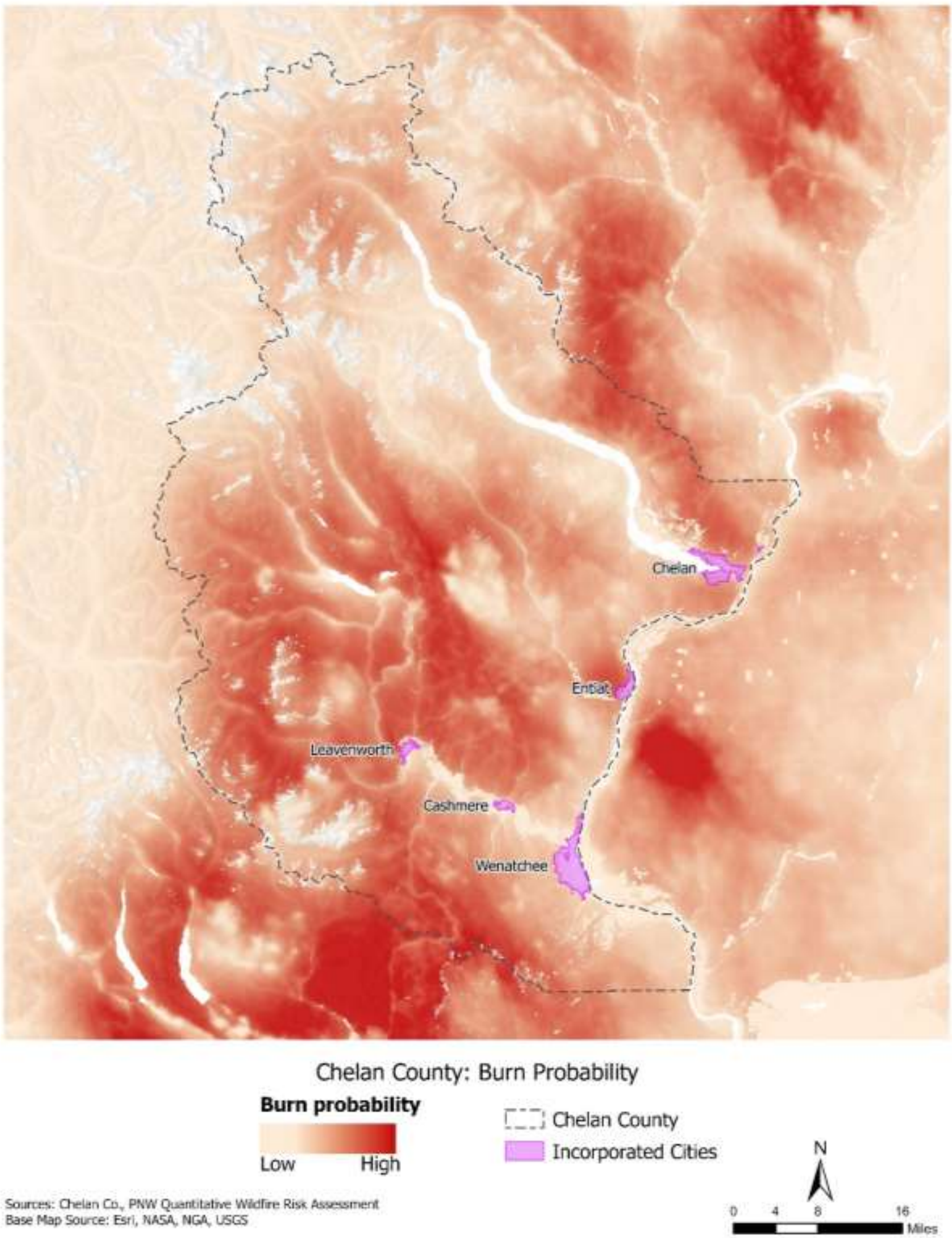


Figure 15-1. Burn probability across Chelan County

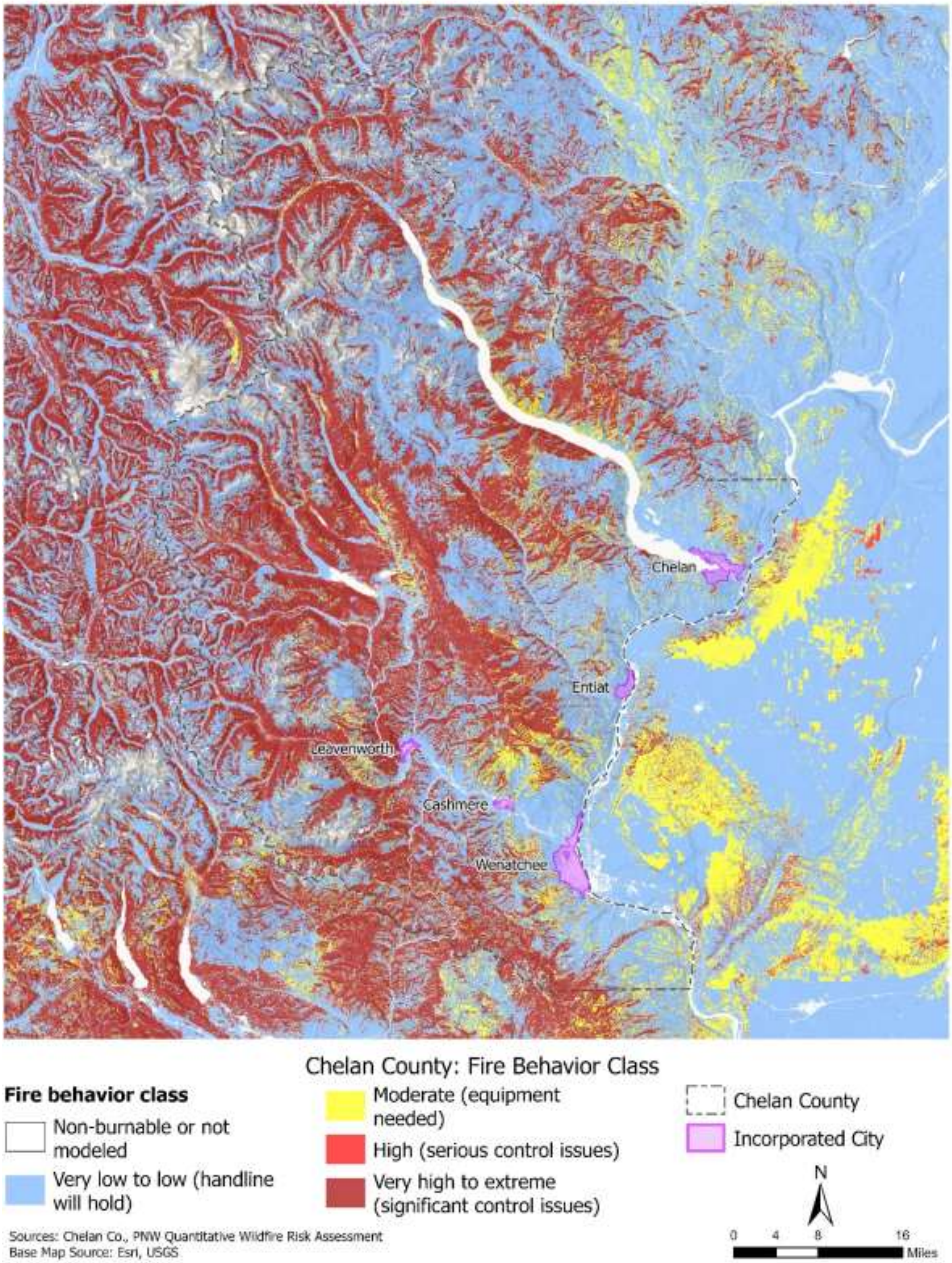


Figure 15-2. Expected fire behavior class across Chelan County

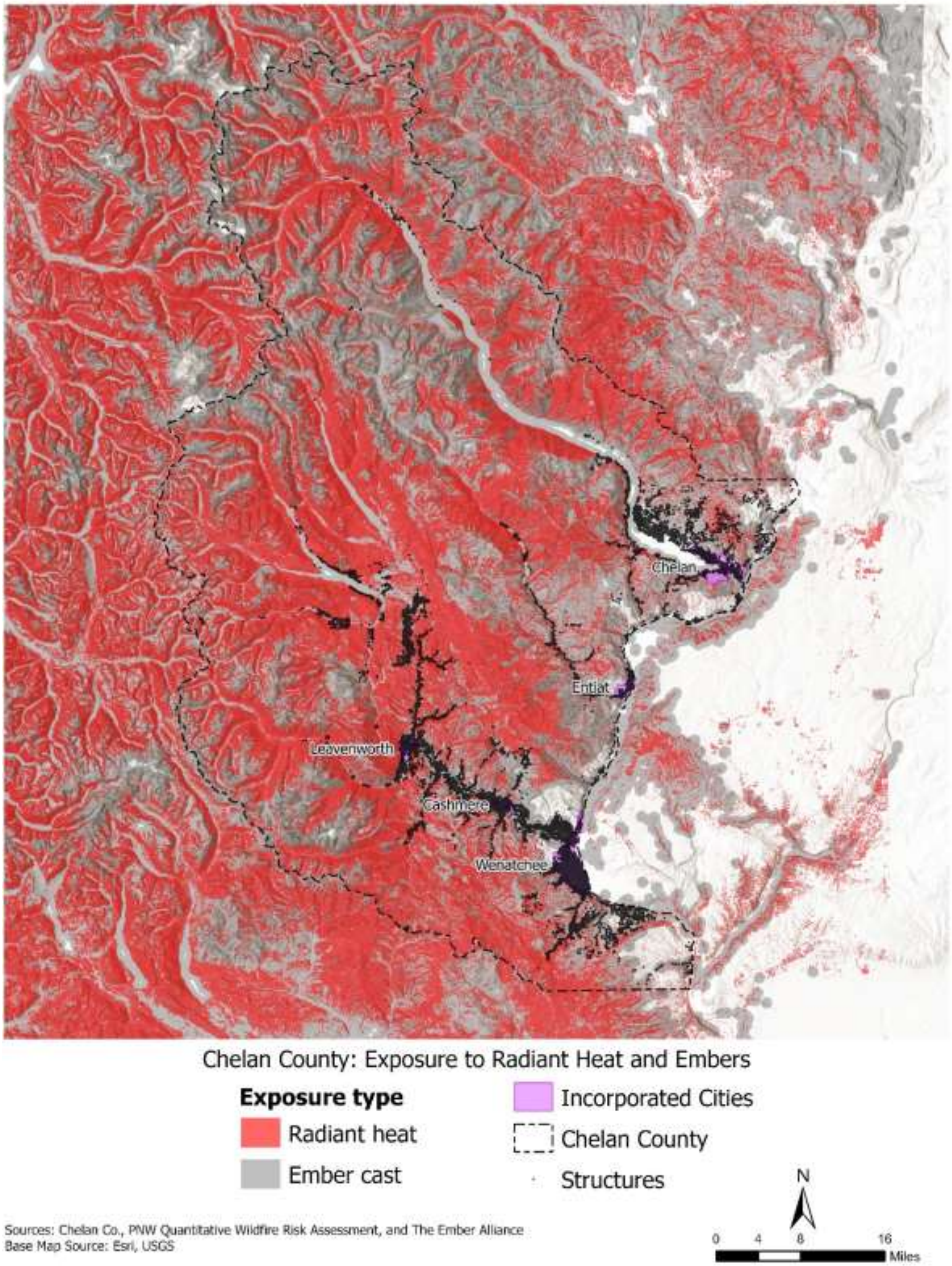


Figure 15-3. Structure exposure to embers and radiant heat across Chelan County

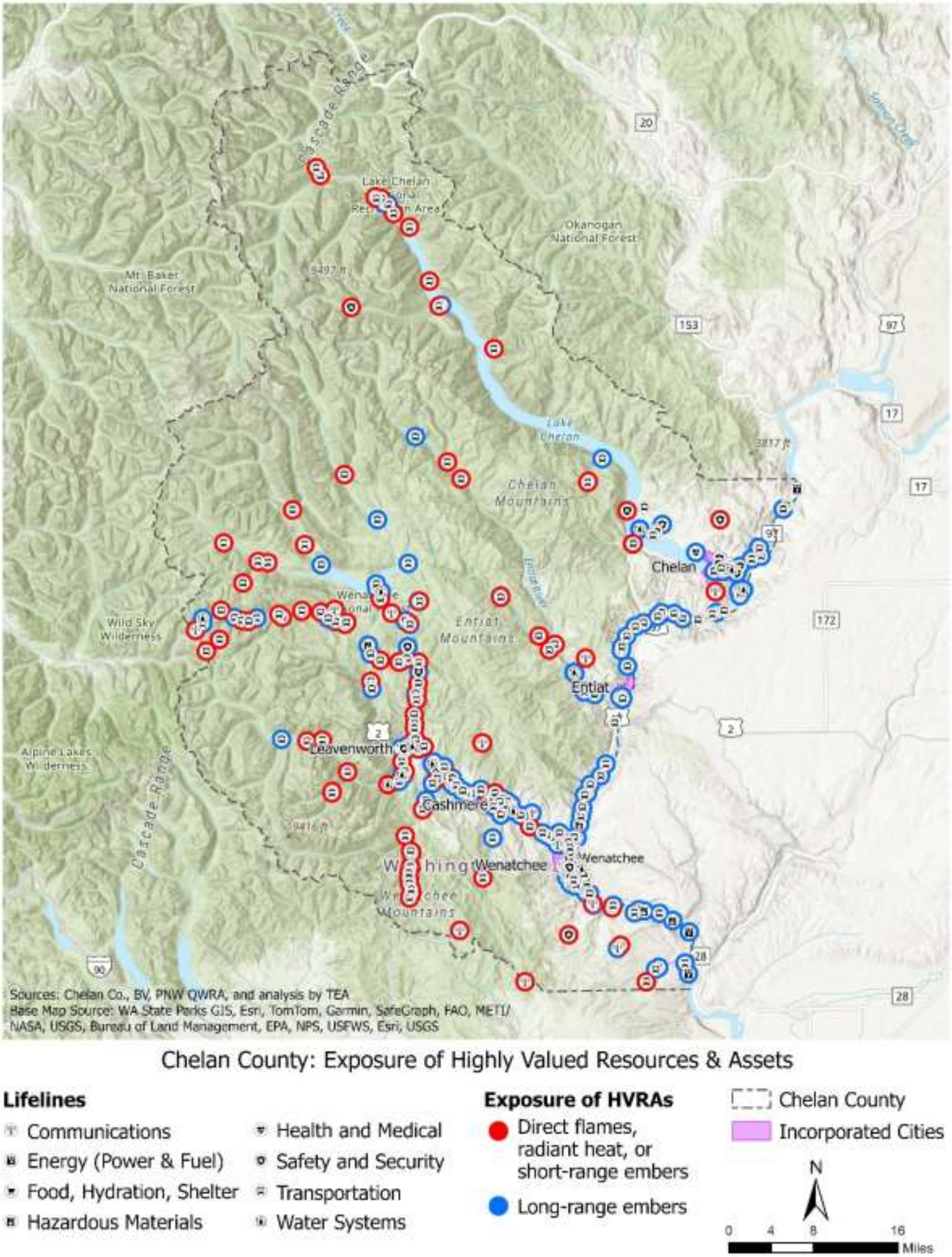


Figure 15-4. Local Level Wildfire Hazard Area

15.2.2 Extent

Significant effects of wildfire include loss of lives, personal injury, damage to private and public property and economic impact. Fires have caused economic impact on local businesses. This impacts not only business, but also government due to loss of tax revenue.

Wildfires also cause negative impacts on watersheds which, among other things, increase the soil erosion and stream degradation that contributes to potential flooding in the County. Short-term loss caused by a wildfire can include the destruction of timber, wildlife habitat, scenic vistas, and watersheds; vulnerability to flooding increases due to the destruction of watersheds. Long-term effects include smaller timber harvests, reduced access to affected recreational areas, and destruction of cultural and economic resources and community infrastructure.

Smoke from wildfires can spread hundreds to thousands of miles away from the fire, settling in low elevation valleys and communities at night. Fires from within Chelan County can affect communities that are many states away, and fires from Oregon, California, and British Columbia can have smoke impacts on communities within Chelan County.

15.2.3 Previous Occurrences

Fire was once an integral function within most ecosystems in Washington. The seasonal cycling of fire across most landscapes was as regular as the July, August and September lightning storms plying across the east slopes of the Cascades. Depending on the plant community composition, structural configuration, and buildup of plant biomass, fire resulted from ignitions with varying intensities and extent across the landscape. Shorter return intervals between fire events often resulted in less dramatic changes in plant composition. These fires burned from one to 47 years apart, with most at 5- to 20-year intervals. With infrequent return intervals, plant communities tended to burn more severely and be replaced by vegetation different in composition, structure, and age. Native plant communities in this region developed under the influence of fire, and adaptations to fire are evident at the species, community, and ecosystem levels.

Historical fire history data for Chelan County is largely unknown. Local knowledge suggests that Native Americans did frequently burn which played an important role in shaping the vegetation throughout the County. Figure 15-5 shows the fire ignition history and perimeter data in Chelan County from 1980 to mid-2023.

The following are some of the more significant fires within the planning area:

- 2024 Pioneer Fire; currently burning NW of Chelan, WA. 38,735 acres burned and still burning as of September 2024. Cause unknown (Inciweb 2024)
- 2021 Twentyfive Mile Fire, 22,217 acres burned starting August 15, 2021. This fire burned most of (more than 80% of) the Twenty-Fire Mile Creek watershed, resulting in degraded soils and high risk of flooding and debris flows.
- 2021 Red Apple Fire, 12,288 acres. The Red Apple Fire was first reported on July 13, 2021 and burned around many homes in a subdivision of north Wenatchee, causing evacuations and significant structure protection efforts that resulted in no homes being lost to the fire, though five outbuildings were damaged.
- 2018 Cougar Creek Fire. A fire was reported 10 miles northwest of the Entiat on July 28th. The fire was ignited by lightning and burned over 42,000 acres according to InciWeb. Fuels involved in the wildland

fire included; lodgepole pine/mixed conifer stands and stands of beetle killed trees. This fire also burned through an old fire scar (Tyee 1994) with dense lodgepole regeneration, snags and dead/down material.

- 2015 Chelan Complex Fires. “These fires burned over 95,000 acres and destroyed over 50 homes in the First Creek Neighborhood and the City of Chelan. The entire Lake Chelan area lost power for three days, which affected their communications network and their ability to pump water from the city fire hydrants”.
- 2015 Wolverine Fire. “This fire ignited earlier than the Chelan Complex fire but burned through the summer. This fire destroyed 4 structures and threatened numerous others including in the Chiwawa Valley and the Ponderosa Neighborhood.”
- 2015 Sleepy Hollow Fire. “This fire burned 3,000 acres and destroyed 30 residences in the Broadview neighborhood located in the western foothills of Wenatchee. The city also experienced fire starts in the center of town at several warehouses due to embers from the burning homes.”

Ignition profile

Detailed records of wildfire ignitions and extents from the Washington Department of Natural Resources and federal databases have been analyzed. In interpreting these data, it is important to keep in mind that the information represents only the lands protected by the agency specified and may not include all fires in areas covered only by local fire departments or other agencies.

The federal and state agencies database of wildfire ignitions (1990-2024) used in this analysis includes ignition and extent data within their jurisdictions and is provided in Table 15-1. During this period, the agencies recorded an average of 46 wildfire ignition per year resulting in an average total burn area of over 15,000 acres per year. The highest number of ignitions (104) occurred in 1990, while the greatest number of acres burned in a single year occurred in 1994 with over 185,671 acres burned. See Figure 15-5 which shows the locations of mapped ignitions within this time period.

Table 15-1. Summary of Cause from State and Federal Databases 1990-2024 (sources: NIFC, FOD, InFORM, FIRESTAT).

General Cause	Number of Ignitions	Percent of Total Ignitions	Acres Burned	Percent of Total Acres
Human-Caused	1,117	43%	305,983	27%
Natural Ignition	1,333	52%	695,385	60%
Unknown	119	5%	153,910	13%
Total	**2,476**	**100%**	**1,155,278**	**100%**

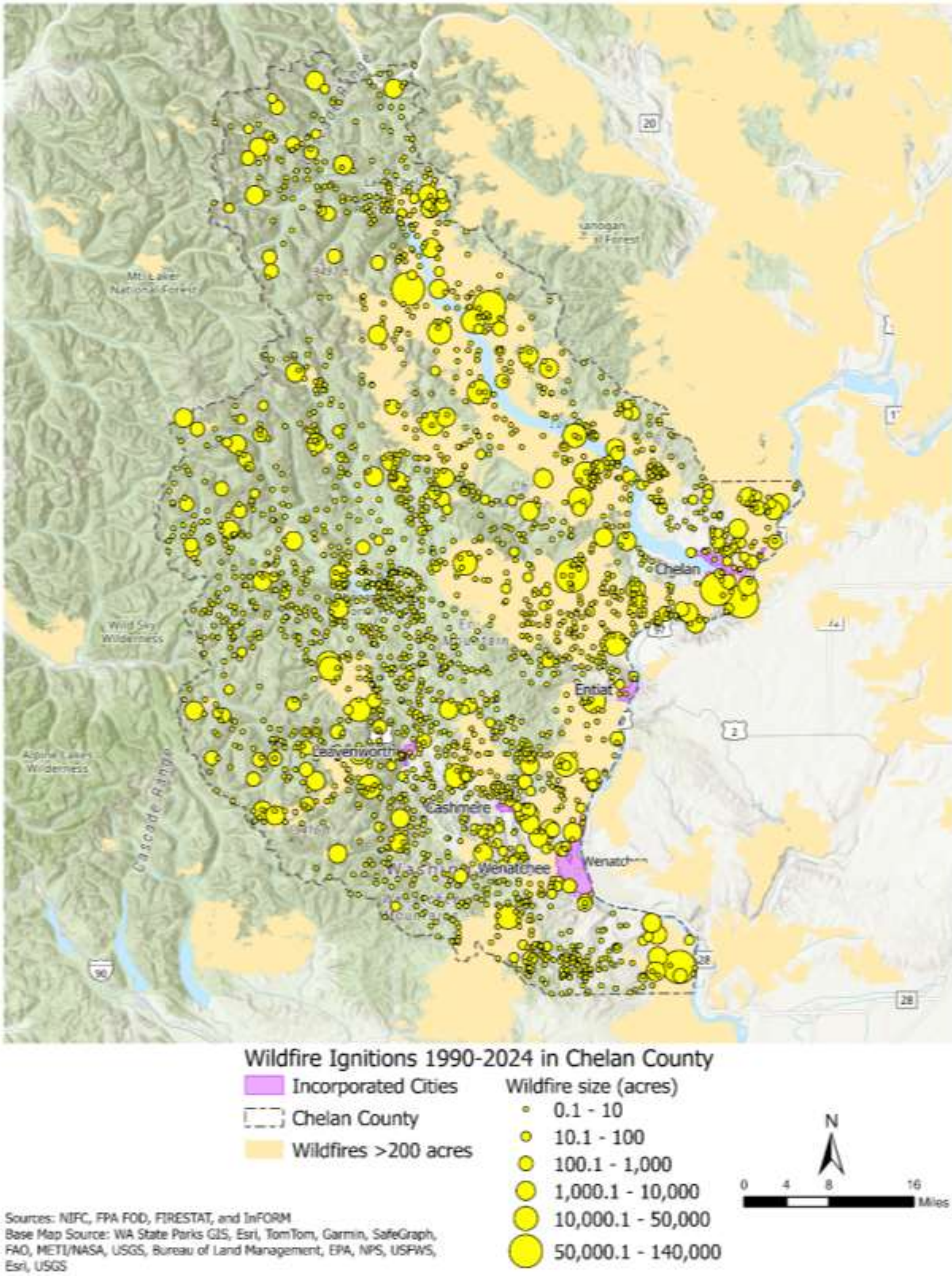


Figure 15-5. Ignition History in Chelan County from 1990-2024

Based on the agencies' combined datasets specific to Chelan County, there is an upward trend in the number of human caused ignitions per year since 1980 (see Figure 15-6), but the number of acres burned annually remains relatively constant regardless of cause (see Figure 15-7). The upward trend in human ignitions could be attributed to a higher amount of people moving to more rural areas of Chelan County.

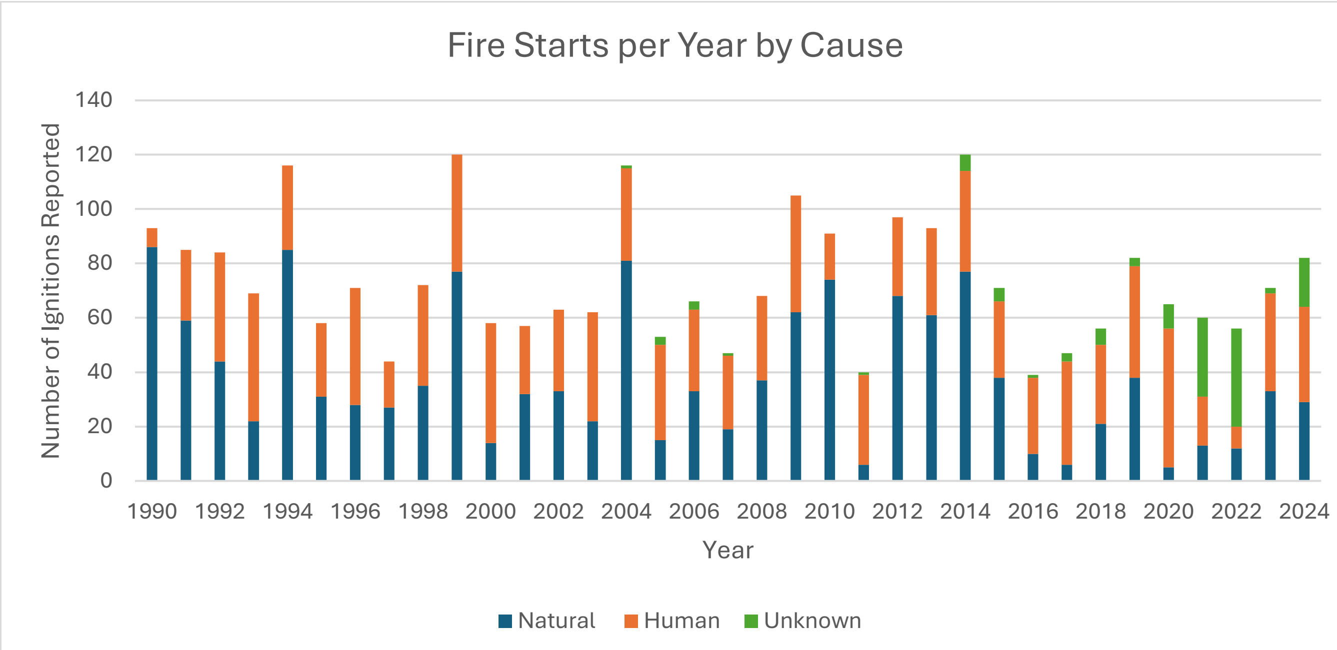


Figure 15-6. Summary of reported ignitions in Chelan County by Cause

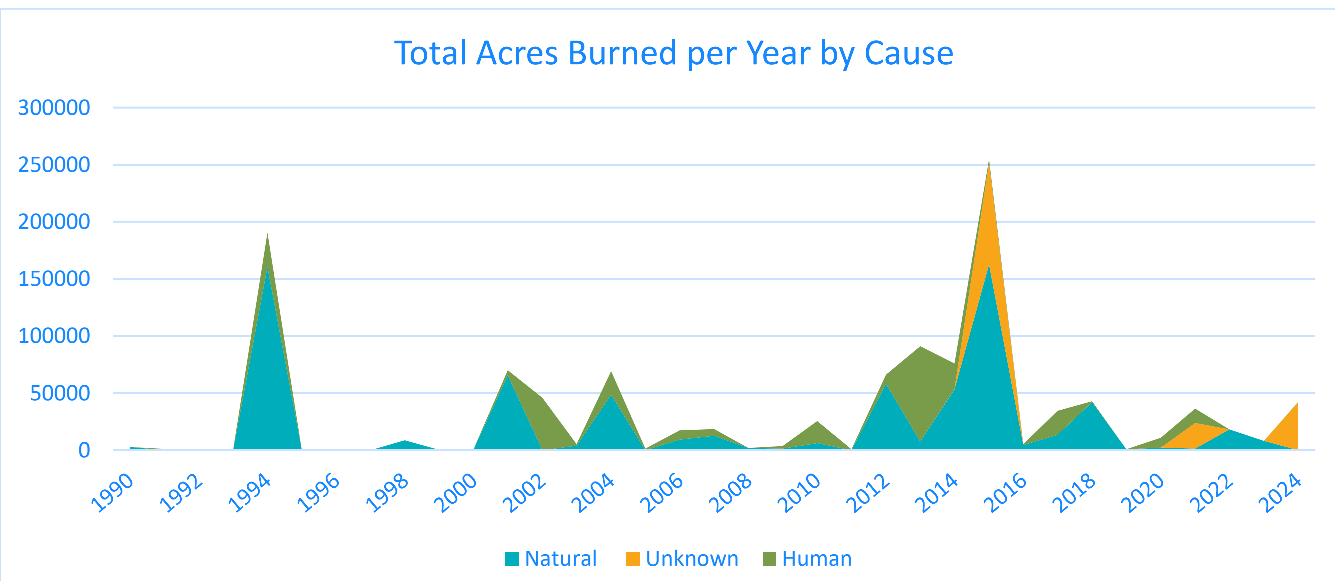


Figure 15-7. Summary of reported acres burned in Chelan County by cause from 1990-2024

The data reviewed above provides a general picture regarding the level of wildland-urban interface fire risk within Chelan County. There are several reasons why the fire risk may be even higher than suggested above, especially in developing wildland-urban interface areas.

- Large fires may occur infrequently, but statistically they will occur. One large fire could significantly change the statistics. In other words, 40 years of historical data may be too short to capture large, infrequent wildland fire events.
- The level of fire hazard depends profoundly on weather patterns. A several year drought period would substantially increase the probability of large wildland fires in Chelan County. For smaller vegetation areas, with grass, brush and small trees, a much shorter drought period of a few months or less would substantially increase the fire hazard.
- The level of fire hazard in wildland-urban interface areas is likely significantly higher than for wildland areas due to the greater risk to life and property. The probability of fires starting in interface areas is much higher than in wildland areas because of the higher population density and increased activities. Many fires in the wildland urban interface are not recorded in agency datasets because the local fire department responded and successfully suppressed the ignition without mutual aid assistance from the state or federal agencies.

Severity Profile

Across the west, wildfires have been increasing in extent and cost of control.

The fire suppression agencies in Chelan County respond to numerous wildland fires each year, but few of those fires grow to a significant size. According to national statistics, only 2% of all wildland fires are not contained by initial attack. However, that 2% accounts for the majority of fire suppression expenditures and threatens lives, properties, and natural resources. These large fires are characterized by a size and complexity that require special management organizations drawing suppression resources from across the nation. These fires create unique challenges to local communities by their quick development and the scale of their footprint.

According to a 2022 Report by the Western Forestry Leadership Coalition, the average number of acres burned, number of structures destroyed, and cost of wildfire suppression is rising across the US and especially in the Western states. Not only are there direct costs associated with suppression, rebuilding, but there are indirect costs to wildfires that communities face before a fire including the costs of planning, education, mitigation, and training, as well as indirect costs following a wildfire including disrupted business income, lower property values, higher insurance premiums, long-term healthcare costs based on air quality, loss of ecological processes including carbon sequestration, water filtration and retention, and slope and soil stabilization.

Disaster and Emergency Declarations

The following summarizes disaster declarations or emergency proclamations related to wildfire hazard.

- Federal DR or EM Declaration covering Chelan County, 1991-2023: Three events classified as wildfire
- Washington State Emergency Proclamations covering Chelan County, 2013-2023: Five events classified as wildfire
- USDA agricultural disaster declarations, 2013-2023: One event classified as wildfire

15.2.4 Overall Probability

Seasonality

The probability of a wildfire starting at a particular location depends on fuel conditions and topography, time of year, weather conditions and the level of human activities occurring that day. For most years, wildfire season in the State of Washington runs from mid-May through October. In Eastern Washington, any prolonged period of low precipitation presents a potentially dangerous problem. The thunderstorm season of late July and early August brings dry lightning. During this period each year, hundreds of ground strikes by lightning are recorded. Wildfires in the summer are difficult to suppress. However, wildfires have occurred in almost every month of the year. Drought, snowpack, and local weather conditions can expand the length of the fire season. The early and late shoulders of the fire season usually are associated with human-caused fires, with the peak period of July, August and early September related to thunderstorms and lightning strikes.

Historical Fire Regime

Historical variability in fire regime is a conservative indicator of ecosystem sustainability, and thus, understanding the natural role of fire in ecosystems is necessary for proper fire management. Fire is one of the dominant processes in terrestrial systems that constrain vegetation patterns, habitats, and ultimately, species composition. Land managers need to understand historical fire regimes, the fire return interval (frequency) and fire severity prior to settlement by Euro-Americans, to be able to define ecologically appropriate goals and objectives for an area. Moreover, managers need spatially explicit knowledge of how historical fire regimes vary across the landscape.

A primary goal in ecological restoration is often to return an ecosystem to a previously existing condition that no longer is present at the site, under the assumption that the site's current condition is somehow degraded or less desirable than the previous condition and needs improvement

Land managers in Chelan County must determine if the past conditions of the County were healthier, had a higher level of integrity, and were more sustainable than the current condition. In other words, is "restoration" an appropriate course of action? After a prolonged absence, if fire is reintroduced to these ecosystems the result could be damaging. Fuel loads throughout most of the County today are quite high and most of the County is inhabited by people, homes, and infrastructure. The ecosystem was adapted to fire in the past, but is no longer adapted today, especially considering the human component.

Many ecological assessments are enhanced by the characterization of the historical range of variability which helps managers understand:

- How the driving ecosystem processes vary from site to site.
- How these processes affected ecosystems in the past.
- How these processes might affect the ecosystems of today and the future.

Historical fire regimes are a critical component for characterizing the historical range of variability in fire-adapted ecosystems. Furthermore, understanding ecosystem departures provides the necessary context for managing sustainable ecosystems. Land managers need to understand how ecosystem processes and functions have changed prior to developing strategies to maintain or restore sustainable systems. In addition, the concept of departure is a key factor for assessing risks to ecosystem components. For example, the departure from historical fire regimes may serve as a useful proxy for the potential of severe fire effects from an ecological perspective.

Table 15-2 summarizes historical fire regimes in Chelan County. This model uses only the current vegetation types to determine the historic fire regime. Native Americans reportedly burned throughout the county on a regular basis. The vegetation types were much different pre-Euro-American settlement than they are today and believed to be a more grassland dominated landscape. A map depicting the historic fire regime is provided in Figure 15-8.

Table 15-2. Historical Fire Regimes in Chelan County

Historic Fire Regime	Description	Percent of Total
Fire Regime Group I	<= 35 Year Fire Return Interval, Low and Mixed Severity	28%
Fire Regime Group II	<= 35 Year Fire Return Interval, Replacement Severity	<2%
Fire Regime Group III	35 – 200 Year Fire Return Interval, Low and Mixed Severity	27%
Fire Regime Group IV	35 – 200 Year Fire Return Interval, Replacement Severity	9%
Fire Regime Group V	> 200 Year Fire Return Interval, Any Severity	26%
Water	Water	3%
Barren	Barren	5%
Sparsely Vegetated	Sparsely Vegetated	<1%
Total		**100%**

Fire Regime Condition Class

A natural fire regime is a general classification of the role fire would play across a landscape in the absence of modern human mechanical intervention but including the influence of aboriginal burning. Coarse scale definitions for historic fire regimes have been developed by Hardy et al and Schmidt et al and interpreted for fire and fuels management by Hann and Bunnell.

A fire regime condition class (FRCC) is a classification of the amount of departure from the historical regime. The three classes are based on low (FRCC 1), moderate (FRCC 2), and high (FRCC 3) departure from the central tendency of the historical regime. The central tendency is a composite estimate of vegetation characteristics (species composition, structural stages, stand age, canopy closure, and mosaic pattern); fuel composition; fire frequency, severity, and pattern; and other associated natural disturbances. Low departure is considered to be within the natural (historical) range of variability, while moderate and high departures are outside.

An analysis of Fire Regime Condition Classes in Chelan County shows that a slight majority of the land in the county is considered moderately departed (37%) from its historic fire regime and associated vegetation and fuel characteristics (see Table 15-3). Less than one third of the vegetation has a low departure and 23% is considered highly departed.

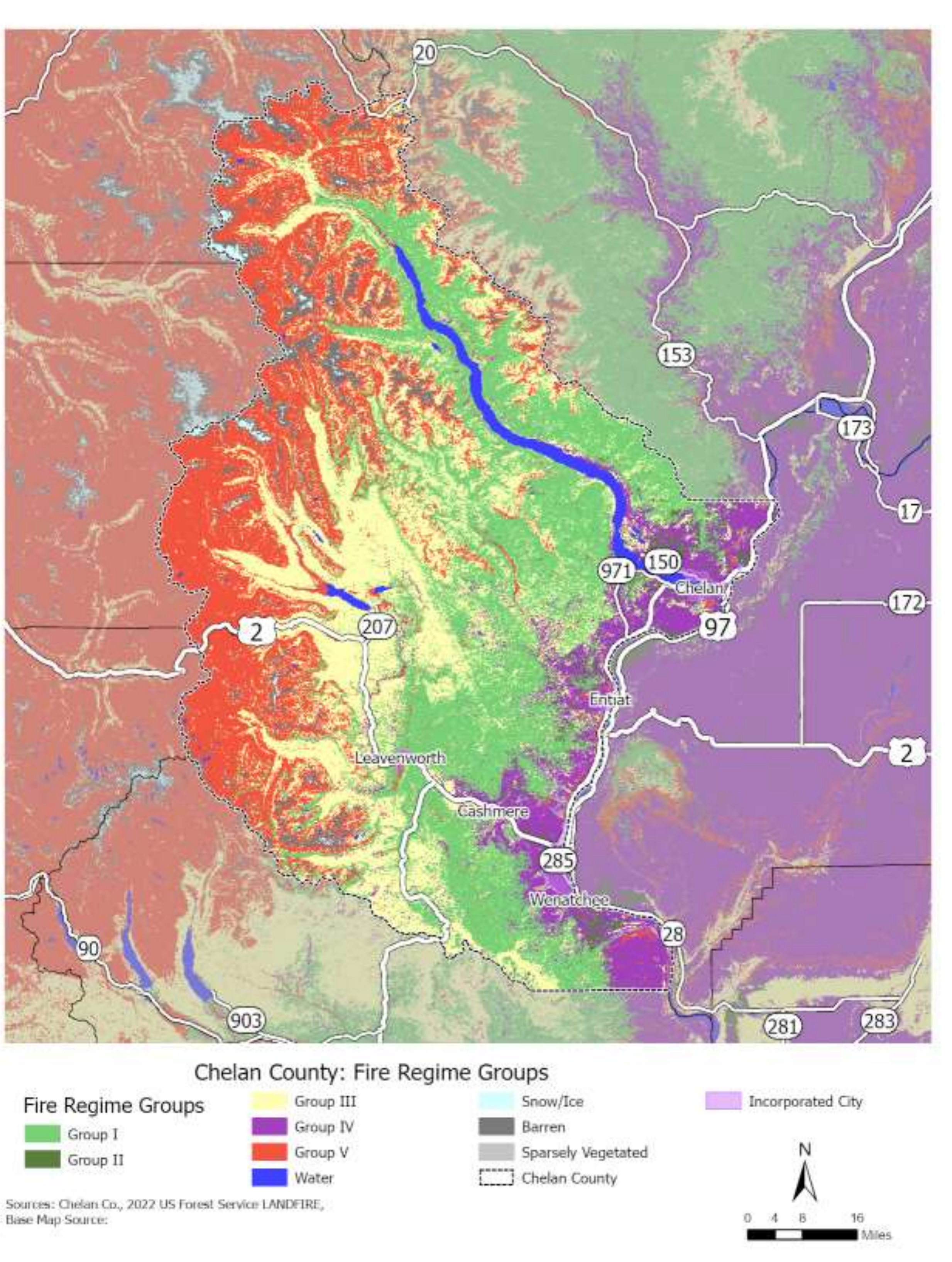


Figure 15-8. Historical Fire Regime for Chelan County

Table 15-3. Fire Regime Condition Class in Chelan County

Fire Regime Condition Class	Description	Percent of Total
Condition Class I	Low Vegetation Departure	27%
Condition Class II	Moderate Vegetation Departure	37%
Condition Class III	High Vegetation Departure	23%
Agriculture	Agriculture	<2%
Water	Water	3%
Urban	Urban	3%
Barren and Sparsely Vegetated	Barren and Sparsely Vegetated	5%
Total		**100%**

The current Fire Regime Condition Class model shows that there is an even distribution of the Fire Regime Groups throughout the County. The highly departed condition classes occur around the higher concentrations of human development and along the ridges in the more remote western portion of the County. Much of the county is dominated by various pine species with a grass/shrub understory. The current structure and density of the forestlands in many areas makes it susceptible to health issues from competition, insects, and disease. The current fire severity model suggests that a higher severity fire than historical norms would be expected in these areas. A map depicting Fire Regime Condition Class is provided in Figure 15-9.

Based on historic frequency and future conditions, the probability of future wildfire occurrences is that it is certain to happen every year, and the county can expect to see upwards of 70 wildfire ignitions each year and an average of 1-6 major wildfires from those.

15.2.5 Warning Time

Wildfires are often caused by humans, intentionally or accidentally. There is no way to predict when a human-caused wildfire 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.

15.2.6 Climate Change Impacts

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.

Changes in climate patterns may impact the distribution and perseverance of insect outbreaks that create dead trees (increase fuel). 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.

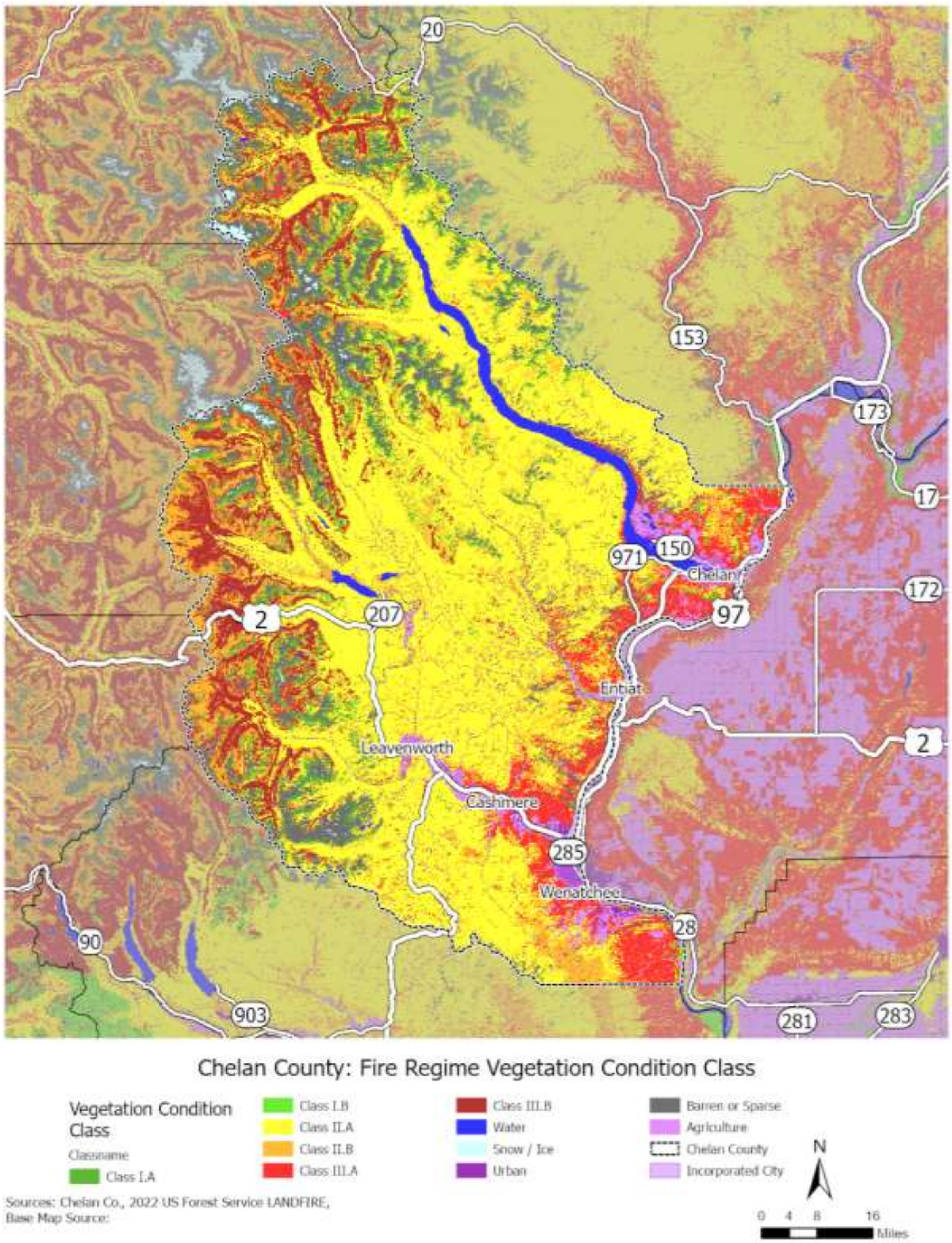


Figure 15-9. Fire Regime Condition Class

Using the Intergovernmental Panel on Climate Change's Representative Concentration Pathways 4.5 and 8.5 scenarios, we can anticipate that between 2024-2039, average 100-hour fuel moistures in June through August are expected to drop from 10.5% to between 10.1-10.2%; vapor pressure deficits are expected to increase from 1.15 kPa to 1.3-1.35 kPa. Chelan County is expected to go from an average of 13 days with maximum temperatures over 86°F and 30 Very High fire danger days up to an average of 21-22 days with temperatures over 86°F and 34-36 Very High fire danger days.

These lower fuel moistures, higher temperatures, and increasing fire weather frequency can lead to additional ignitions, faster fire spread, more intense fire behavior, increased suppression difficulty, and additional need for air support.

15.2.7 Future Trends in Development

As Chelan County grows and citizens continue to build in the wildland urban interface, wildfire potential grows and the probability of fire starts increases. Combined with a lack of public understanding and the lack of preventive measures on the part of the public, the potential for devastating losses continues to increase. The expansion of the wildland urban interface can be managed with strong land use and building codes. The planning area is well equipped with these tools and this planning process has asked each planning partner to assess its capabilities with regards to the tools. The 2025 update of the County's Community Wildfire Protection Plan (CWPP) will be a critical tool available to the County and its planning partners in managing future growth in the interface and intermix areas of the County. The integration of the CWPP with this plan will strengthen the capabilities of both documents.

15.3 SECONDARY HAZARDS

Wildfires can generate a range of secondary effects, some of which 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. Landslides can be a significant secondary hazard of wildfires. Wildfires strip slopes of vegetation, exposing them to greater amounts of rain and run-off. 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.

15.4 VULNERABILITY

A quantitative assessment of vulnerability to the wildfire and wildfire smoke hazard was conducted using the fire risk zone mapping shown in Figure 15-2 and Figure 15-3 and the asset inventory developed for this plan. Detailed results are provided in Appendix C and summarized below.

15.4.1 People

Population was estimated using the residential building count in each mapped hazard area and multiplying by the 2018 estimated average population per household. Using this approach, the estimated population living in mapped landscape-level wildfire risk areas is 34.3% of the planning area population (26,715 people), and 95.7% of the planning area population (74,520 people) live in the local-level wildfire risk area. The population vulnerability estimates by risk area are shown in Table 15-4. In addition to populations who reside in risk areas where fires may occur, hikers and campers in the mountains may be vulnerable to wildfires and the entire population of the planning area is vulnerable to smoke from nearby or distant wildfires.

Table 15-4. Chelan County Population Exposure to the Wildfire Hazard

Jurisdiction	Population Vulnerable	% of Total Population
Cashmere	2,983	3.7%
Chelan	3,342	4.1%
Entiat	817	1.0%
Leavenworth	2,590	3.2%
Wenatchee	6,894	8.5%
Unincorporated	29,258	35.9%
Total	54,202	66.5%

15.4.2 Structures

Figure 15-10 shows the percentage and number of structures in the County that are vulnerable to the wildfire hazard.

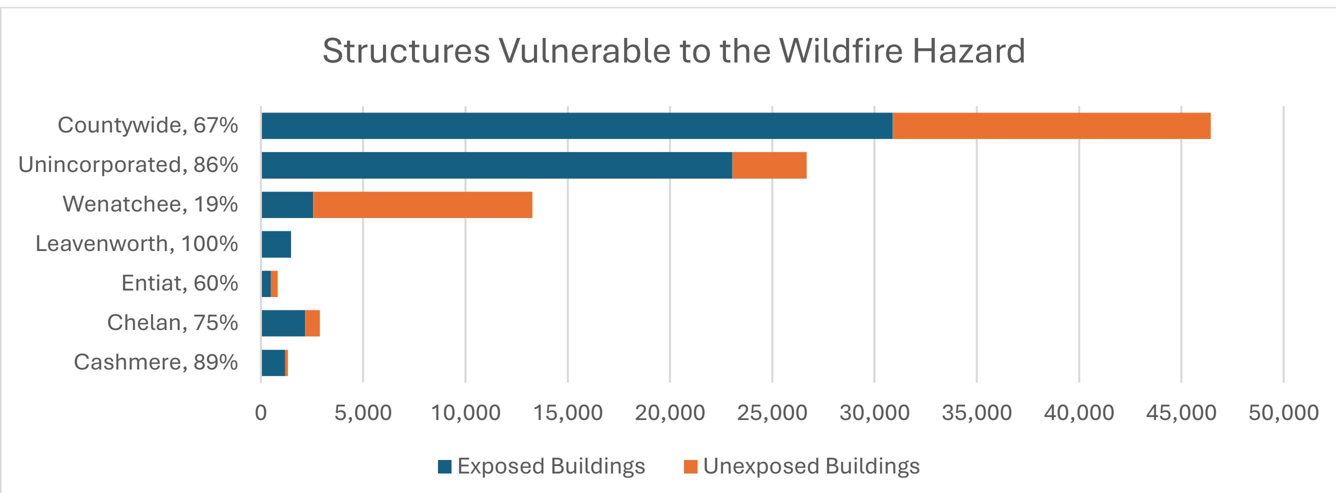


Figure 15-10. Structures exposed to the wildfire hazard, by jurisdiction

The total replacement value of vulnerable property is more than $14 billion, or 56% of the planning area total, as shown in Table 15-5.

Table 15-5. Chelan County Structure Exposure to the Wildfire Hazard

Jurisdiction	Total Number of Buildings	Buildings Exposed	Value (Structure and contents in $) Exposed	% of Total Value Exposed
Cashmere	1,316	1,170	$911,329,209	84.2%
Chelan	2,884	2,156	$1,591,449,477	71.6%
Entiat	822	494	$242,746,101	54.3%
Leavenworth	1,467	1,467	$1,169,977,259	100.0%
Wenatchee	13,266	2,551	$1,968,905,819	19.0%
Unincorporated	26,683	23,046	$8,246,622,114	83.8%
Total	**46,438**	**30,884**	$14,131,029,978	56.3%

Critical facilities and infrastructure exposed to the wildfire hazard represent 73% of the total critical infrastructure and facilities in the planning area. The breakdowns of exposure by category and jurisdiction are shown in Figure 15-11 and Table 15-6. Approximately 25% of critical infrastructure is directly exposed to wildfire through radiant heat or short-range embers.

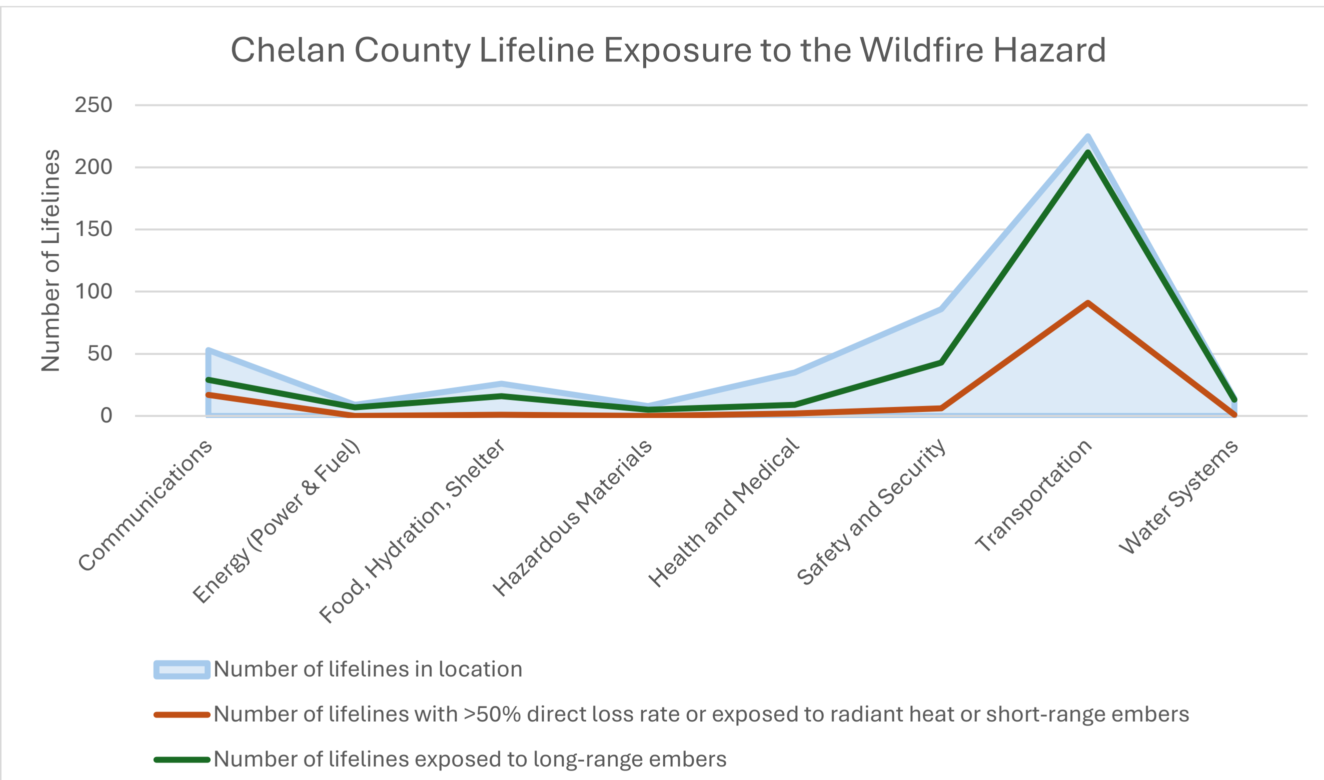


Figure 15-11. Community lifelines exposed to the wildfire hazard, by category

Table 15-6. Community Lifeline Vulnerable to the Wildfire Hazard

Lifeline category	Number of lifelines in location	Number of lifelines vulnerable to radiant heat or short-range embers	Number of lifelines exposed to long-range embers
Countywide			
Communications	53	17	29
Energy (Power and Fuel)	9	0	7
Food, Hydration, Shelter	26	1	16
Hazardous Materials	8	0	5
Health and Medical	35	2	9
Safety and Security	86	6	43
Transportation	225	91	212
Water Systems	14	1	13
Total in County	**456**	**118**	**334**
Cashmere			
Communications	1	0	0
Food, Hydration, Shelter	2	0	2
Hazardous Materials	1	0	1
Health and Medical	3	0	1
Safety and Security	4	0	3
Transportation	4	0	4
Water Systems	1	0	1
Total in Cashmere	**16**	**0**	**12**
Chelan			
Communications	7	0	1
Food, Hydration, Shelter	2	0	1
Health and Medical	8	0	1
Safety and Security	17	0	12
Transportation	4	0	4
Water Systems	1	0	1
Total in Chelan	**39**	**0**	**20**
Entiat			
Safety and Security	3	0	3
Total in Entiat	**3**	**0**	**3**
Leavenworth			
Communications	3	0	3
Food, Hydration, Shelter	1	0	1
Health and Medical	3	1	3
Safety and Security	6	1	6
Transportation	1	0	1
Total in Leavenworth	**14**	**2**	**14**
Wenatchee			
Communications	19	0	2

Energy (Power and Fuel)	1	0	0
Food, Hydration, Shelter	12	0	3
Hazardous Materials	4	0	1
Health and Medical	20	0	3
Safety and Security	31	0	1
Transportation	14	0	9
Water Systems	1	0	0
Total in Wenatchee	**102**	**0**	**19**

15.4.3 Systems

All systems are vulnerable to wildfires and wildfire smoke.

15.4.4 Natural, Historic, and Cultural Resources

All natural, cultural, and historic resources in Chelan County are exposed to the risk of wildfire.

15.4.5 Activities that Have Value to the Community

Tourism within Chelan County relies on open and accessible transportation, which is the most commonly expected impacted community lifeline. Tourism is also subject to decrease when wildfires cause area closures, evacuations, detours, and smokey conditions.

15.4.6 Agriculture

The obvious impacts from wildfires on agriculture would be the destruction of crops by the fire. However, since most agricultural lands are irrigated and actively maintained to assure their production, these activities actually reduce the vulnerability to the key components that drive wildfire, namely fuels. Most of the agricultural lands within the planning area were identified as having moderate fire risk. Therefore, associated risk from wildfire to agriculture is considered to be moderate to low.

15.5 IMPACTS

Impact estimates for the wildfire hazard are described qualitatively. No loss estimation of these facilities was performed because damage functions have not been established for the wildfire hazard. Modeling based on identified fire hazard areas would overestimate potential losses because it is unlikely that all areas susceptible to wildfire would experience a fire at the same time.

15.5.1 People

All people vulnerable to wildfire hazards are may be impacted by wildfire. 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. In addition, wildfire may threaten the health and safety of those fighting the fires. First responders are exposed to dangers from the initial incident and after-effects from smoke inhalation and heat stroke. Persons with access and functional needs, the elderly and very young may be especially vulnerable to wildfire if there is not adequate warning time before evacuation is needed.

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. The Department of Ecology monitors smoke impacts from active wildfires and issues wildfire smoke air quality notifications ranging from "good" to "hazardous."

15.5.2 Structures

All property vulnerable to wildfire hazard may be impacted. Structures that were not constructed to standards designed to protect a building from wildfire may be especially impacted. Table 15-7 shows the number of critical facilities located in each community within the wildfire hazard areas.

Table 15-7. Critical Facilities in Wildfire Hazard Areas

	Long Range Embers	Radiant Heat or Short Range Embers	Total in Area
Cashmere	12	0	16
Chelan	20	0	39
Entiat	3	0	3
Leavenworth	14	2	14
Wenatchee			
Countywide	334	118	456

15.5.3 Systems

Systems not built to fire protection standards, utility poles and lines, and facilities containing hazardous materials are most vulnerable to the wildfire hazard. Most road and railroads would be without damage except in the worst scenarios, although roads and bridges can be blocked by debris or other wildfire-related conditions and become impassable. The following systems are directly exposed to wildfire through radiant heat or short-range embers and their vulnerability could complicate response and recovery efforts during and following an event:

- **Communication Facilities**—32% of communication facilities in the county are directly exposed to wildfire. If these facilities are damaged and become inoperable, it would exacerbate already difficult communication in the planning area.
- **Water Facilities**— 7% of water infrastructure as defined for this plan is directly exposed to wildfire. This is critical in the event that post-fire flooding and debris flows impact water intakes or treatment for the area.
- **Transportation**—During a wildfire event, access to the location of the fire and routes out of the impacted area are essential to protecting the safety of residents and visitors evacuating and of emergency response personnel entering the area. 40% of transportation infrastructure is directly exposed to wildfire within the planning area.
- **Safety and Security**— Seven percent of safety and security facilities such as fire stations, police stations, and emergency operations centers are directly exposed to the wildfire hazard.

15.5.4 Natural, Historic, and Cultural Resources

Fire is a natural and critical ecosystem process in most terrestrial ecosystems, affecting the types, structure, and spatial extent of native vegetation. However, it also 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**—Fire can have negative consequences for endangered species.
- **Soil Sterilization**—Some fires burn so hot that they can sterilize the soil. Topsoil exposed to extreme heat can become water repellant, and soil nutrients may be lost.
- **Reduced Timber Harvesting**—Timber can be destroyed and lead to smaller available timber harvests.
- **Damaged Cultural Resources**—Scenic vistas can be damaged, access to recreational areas can be reduced and destruction of cultural resources may occur.

The sections below provide further detail on environmental elements that can experience harmful impacts from wildfire.

15.5.5 Activities that Have Value to the Community

Communities and local businesses in Chelan County rely on tourism as a source of revenue, and wildfires can drastically change how and where people recreate. Not only do many tourists avoid locations with active wildfires, but wildfire closures can also prevent people from travelling through the area or stopping at local businesses.

15.5.6 Agriculture

Agricultural resources include rangelands, timberlands, cultivated farmlands and dairy lands. Agricultural lands are an important element of the Chelan County identity and economy. Although fire has been used as a tool in rangeland and timber management, wildfire can have disastrous consequences on such resources, removing them from production and necessitating lengthy restoration programs.

15.5.7 National Risk Index

According to the National Risk Index (NRI), Chelan County has a “Relatively High” risk index for the wildfire hazard. Table 15-8 provides the risk factor breakdown. See Section 7.2 for a description of the components of the NRI.

Table 15-8. NRI Scoring for Wildfire in Chelan County

Expected Annual Loss	Social Vulnerability	Community Resilience	Social Vulnerability	Risk Value	Risk Index Score
$16,766,346	Relatively High	Relatively Moderate	Relatively High	$19,383,696	99.2

15.6 SCENARIO

A major wildfire in the planning area might begin with a wet spring, adding to fuels already present on the forest floor. Flashy fuels would build throughout the spring. The summer could see the onset of insect infestation. A dry summer could follow the wet spring, exacerbated by dry hot winds. Carelessness with combustible materials or a tossed lit cigarette, or a sudden lighting storm could trigger a multitude of small, isolated fires.

The embers from these smaller fires could be carried for long distances by hot, dry winds, creating spot fires. Fires that start in flat areas move slower, but wind still pushes them. It is not unusual for a wildfire pushed by wind to burn the ground fuel and later climb into the crown and reverse its track. This is one of many ways that fires can escape containment, typically during periods when response capabilities are overwhelmed. These new small fires would most likely merge. Suppression resources would be redirected from protecting the natural resources to saving more remote subdivisions.

The worst-case scenario would include an active fire season throughout the American west, spreading resources thin. Firefighting teams would be exhausted or unavailable. Many federal assets would be responding to other fires that started earlier in the season.

To further complicate the problem, heavy rains could follow, causing flooding and landslides and releasing tons of sediment into rivers, permanently changing floodplains and damaging sensitive habitat and riparian areas. Such a fire followed by rain could release millions of cubic yards of sediment into streams for years, creating new floodplains and changing existing ones. With the forests removed from the watershed, stream flows could easily double. Floods that could be expected every 50 years may occur every couple of years. With the streambeds unable to carry the increased discharge because of increased sediment, the floodplains and floodplain elevations would increase.

15.7 ISSUES

The major issues for wildfire are the following:

- Human activities have been the cause of 43% of wildfires in the planning area.
- More than 66% of the planning area population lives in the Very High, Local Level wildfire risk areas.
- An estimated 26% of the critical facilities in the planning area are directly exposed to wildfire and an estimated 73% of critical facilities are indirectly exposed to wildfire. These facilities could have a significant amount of functional downtime after a wildfire. This creates not only a need for mitigation but also a need for continuity of operations planning to develop procedures for providing services without access to critical facilities.
- Several vulnerable and isolated populations are directly exposed to wildfire.
- Since people start a significant majority of wildfires, wildfire prevention education and enforcement programs can significantly reduce the total number of wild land fires. Public education and outreach to

people living in the fire hazard zones should include information about and assistance with mitigation activities such as defensible space, home hardening, and evacuation preparation.

- Residents should know to reduce their risk to fire. Public education programs on fire safety, fire alarms and fire response are important. People should be encouraged to purchase fire insurance if not included in standard homeowner or renter policies and understand building codes.
- An effective early fire detection program and an emergency communications system are essential. The importance of immediately reporting any wildfire must be impressed upon local residents and persons using forest areas.
- An effective warning system is essential to notify local inhabitants and persons in the area of the fire. An evacuation plan detailing primary and alternate escape routes is also important.
- Fire-safe development planning should be done with local government planners to reduce the risk to local residents and businesses. Safety recommendations to implement could include the following:
    - Sufficient fuel-free areas around structures
    - Fire-resistant roofing materials
    - Adequate two-way (ingress and egress) routes and turnarounds for emergency response units
    - Adequate water supplies with backup power generation equipment or other means to cost-effectively support firefighting efforts
    - Development of local ordinances to control human-caused fires (from debris burning, fireworks, campfires, etc.)
- Road criteria to ensure adequate escape routes for new sections of development in forest areas.
- Road closures to be increased during peak fire periods to reduce access to fire-prone areas.
- Steps by the public to better protect lives, property, and the environment from wildfires:
    - Maintaining defensible space around homes
    - Providing adequate access routes (two-way with turnaround) to homes for emergency equipment
    - Minimizing “fuel hazards” adjacent to homes
    - Using fire-resistant roofing materials
    - Maintaining adequate water supplies
    - Ensuring home addresses are visible to first responders.
- Some forest fires should be allowed to burn in limited areas as part of forest management.
- During peak wildfire season, if resources from Chelan County are deployed to other areas of the State, the availability of firefighting resources could play a role in the severity of wildfire and the size of area effected.

15.8 MITIGATING THE HAZARD

Table 15-9 presents a range of potential opportunities for mitigating the wildfire hazard.

Table 15-9. Potential Opportunities to Mitigate the Wildfire and Wildfire Smoke Hazard

Community Scale	Organizational Scale	Government Scale
Manipulate the Hazard		
• Clear potential fuels on property such as dry overgrown underbrush and diseased trees	• Clear potential fuels on property such as dry overgrown underbrush and diseased trees	• Clear potential fuels on property such as dry overgrown underbrush and diseased trees • Implement best management practices on public lands
Reduce Vulnerability and Impacts		
• Create and maintain defensible space around structures and provide water on site • Locate outside of hazard area • Mow regularly • Use fire-resistant building materials • Use fire-resistant landscaping	• Create and maintain defensible space around structures and infrastructure and provide water on site • Locate outside of hazard area • Use fire-resistant building materials • Use fire-resistant plantings in buffer areas of high wildfire threat • Provide air filtration resources for employees	• Create and maintain defensible space around structures and infrastructure • Locate outside of hazard area • Use fire-resistant building materials • Enhance building code to include use of fire-resistant materials in high hazard area • Use fire-resistant plantings in buffer areas of high wildfire threat • Establish biomass reclamation activities • Reintroduce fire (controlled or prescribed burns) to fire-prone ecosystems • Manage fuel load through thinning and brush removal • Designate clean air facilities with air filtration systems • Implement WUI Code and higher regulatory standards • Continue interagency coordination in setting fire danger levels and instituting fire restrictions.
Build Local Capacity		
• Employ techniques from the National Fire Protection Association's Firewise Communities program to safeguard home • Identify alternative water supplies for fire fighting • Install/replace roofing material with non-combustible roofing materials	• Support Firewise USA community initiatives • Create/establish stored water supplies to be utilized for fire fighting	• More public outreach and education efforts, including an active Firewise program • Possible weapons of mass destruction funds available to enhance fire capability in high-risk areas • Identify fire response and alternative evacuation routes • Seek alternative water supplies • Become a Firewise community • Use academia to study impacts/solutions to wildfire risk • Establish/maintain mutual aid agreements between fire service agencies • Develop, adopt, and implement integrated plans for mitigating wildfire impacts in wildland-urban interface areas • Consider the probable impacts of climate change on the risk associated with the wildfire hazard in future land use decisions • Provide incentives for existing structures to be hardened against wildfire • Use tools to detect, forecast, and take action ahead of wildfire • Establish a management program to track forest and rangeland health • Consider probable impacts of climate change on risk associated with wildfire hazards in future land use decisions

Community Scale	Organizational Scale	Government Scale
Nature-Based Opportunities		
• Manage invasive species that are susceptible to increased wildfire risk • Create riparian corridors in wildfire hazard areas as fire breaks • Incorporate nature-based wildfire risk reduction buffers into existing ecosystem-friendly land uses (e.g., green space, trains, or parks)		

16. RISK RANKING

FEMA requires all hazard mitigation planning partners to have jurisdiction-specific mitigation actions based on local risk, vulnerability and community priorities (FEMA, 2022). This plan included a risk ranking protocol for each planning partner, in which "risk" was calculated by multiplying probability by impacts. The risk estimates were generated using methodologies promoted by FEMA. The Steering Committee reviewed, discussed and approved the methodology and results. The risk ranking assesses factors such as:

- **Probability**—The likelihood of each hazard's occurrence
- **Impact on Property**—The likely impact on structures, including residential, commercial, and critical facilities (community lifelines)
- **Impact on People**—The population vulnerable to the hazard (both total populations and the population that is socially vulnerable according to the SVI)
- **Impacts on the Economy**—The likely interruption of services, businesses and jobs

This risk rating was conducted using a combination of quantitative and qualitative data on each hazard for these selected metrics. Metrics are the quantifiable measures that are used to compare and assess the identified risk of each hazard. The risks of each hazard were rated as high, medium, or low based on parameters established by the Core Planning Team. These impacts are then multiplied by the probability factor to generate the hazard risk rating for each hazard. The quantitative analysis aspect of this exercise was limited to hazards with a clearly defined extent and location. For other hazards, such as drought, a more qualitative approach was applied.

This risk ranking methodology was applied to all jurisdictional planning partners.

Numerical ratings of probability and impact were based on the hazard profiles and exposure and vulnerability evaluations presented in Chapters 8 through 15. When available, estimates of risk were generated with data from Hazus or GIS. For hazards of concern with less specific data available, qualitative assessments were used. As appropriate, results were adjusted based on local knowledge and other information not captured in the quantitative assessments.

Risk ranking results are used to help establish mitigation priorities. Each partner used the risk ranking for their jurisdiction to inform the development of its action plan. Planning partners were directed to identify mitigation actions, at a minimum, to address each hazard with a "high" or "medium" risk ranking. Actions that address hazards with a low hazard ranking are optional.

Volume 2 presents the risk rankings for each planning partner. The following planning-area-wide risk ranking was prepared by the planning team.

16.1 PROBABILITY OF OCCURRENCE

The probability of occurrence of a hazard is indicated by a probability factor based on likelihood of annual occurrence:

- High—Hazard event is likely to occur within 25 years (Probability Factor = 3)
- Medium—Hazard event is likely to occur within 100 years (Probability Factor =2)

- Low—Hazard event is not likely to occur within 100 years (Probability Factor =1)
- No vulnerability—There is no probability of occurrence (Probability Factor = 0)

The assessment of hazard frequency is based on past hazard events in the area and the potential for changes in the frequency of these events resulting from climate change. Table 16-1 summarizes the probability assessment for each natural hazard of concern for this plan.

Table 16-1. Probability of Hazards

Hazard Event	Probability (High, Medium, Low)	Probability Factor
Avalanche	Medium	2
Dam or Levee Failure	Low	1
Drought	Medium	2
Earthquake[a]	Medium	2
Flooding[b]	High	3
Landslide	High	3
Severe Weather	High	3
Wildfire	High	3

a. Earthquake risk ranking is based on Chelan 7.2 scenario..
b. Flood risk ranking is based on 1%-annual-chance flood zone (otherwise known as the special flood hazard area).

16.2 IMPACT

Hazard impacts were assessed in four categories: impacts on assets, impacts on people (total and socially vulnerable populations), impacts on the local economy, and future impacts. Numerical impact factors were assigned as follows:

- Assets—Values were assigned based on the percentage of the total property value exposed to the hazard event:
  - High—25% or more of the total assessed property value and community lifelines exposed to a hazard (Impact Factor = 3)
  - Medium—10% to 25% of the total assessed property value and community lifelines exposed to a hazard (Impact Factor = 2)
  - Low—10% or less of the total assessed property value and community lifelines exposed to the hazard (Impact Factor = 1)
  - No impact—None of the total assessed property value or community lifelines exposed to a hazard (Impact Factor = 0)
- People—Values were assigned based on the percentage of the total population and the socially vulnerable population exposed to the hazard event. The degree of impact on individuals will vary and is not measurable, so the calculation assumes for simplicity and consistency that all people exposed to a hazard because they live in a hazard zone will be equally impacted when a hazard event occurs. It should be noted that planners can use an element of subjectivity when assigning values for impacts on people.
- Impact factors were assigned as follows for the total population:
  - High—25% or more of the population is exposed to a hazard (Impact Factor = 3)

  - Medium—10% to 24% of the population is exposed to a hazard (Impact Factor = 2)
  - Low—9% or less of the population is exposed to the hazard (Impact Factor = 1)
  - No impact—None of the population is exposed to a hazard (Impact Factor = 0)

- Economy— Values were assigned based on the percentage of the total property value vulnerable to the hazard event. Values represent estimates of the loss from a major event of each hazard in comparison to the total replacement value of the property exposed to the hazard. Loss estimates separate from the exposure estimates were generated for the earthquake and flooding hazards using Hazus. For other hazards, such as dam failure, landslide and wildfire, vulnerability was estimated as a percentage of exposure, due to the lack of loss estimation tools specific to those hazards.
  - High—Estimated loss from the hazard is 10% or more of the total exposed property value (Impact Factor = 3)
  - Medium—Estimated loss from the hazard is 5% to 10% of the total exposed property value (Impact Factor = 2)
  - Low—Estimated loss from the hazard is 5% or less of the total exposed property value (Impact Factor = 1)
  - No impact—No loss is estimated from the hazard (Impact Factor = 0)

Each hazard category was assigned a weighting factor to reflect its significance. These weighting factors are consistent with those typically used for measuring the benefits of hazard mitigation actions: impact on people was given a weighting factor of 3; impact on property was given a weighting factor of 2; and impact on the economy and future impacts were given a weighting factor of 1. Table 16-2, Table 16-3, and Table 16-4 summarize the impacts for each hazard.

Table 16-2. Impact on People from Hazards

Hazard Event	Impact (high, medium, low)	Impact Factor	Multiplied by Weighting Factor (2)
Avalanche	Low	1	1X3=3
Dam or Levee Failure	Low	1	1X3=3
Drought[a]	Low	1	1X3=3
Earthquake	High	3	3X3=9
Flooding[b]	Low	1	1X3=3
Landslide	Low	1	1X3=3
Severe Weather	High	3	3X3=9
Wildfire	High	3	3X3=9

a. Drought generally does not directly cause death or injury to people.
b. Based on population exposed to the 100-year floodplain

Table 16-3. Impact on Property from Hazards

Hazard Event	Impact (high, medium, low)	Impact Factor	Multiplied by Weighting Factor (2)
Avalanche	Low	1	1x2=2
Dam or Levee Failure	Low	1	1x2=2
Drought[a]	None	0	0x3=0
Earthquake	High	2	3x2=6

Flooding[b]	Low	1	1x2=2
Landslide	Medium	2	2x2=4
Severe Weather	Medium	2	2x2=4
Wildfire	High	3	3x2=6

a. Although all property is exposed to drought, direct impacts on property are limited.
b. Based on structures exposed to the 100-year floodplain

Table 16-4. Impact on Economy from Hazards

Hazard Event	Impact (high, medium, low)	Impact Factor	Multiplied by Weighting Factor (1)
Avalanche	Low	1	1x1=1
Dam or Levee Failure	Low	1	1x1=1
Drought[a]	Low	1	1x1=1
Earthquake[b]	Medium	2	2x1=2
Flooding	Low	1	1x1=1
Landslide	Low	1	1x1=1
Severe Weather	Medium	2	2x1=2
Wildfire	High	3	3x1=3

a. Drought may have economic impacts on water using industries and agriculture
b. Based on the Chelan M7.2 scenario

16.3 RISK RATING AND RANKING

The risk rating for each hazard was determined by multiplying the probability factor by the sum of the weighted impact factors, as summarized in Table 16-5. Based on these ratings, a priority of high, medium, or low was assigned to each hazard. Table 16-5 shows the hazard risk ranking for the planning area. Hazard risk ranking for each participating planning partner can be found in Volume 2 of this plan.

Table 16-5. Hazard Risk Rating

Hazard Event	Probability Factor	Sum of Weighted Impact Factors	Total (Probability x Impact)
Avalanche	2	3+2+1=6	2x6=12
Dam or Levee Failure	1	3+2+1=6	1x6=6
Drought	1	3+0+1	2x4=8
Earthquake	2	9+6+2=17	2x17=34
Flooding	3	3+2+1=6	3x6=18
Landslide	3	3+2+1=6	3x6=18
Severe Weather	3	9+4+2=15	3x15=45
Wildfire	3	9+6+3=18	3x18=54

Part 3. Mitigation Plan

17. MISSION STATEMENT, GOALS, AND OBJECTIVES

Local Plan Requirement C3— 44 CFR Part 201.6(c)(3)(i)	Local Plan Requirement E1— 44 CFR Part 201.6(d)(3)
The mitigation strategy shall include a description of mitigation goals to reduce or avoid long-term vulnerabilities to the identified hazards.	*A local jurisdiction must review and revise its plan to reflect […] changes in priorities.*

Mitigation goals represent broad statements that are consistent with the hazards identified in the Plan and achieved through the implementation of specific mitigation actions. The Steering Committee reviewed the mission statement and goals from the 2019 Hazard Mitigation Plan and made revisions to clarify intent, meaning, and adapt to new guidance set by FEMA. The Steering Committee reviewed the 12 objectives from the 2019 plan and made revisions to better address current priorities in Chelan County. The mission statement and goals, objectives, and actions in this plan all support each other. Goals were selected to support the guiding principle. Objectives were selected that met multiple goals. Actions (presented in Chapter 19) were prioritized based on their ability to meet multiple objectives.

17.1 PLAN MISSION STATEMENT

A plan's mission statement focuses the range of objectives and actions to be considered. This is not a goal because it does not describe a hazard mitigation outcome, and it is broader than a hazard-specific objective. The mission statement for this hazard mitigation plan is as follows:

The mission of the plan is:

To promote sound public policy designed to protect the whole community, critical facilities, infrastructure, private property and the environment from natural hazards by increasing public awareness, documenting the resources for risk reduction and loss-prevention from current and future hazard impacts, and identifying activities to guide Chelan County toward building a safer, more sustainable community.

17.2 GOALS

The following are the mitigation goals for this plan:

1. **To Protect People and Property** by making Chelan County homes, businesses, infrastructure, critical facilities, dams and their related infrastructure, and other property more resilient and resistant to losses from current and future natural hazard conditions
2. **To Protect the Economy** by developing mechanisms that ensure commerce, trade, and essential business activities remain viable in the event of a natural disaster
3. **To Protect the Environment** by preserving, rehabilitating, and enhancing natural systems to serve natural hazard mitigation functions
4. **To Strengthen Emergency Services** by increasing collaboration, coordination, and capabilities among public agencies, non-profit organizations, business, and industry

5. **To Increase Public Awareness and Education** of the whole community by providing the public information, tools, and funding resources for implementing mitigation activities to prevent future losses from natural hazards
6. **To Establish and Strengthen Partnerships** for implementation through coordination and collaboration of the whole community, including public agencies, citizens, non-profit organizations, businesses, tribes, and industries whose authorities and capabilities will support implementation of planning for a disaster-resistant Chelan County. The effectiveness of a mitigation strategy is assessed by determining how well these goals are achieved.

17.3 OBJECTIVES

The selected objectives meet multiple goals, as listed in Table 17-1. Therefore, the objectives serve as a stand-alone measurement of the effectiveness of a mitigation action, rather than as a subset of a goal. The objectives also are used to help establish priorities.

Table 17-1. Objectives for the Hazard Mitigation Plan

Objective Number	Objective Statement	Goals for Which It Can Be Applied
O-1	Improve and protect early warning emergency response systems and plans.	1, 2, 3, 4
O-2	Sustain continuity of local emergency and government operations, including the operation of identified critical facilities, during and after a disaster.	1, 2, 4
O-3	Provide/improve fire protection thru proactive fuels management and structural ignition resistance programs.	1, 2, 3
O-4	Seek mitigation projects that provide the highest degree of hazard protection in a cost-effective manner and that will provide protection to the natural and built environments.	1, 2, 3, 4, 6
O-5	Encourage and incentivize mitigation of private property through programs such as the Community Rating System, Firewise USA and Storm Ready programs.	1, 2, 5, 6
O-6	Reduce natural hazard-related risks and vulnerability to populations, critical facilities and infrastructure within the planning area.	1, 4, 5, 6
O-7	Collect, use and share the best available data, science and technologies to improve understanding of the location and potential impacts of natural hazards, the vulnerability of building types, and community development patterns and the measures needed to protect life safety and natural and built environments.	1, 5
O-8	Enhance emergency response partnership capabilities.	1, 2, 4, 6
O-9	Create and enhance partnerships among all levels of government, community based organizations, and the business community to coordinate mutually beneficial mitigation strategies.	1, 2, 6
O-10	Strengthen codes so that new construction can withstand the impacts of identified natural hazards and lessen the impact of that development on the environment's ability to absorb the impact of natural hazards.	1, 2, 3
O-11	Educate the whole community on their risk exposure to hazards and ways to increase their capability to prepare, respond, recover, and mitigate the impacts of these events.	1, 2, 4, 5, 6

18. MITIGATION BEST PRACTICES AND ADAPTIVE CAPACITY

18.1 MITIGATION BEST PRACTICES

Local Plan Requirement C4—44 CFR Part 201.6(c)(3)(ii)

The mitigation strategy shall include a section that identifies and analyzes a comprehensive range of specific mitigation actions and projects being considered to reduce the effect of each hazard, with particular emphasis on new and existing buildings and infrastructure.

Catalogs of hazard mitigation best practices were developed that present a broad range of alternatives to be considered for use in Chelan County. One catalog was developed for each hazard of concern evaluated in this plan. The catalogs present potential mitigation opportunities that are categorized by:

- Who would have responsibility for implementation:
  - Community scale (individuals or groups)
  - Organizational scale (businesses, non-profits, community-based organizations)
  - Government scale (any government agency that has permit authorities and police powers within the planning area).
- What the alternative would do:
  - Manipulate the hazard (actions to prevent hazard events from occurring)
  - Reduce exposure and vulnerability (actions to safeguard people, property, and the environment from the impacts of the hazard)
  - Build local capacity (actions to improve abilities to mitigate and respond to hazard events).

The alternatives presented include actions that will mitigate current risk from hazards and actions that will help reduce risk from changes in the impacts of these hazards resulting from climate change. Hazard mitigation actions recommended in this plan were selected from an analysis of the alternatives presented in the catalogs. The catalogs provide a baseline of mitigation alternatives that are backed by a planning process, are consistent with the established goals and objectives, and are generally within the capabilities of the planning partners to implement. Some of these actions may not be feasible based on the selection criteria identified for this plan. The purpose of the catalogs was to provide a list of what could be considered to reduce risk from natural hazards within the planning area. Actions selected out of the catalogs were based on an analysis of the planning partner’s ability to implement the action and general feasibility. Actions in the catalog that are not included for the partnership’s action plan were not selected for one or more of the following reasons:

- The action is not feasible.
- The action is already being implemented.
- The planning partner does not have the capability to implement the action.
- There is an apparently more cost-effective alternative.
- The action does not have public or political support.

The catalogs for each hazard are presented in the respective hazard chapters under the heading "Opportunities for Mitigating the Hazard."

18.2 ADAPTIVE CAPACITY

Adaptive capacity is defined as "the ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences" (IPCC, 2014b). This term is typically used while discussing climate change adaptation; however, it is similar to the alternatives presented in the tables for building local capacity. In addition to hazard-specific capacity building, the following list provides general alternatives that planning partners considered to build capacity for adapting to both current and future risks:

- Incorporate climate change adaptation into relevant local and regional plans and projects.
- Establish a climate change adaptation and hazard mitigation public outreach and education program.
- Build collaborative relationships between regional entities and neighboring communities to promote complementary adaptation and mitigation strategy development and regional approaches.
- Establish an ongoing monitoring program to track local and regional climate impacts and adaptation strategy effectiveness.
- Increase participation of low-income, immigrant, non-English-speaking, racially and ethnically diverse, and special-needs residents in planning and implementation.
- Ask local employers and business associations to participate in local efforts to address climate change and natural hazard risk reduction.
- Conduct a communitywide assessment and develop a program to address health, socioeconomic, and equity vulnerabilities.
- Focus planning and intervention programs on neighborhoods that currently experience social or environmental injustice or bear a disproportionate burden of potential public health impacts.
- Use performance metrics and data to evaluate and monitor the impacts of climate change and natural hazard risk reduction strategies on public health and social equity.
- Develop coordinated plans for mitigating future flood, landslide, and related impacts through concurrent adoption of updated comprehensive plan safety elements and local hazard mitigation plans.
- Implement comprehensive plan safety elements through zoning and subdivision practices that restrict development in floodplains, landslide, and other natural hazard areas.
- Identify and protect locations where native species may shift or lose habitat due to climate change impacts (loss of wetlands, warmer temperatures, drought).
- Collaborate with agencies managing public lands to identify, develop, or maintain corridors and linkages between undeveloped areas.
- Promote economic diversity.
- Incorporate consideration of climate change impacts as part of infrastructure planning and operations.
- Conduct a climate impact assessment on community infrastructure.
- Identify gaps in legal and regulatory capabilities and develop ordinances or guidelines to address those gaps.
- Identify and pursue new sources of funding for mitigation and adaptation activities.
- Hire new staff or provide training to current staff to ensure an adequate level of administrative and technical capability to pursue mitigation and adaptation activities.

19. AREA-WIDE ACTION PLAN

	Local Plan Requirement C4— 44 CFR Part 201.6(c)(3)(ii)	Local Plan Requirement C5— 44 CFR Part 201.6(c)(3)(iii)
	The mitigation strategy shall include a section that identifies and analyzes a comprehensive range of specific mitigation actions and projects being considered to reduce the effect of each hazard, with particular emphasis on new and existing buildings and infrastructure.	***The hazard mitigation strategy shall include an action plan, describing how the action identified in paragraph (c)(3)(ii) of this section will be prioritized, implemented, and administered by the local jurisdiction.***

19.1 RECOMMENDED MITIGATION ACTIONS

The Steering Committee reviewed the catalogs of hazard mitigation alternatives and selected area-wide actions to be included in a hazard mitigation action plan. The selection of area-wide actions was based on the risk assessment of identified hazards of concern and the defined hazard mitigation goals and objectives. Table 19-1 lists the recommended hazard mitigation actions that make up the action plan. The timeframe indicated in the table is defined as follows:

- Short Term = to be completed in less than 5 years
- Long Term = to be completed in more than 5 years

Table 19-1. County-Wide Action Plan

Hazards Addressed	Funding Options	Timeframe	Goals Met	In Previous Plan?
CW-1—To the extent possible based on available resources, provide coordination and technical assistance in the application for grant funding that includes assistance in cost vs. benefit analysis for grant eligible projects. **Responsible Agency:** County Natural Resource Department				
All	Existing County programs; grant funding	Short-term	6	Yes
CW-2—Encourage the development and implementation of a county-wide hazard mitigation public-information strategy that meets the needs of all planning partners. Leverage public outreach partnering capabilities to inform and educate the public about hazard mitigation and preparedness. Seek opportunities to promote the mitigation of natural hazards within the planning area, utilizing information contained within this plan. Sponsor and maintain a natural hazards informational website to include information such as: • Hazard-specific information such as GIS layers, private property mitigation alternatives, important facts on risk and vulnerability • Pre- and post-disaster information such as notices of grant funding availability • Links to Planning Partners' pages, FEMA, Red Cross, NOAA, USGS and the National Weather Service. • Information such as progress reports, mitigation success stories, update strategies, Steering Committee meetings. **Responsible Agency:** County Emergency Management with participation of all planning partners				
All	Cost sharing from the Partnership, General Fund Allocations, Cost sharing with Stakeholders	Short-term	5, 6	Yes

CW-3—Coordinate updates to land use and building regulations as they pertain to reducing the impacts of natural hazards, to seek a regulatory cohesiveness within the planning area. This can be accomplished via a commitment from all planning partners to involve each other in their adoption processes, by seeking input and comment during the course of regulatory updates or comprehensive planning. **Responsible Agency:** Governing body of each eligible planning partner.				
All	General funds	Short-term	1, 2, 3	Yes
CW-4— Enhance emergency preparedness, response, and recovery efforts to mitigate risks and impacts associated with extreme weather, wildfire, and other hazards worsened by climate change. **Responsible Agency:** County Emergency Management				
All	County general fund through existing programs, grant funding	Short-term	1, 2, 4	No
CW-5— Support actions that mitigate wildfire smoke, such as promoting HVAC updates for facilities that serve high-risk and vulnerable populations, such as hospitals, libraries, schools, and other community facilities. **Responsible Agency:** County Emergency Management with participation of all planning partners				
Wildfire Smoke	County general fund through existing programs, grant funding	Short-term	1, 2	No
CW-6— Encourage and support the local agricultural community to become more resilient to the impacts of natural hazards, such as drought, severe weather, wildfire, and the effects of climate change. **Responsible Agency:** County with participation of all planning partners				
All	Ongoing programs, grant funding depending on the mandate	Short-term	1, 2, 3, 6	No
CW-7— Support the collection of improved data (hydrologic, geologic, topographic, volcanic, historical, etc.) to better assess risks and vulnerabilities. **Responsible Agency:** All planning partners				
All	Ongoing programs and grant funding	Short-term	1, 2, 3, 4, 5	Yes
CW-8— Utilize information within this plan to support updates to other emergency management plans in effect within the planning area. **Responsible Agency:** All planning partners				
All	Can be funded under existing programs	Short-term	1, 2, 4, 6	Yes
CW-9— Implement the wildfire mitigation actions identified within the updated 2025 CWPP **Responsible Agency:** All planning partners				
All	Ongoing programs and grant funding	Short-term	1, 2, 3, 4, 5, 6	No

19.2 BENEFIT-COST REVIEW

Local Plan Requirement C5—44 CFR Part 201.6(c)(3)(iii)

Prioritization shall include a special emphasis on the extent to which benefits are maximized according to a cost benefit review of the proposed projects and their associated costs.

The benefits of proposed actions were weighed against estimated costs as part of the action 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 actions 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 action was performed. Parameters were established for assigning subjective ratings to the costs and benefits of these actions.

Cost ratings were defined as follows:

- **Very High**—Cost exceeds $250,000
- **High**—Cost is from $50,000-$250,000
- **Moderate**—Cost is from $5,000 to $50,000
- **Low**—Cost is less than $5,000

Benefits of the action were described. Each action was evaluated to determine if the estimated cost outweighed the estimated benefit.

Using this approach, actions with positive benefit versus cost ratios considered cost-effective and are prioritized accordingly.

For many of the strategies identified in this action plan, financial assistance may be available through the HMGP or BRIC 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 actions not seeking financial assistance from grant programs that require detailed analysis, “benefits” can be defined according to parameters that meet the goals and objectives of this plan.

19.3 ACTION PLAN PRIORITIZATION

Local Plan Requirement C5— 44 CFR Part 201.6(c)(3)(iii)	Local Plan Requirement E2— 44 CFR Part 201.6(d)(3)
Prioritization shall include a special emphasis on the extent to which benefits are maximized according to a cost benefit review of the proposed projects and their associated costs.	***A local jurisdiction must review and revise its plan to reflect […] changes in priorities.***

Table 19-2 shows the prioritization of each action. Actions were prioritized based on a numerical system in the mitigation action worksheets that examined 15 different criteria. The criteria include life safety, property protection, cost-effectiveness, feasibility, legal authority, funding availability, grant eligibility, incorporation of nature-based solutions, examining climate change, benefitting socially vulnerable communities, administrative capability, multi-hazard risk reduction, timeline, policy and objective support, and community support. Each criteria was given a score based on the following answers:

- Yes = 3 points
- Maybe = 1 point
- No = 0 points

The scores were added together to determine prioritization:

- High = 31-45
- Medium = 16-30
- Low = 1-15

Table 19-2. Prioritization of County-Wide Mitigation Actions

Action	Life Safety	Property Protection	Cost-Effective	Technically Feasible	Legal Authority	Funding Available	Eligible for Grants	Climate Change	Nature-based Solution	Socially Vulnerable Community	Administrative Capacity	Multi-Hazard	Timeline	Community Support	Policy and Objective Support	Total Score	Priority
CW-1	3	3	3	3	3	3	1	0	0	0	3	0	3	3	3	31	High
CW-2	3	3	3	3	3	1	3	0	0	3	3	0	3	3	3	34	High
CW-3	3	3	3	3	3	1	3	1	0	1	1	1	1	1	1	26	Medium
CW-4	3	1	3	3	3	0	3	3	0	3	3	3	3	3	3	37	High
CW-5	3	0	3	3	3	1	3	3	0	3	1	1	3	3	3	33	High
CW-6	3	1	3	3	3	0	1	3	0	3	1	3	1	3	3	31	High
CW-7	3	3	1	1	3	0	1	1	0	1	1	3	1	1	1	21	Medium
CW-8	3	3	3	3	3	1	1	0	0	3	3	3	3	3	3	35	High
CW-9	3	3	1	3	3	3	1	3	3	3	3	1	1	3	3	37	High

19.4 CLASSIFICATION OF MITIGATION ACTIONS

Each recommended action was classified based on the hazard it addresses and the type of mitigation it involves. Table 19-3 shows these classifications.

Mitigation types used for this categorization are as follows:

- **Prevention**—Government, administrative or regulatory actions that influence the way land and buildings are developed to reduce hazard losses. Includes planning and zoning, floodplain laws, capital improvement programs, open space preservation, and stormwater management regulations.
- **Property Protection**—Modification of buildings or structures to protect them from a hazard or removal of structures from a hazard area. Includes acquisition, elevation, relocation, structural retrofit, storm shutters, and shatter-resistant glass.
- **Public Education and Awareness**—Actions to inform residents and elected officials about hazards and ways to mitigate them. Includes outreach projects, real estate disclosure, hazard information centers, and school-age and adult education.
- **Natural Resource Protection**—Actions that minimize hazard loss and preserve or restore the functions of natural systems. Includes sediment and erosion control, stream corridor restoration, watershed management, forest and vegetation management, wetland restoration and preservation, and green infrastructure.
- **Emergency Services**—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.
- **Structural Projects**—Actions that involve the construction of structures to reduce the impact of a hazard. Includes dams, setback levees, floodwalls, retaining walls, and safe rooms.

- **Climate Resiliency**—Actions that incorporate methods to mitigate and/or adapt to the impacts of climate change. Includes aquifer storage and recovery activities, incorporating future conditions projections in project design or planning, or actions that specifically address jurisdiction-specific climate change risks.
- **Community Capacity Building**—Actions that increase or enhance local capabilities to adjust to potential damage, to take advantage of opportunities, or to respond to consequences. Includes staff training, memorandums of understanding, development of plans and studies, and monitoring programs.

Table 19-3. Analysis of Mitigation Actions

	Actions That Address the Hazard, by Mitigation Type[a]							
Hazard	Prevention	Property Protection	Public Education and Awareness	Natural Resource Protection	Emergency Services	Structural Projects	Climate Resiliency	Community Capacity Building
Avalanche	CW-1, 2, 3, 4, 7,	CW-3	CW-2, 4, 6	CW-6	CW-4, 8		CW-4, 6, 7	CW-2, 5, 6, 7, 8
Dam Failure	CW-1, 2, 3, 4, 7,	CW-3	CW-2, 4, 6	CW-6	CW-4, 8		CW-4, 6, 7	CW-2, 5, 6, 7, 8
Drought	CW-1, 2, 3, 4, 7,	CW-3	CW-2, 4, 6	CW-6	CW-4, 8		CW-4, 6, 7	CW-2, 5, 6, 7, 8
Earthquake	CW-1, 2, 3, 4, 7,	CW-3	CW-2, 4, 6	CW-6	CW-4, 8		CW-4, 6, 7	CW-2, 5, 6, 7, 8
Flooding	CW-1, 2, 3, 4, 7,	CW-3	CW-2, 4, 6	CW-6	CW-4, 8		CW-4, 6, 7	CW-2, 5, 6, 7, 8
Landslide	CW-1, 2, 3, 4, 7,	CW-3	CW-2, 4, 6	CW-6	CW-4, 8		CW-4, 6, 7	CW-2, 5, 6, 7, 8
Severe Weather	CW-1, 2, 3, 4, 7,	CW-3	CW-2, 4, 6	CW-6	CW-4, 8		CW-4, 6, 7	CW-2, 5, 6, 7, 8
Wildfire	CW-1, 2, 3, 4, 7, 9	CW-3, 9	CW-2, 4,6, 9	CW-6, 9	CW-4, 8, 9		CW-4, 5, 6, 7	CW-2, 5, 6, 7, 8, 9

19.5 ACTION PLAN IMPLEMENTATION

The area-wide action plan here and jurisdiction-specific action plans in Volume 2 present a range of action items for reducing loss from hazard events. The planning partners have prioritized actions and can begin to implement the highest-priority actions over the next five years. The effectiveness of the hazard mitigation plan depends on its effective implementation and incorporation of the outlined action items into all partners' existing plans, policies, and programs. Some action items do not need to be implemented through regulation but can be implemented through the creation of new educational programs, continued interagency coordination, or improved public participation.

The Chelan County Natural Resources Department will assume lead responsibility for facilitating hazard mitigation plan implementation. Plan implementation will be a shared responsibility among all planning partnership members and agencies identified as lead agencies in the area-wide and jurisdiction-specific action plans.

19.6 INTEGRATION INTO OTHER PLANNING MECHANISMS

Integrating relevant information from this hazard mitigation plan into other plans and programs where opportunities arise will be the ongoing responsibility of the governing bodies for all planning partners covered by this plan. By adopting comprehensive plans and zoning ordinances, the planning partners have planned for the impact of natural hazards, and these documents are integral parts of this hazard mitigation plan. The hazard mitigation planning process provided the partners with an opportunity to review and expand on policies contained within these documents, based on the best science and technology available at the time this plan was prepared. The partners should use their comprehensive plans and the hazard mitigation plan as complementary documents to achieve the ultimate goal of reducing risk exposure to citizens of the planning area. An update to a comprehensive plan may trigger an update to the hazard mitigation plan.

All municipal planning partners have committed to creating a linkage between the hazard mitigation plan and their individual comprehensive plans or similar plans identified in the core capability assessment. Each municipal jurisdiction-specific action plan includes a high-priority mitigation action to create such a linkage.

Other planning processes and programs to be coordinated with the recommendations of the hazard mitigation plan may include the following:

- Capital improvement programs
- Climate action/adaptation plans
- Community design guidelines
- Critical areas regulations
- Debris management plans
- Emergency response plans
- Municipal codes
- Post-disaster action/recovery plans
- Stormwater management programs
- Water system vulnerability assessments
- Water-efficient landscape design guidelines.

All planning partners have identified opportunities and strategies for integration in their annexes in Volume 2 of this plan.

20. PLAN ADOPTION AND MAINTENANCE

20.1 PLAN ADOPTION

Local Plan Requirement F1—44 CFR Part 201.6(c)(5)
The plan shall include documentation that the plan has been formally adopted by the governing body of the jurisdiction requesting approval of the plan.

For multi-jurisdictional plans, each jurisdiction requesting approval must document that is has been formally adopted. This plan will be submitted for a pre-adoption review prior to adoption to Washington State Emergency Management Division. Once pre-adoption approval has been provided, all planning partners will formally adopt the plan. All partners understand that DMA compliance and its benefits cannot be achieved until the plan is adopted. Copies of the resolutions adopting this plan for all planning partners can be found in Appendix D of this volume, along with FEMA's letter of approval for the plan.

20.2 PLAN MAINTENANCE STRATEGY

Local Plan Requirement D2— 44 CFR Part 201.6(c)(4)(i)	Local Plan Requirement D3— 44 CFR Part 201.6(c)(4)(ii)
The plan shall include a plan maintenance process that includes a section describing the method and schedule of monitoring, evaluating and updating the mitigation plan within a 5-year-cycle.	*The plan maintenance process shall include a process by which local governments incorporate the requirements of the mitigation plan into other planning mechanisms such as comprehensive or capital improvement plans, when appropriate.*

Plan maintenance is the formal process for achieving the following:

- Ensuring that the hazard mitigation plan remains an active and relevant document and that the planning partnership maintains its eligibility for applicable funding sources
- Monitoring and evaluating the plan annually and producing an updated plan every five years
- Integrating public participation throughout the plan maintenance and implementation process
- Incorporating the mitigation strategies outlined in this plan into existing planning mechanisms and programs, such as any relevant comprehensive land-use planning process, capital improvement planning process, and building code enforcement and implementation.

Table 20-1 summarizes the plan maintenance strategy. The sections below further describe each element (except "integration into other planning mechanisms," which is discussed in Section 19.6).

20.2.1 Plan Monitoring

Chelan County will be the lead agency responsible for monitoring the plan, and each partner will monitor plan implementation by tracking the status of all recommended mitigation actions in its action plan. Staff or departments with primary responsibility are identified in each jurisdictional annex (see Volume 2) and summarized in Table 20-1.

Table 20-1. Plan Maintenance Matrix

Approach	Timeline	Lead Responsibility[a]
Integration into Other Planning Mechanisms		
Create a linkage between the hazard mitigation plan and individual jurisdictions' comprehensive plans or similar plans identified in the core capability assessments	Continuous over the 5-year performance period of the plan	Chelan County, City of Wenatchee, City of Cashmere, City of Entiat, City of Leavenworth, City of Chelan, Chelan County Flood Control Zone District, Chelan County Fire Districts 1, 3, 5, 6, 7, 8, 9, Cascadia Conservation District
Plan Monitoring[b]		
Track the implementation of actions over the performance period of the plan	Biennially (Year 2 and Year 4)	Chelan County Natural Resources Department will be the lead agency responsible for the plan, all planning partners will monitor themselves and report to Chelan County Emergency Management. All monitoring contacts will be as designated at the primary point of contacts in their jurisdictional annexes
Plan Evaluation		
Review the status of previous actions; assess changes in risk; update action plan matrix, evaluate success of integration	Biennially (Year 2 and Year 4)	Chelan County, City of Wenatchee, City of Cashmere, City of Entiat, City of Leavenworth, City of Chelan, Chelan County Flood Control Zone District, Chelan County Fire Districts 1, 3, 5, 6, 7, 8, 9, Cascadia Conservation District
Grant Monitoring and Coordination		
As grant opportunities present themselves, the planning partners will consider options to pursue grants to fund actions identified in this plan	As grants become available	Chelan County Natural Resources Department provides notification to planning partners and convenes grant funding meeting as needed
Plan Update		
The planning partnership will reconvene, at a minimum, every 5 years to guide a comprehensive update of the plan.	Every 5 years or upon update to comprehensive plan or major disaster; funding and organizing for plan update will begin in FY 2026/2027	The governing body for all planning partners covered by this plan

Approach	Timeline	Lead Responsibility[a]
Continuing Public Participation		
Chelan County Natural Resources Department will keep the website maintained, post bi-annual progress reports online, and receive comments through the website. The website and comments will be maintained over the course of the plan.	Continuous over the 5-year performance period of the plan	Chelan County Natural Resources Department will be the lead agency responsible, supported by Chelan County Emergency Management. Other jurisdictional point of contacts identified in volume 2 annexes will help support.

a. Responsible lead party may designate an alternate. Jurisdictional points of contact identified in Volume 2 annexes have support responsibility.
b. For the monitoring task, agencies identified as lead agencies in each jurisdictions' action plan will report status as requested to the agency charged with lead responsibility for plan monitoring

20.2.2 Plan Evaluation

The plan will be evaluated by how successfully the implementation of identified actions has helped to achieve the goals and objectives identified in this plan. This will be assessed by a review of the changes in risk that occur over the performance period and by the degree to which mitigation goals and objectives are incorporated into existing plans, policies and programs. Plan evaluation will be a shared responsibility among all planning partnership members and agencies identified as lead agencies in the area-wide and jurisdiction-specific action plans.

20.2.3 Grant Monitoring and Coordination

Chelan County Natural Resources Department will identify grant funding opportunities and send notifications to participating partner jurisdictions. Once these opportunities are identified, planning partners interested in pursuing a grant opportunity will convene in a short meeting to review the hazard mitigation plan and pursue a strategy to capture that grant funding. Chelan County Natural Resources Department will assume lead responsibility for planning and facilitating grant opportunity meetings. Review of the hazard mitigation plan at these meetings can include the following:

- Discussion of any hazard events that occurred during the prior year and their impact on the planning area
- Impact of potential grant opportunities on the implementation of mitigation actions
- Re-evaluation of the action plans to determine if the timeline for identified actions need to be amended (such as changing a long-term action to a short-term action because of funding availability)
- Recommendations for new actions
- Impact of any other planning programs or initiatives that involve hazard mitigation.

If multiple planning partners decide to pursue the same grant funding opportunity, partnerships can be formed to utilize the hazard mitigation plan in the grant application.

20.2.4 Plan Update

Local Plan Requirement E—44 CFR Part 201.6(d)(3)

A local jurisdiction must review and revise its plan to reflect changes in development, progress in local mitigation efforts, and changes in priorities, and resubmit if for approval within five years in order to continue to be eligible for mitigation project grant funding.

Federal regulations require that local hazard mitigation plans be reviewed, revised if appropriate, and resubmitted for approval in order to remain eligible for benefits awarded under the Disaster Mitigation Act. This plan's format allows the planning partnership to review and update sections when new data become available. New data can be easily incorporated, resulting in a plan that will remain current and relevant. The planning partnership intends to update the plan on a five-year cycle from the date of plan approval. This cycle may be accelerated to less than five years based on the following triggers:

- A presidential disaster declaration that impacts the planning area
- A natural hazard event that causes loss of life
- A 10-year plan update of a participating jurisdiction's comprehensive plan

It will not be the intent of the update process to develop a complete new hazard mitigation plan. Based on needs identified by the planning team, the update will, at a minimum, include the following elements:

- The update process will be convened through a new steering committee.
- The hazard risk assessment will be reviewed and, if necessary, updated using best available information and technologies.
- Action plans will be reviewed and revised to account for any actions completed, dropped, or changed and to account for changes in the risk assessment or planning partnership 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.
- Partners' governing bodies will adopt their respective portions of the updated plan.

Because plan updates can require a year or more to complete, the Chelan County Natural Resources Department will initiate efforts to update the plan before it expires. Chelan County Natural Resources Department will consider applying for funding to update the plan in the Fiscal Year 2026/2027 grant cycle or will identify an alternate source of funding for the plan update in order to begin the update process in the fall of 2028.

20.2.5 Continuing Public Participation

Local Plan Requirement D1—44 CFR Part 201.6(c)(4)(iii)

The plan maintenance process shall include a discussion on how the community will continue public participation in the plan maintenance process.

The public outreach strategy used during development of the current update will provide a framework for public engagement through the plan maintenance process. It can be adapted for ongoing public outreach as determined to be feasible by the planning partnership. A steering committee similar to the one involved in developing this hazard mitigation plan update will be put in place to provide stakeholder input on plan maintenance activities.

The public will continue to be apprised of hazard mitigation activities through the website and reports on successful hazard mitigation actions provided to the media. Chelan County Natural Resources Department will keep the website maintained, including monitoring the email address where members of the public can submit comments to the steering committee. This site will house the final plan and will be a one-stop shop for information regarding the plan, the partnership and plan implementation. Copies of the plan also will be distributed to the North Central Regional Library.

Biennially, in years 2 and 4, the Chelan County Emergency Management and Chelan County Natural Resources Department will request a progress report from planning partners which summarizes the status or implementation of plan actions, assesses any changes to risk, updates the action plan matrix, evaluates the success of plan integration, and summarizes other changes to plan content. The progress reports will be combined and posted on the County website for public review.

Upon initiation of the next plan update process, a new public involvement strategy will be initiated, with guidance from the new steering committee. This strategy will be based on the needs and capabilities of the planning partnership at the time of the update. At a minimum, it will include the use of local media outlets.

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LIST OF ACRONYMS

ADA—American with Disabilities Act

BLM—Bureau of Land Management

CCNRD—Chelan County Natural Resources Department

CDBG-DR—Community Development Block Grant Disaster Recovery

CFR—Code of Federal Regulations

CRS—Community Rating System

CWA—Clean Water Act

CWPP—Community Wildfire Protection Plan

DMA —Disaster Mitigation Act

EPA—U.S. Environmental Protection Agency

ESA—Endangered Species Act

ESD—Employment Security Department (Washington State)

EWP—Emergency Watershed Protection

FEMA—Federal Emergency Management Agency

FERC—Federal Energy Regulatory Commission

FIRM—Flood Insurance Tate Map

FRCC—Fire regime condition class

GIS—Geographic Information System

Hazus—Hazards, United States

HMGP—Hazard Mitigation Grant Program

IPCC—Intergovernmental Panel on Climate Change

Mw—Moment Magnitude Scale

mph—Miles per hour

NASA—National Aeronautics and Space Administration

NEHRP—National Earthquake Hazards Reduction Program

NFIP—National Flood Insurance Program

NIDIS—National Integrated Drought Information System

NIMS—National Incident Management System

NOAA—National Oceanic and Atmospheric Administration

NPS—National Park Service

NRCS—Natural Resources Conservation Service

NWS—National Weather Service

OFM—Office of Financial Management (Washington State)

PDM—Pre-Disaster Mitigation Grant Program

PGA—Peak Ground Acceleration

RCW—Revised Code of Washington

SEPA—State Environmental Policy Act

SFHA—Special flood hazard area

USDA—U.S. Department of Agriculture

USGCRP—U.S. Global Change Research Program

USGS—U.S. Geological Survey

WAC—Washington Administrative Code

WDNR—Washington Department of Natural Resources

WPPSS—Washington Public Power Supply System

WRIA—Water Resource Inventory Area

A. Public Outreach Materials

B. Federal and State Agencies, Programs, and Regulations

Existing laws, ordinances, plans and programs at the federal and state level can support or impact hazard mitigation actions identified in this plan. Hazard mitigation plans are required to include a review and incorporation, if appropriate, of existing plans, studies, reports, and technical information as part of the planning process (44 CFR, Section 201.6(b)(3)). The following federal and state programs have been identified as programs that may interface with the actions identified in this plan. Each program enhances capabilities to implement mitigation actions or has a nexus with a mitigation action in this plan. Information presented in this section can be used to review local capabilities to implement the actions found in the jurisdictional annexes of Volume 2. Each planning partner has individually reviewed existing local plans, studies, reports, and technical information in its jurisdictional annex, presented in Volume 2.

FEDERAL

Americans with Disabilities Act

The Americans with Disabilities Act (ADA) seeks to prevent discrimination against people with disabilities in employment, transportation, public accommodation, communications, and government activities. Title II of the ADA deals with compliance with the Act in emergency management and disaster-related programs, services, and activities. It applies to state and local governments as well as third parties, including religious entities and private nonprofit organizations.

The ADA has implications for sheltering requirements and public notifications. During an emergency alert, officials must use a combination of warning methods to ensure that all residents have all necessary information. Those with hearing impairments may not hear radio, television, sirens, or other audible alerts, while those with visual impairments may not see flashing lights or other visual alerts. Two technical documents for shelter operators address physical accessibility needs of people with disabilities, as well as medical needs and service animals.

The ADA intersects with disaster preparedness programs in regards to transportation, social services, temporary housing, and rebuilding. Persons with disabilities may require additional assistance in evacuation and transit (e.g., vehicles with wheelchair lifts or paratransit buses). Evacuation and other response plans should address the unique needs of residents. Local governments may be interested in implementing a special-needs registry to identify the home addresses, contact information, and needs for residents who may require more assistance.

FEMA hazard mitigation project grant applications require full compliance with applicable federal acts. Any action identified in this plan that falls within the scope of this act will need to meet its requirements.

Bureau of Indian Affairs

The U.S. Bureau of Indian Affairs' Fire and Aviation Management National Interagency Fire Center provides wildfire protection, fire use and hazardous fuels management, and emergency rehabilitation on Indian forest and rangelands held in trust by the United States, based on fire management plans approved by the appropriate Indian Tribe.

Bureau of Land Management

The U.S. Bureau of Land Management (BLM) funds and coordinates wildfire management programs and structural fire management and prevention on BLM lands. BLM works closely with the Forest Service and state and local governments to coordinate fire safety activities. The Interagency Fire Coordination Center in Boise, Idaho serves as the center for this effort.

Civil Rights Act of 1964

The Civil Rights Act of 1964 prohibits discrimination based on race, color, religion, sex or nation origin and requires equal access to public places and employment. The Act is relevant to emergency management and hazard mitigation in that it prohibits local governments from favoring the needs of one population group over another. Local government and emergency response must ensure the continued safety and well-being of all residents equally, to the extent possible. FEMA hazard mitigation project grant applications require full compliance with applicable federal acts. Any action identified in this plan that falls within the scope of this act will need to meet its requirements.

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, and 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. Numerous 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 CWA is important to hazard mitigation in several ways. There are often permitting requirements for any construction within 200 feet of water of the United States, which may have implications for mitigation projects identified by a local jurisdiction. Additionally, CWA requirements apply to wetlands, which serve important functions related to preserving and protecting the natural and beneficial functions of floodplains and are linked with a community's floodplain management program. Finally, the National Pollutant Discharge Elimination System is part of the CWA and addresses local stormwater management programs. Stormwater management plays a critical role in hazard mitigation by addressing urban drainage or localized flooding issues within jurisdictions.

FEMA hazard mitigation project grant applications require full compliance with applicable federal acts. Any action identified in this plan that falls within the scope of this act will need to meet its requirements.

Community Development Block Grant Disaster Resilience Program

In response to disasters, Congress may appropriate additional funding for the U.S. Department of Housing and Urban Development Community Development Block Grant programs to be distributed as Disaster Recovery grants (CDBG-DR). These grants can be used to rebuild affected areas and provide seed money to start the recovery process. CDBG-DR assistance may fund a broad range of recovery activities, helping communities and neighborhoods that otherwise might not recover due to limited resources. CDBG-DR grants often supplement disaster programs of FEMA, the Small Business Administration, and the U.S. Army Corps of Engineers. Housing and Urban Development generally awards noncompetitive, nonrecurring CDBG-DR grants by a formula that considers disaster recovery needs unmet by other federal disaster assistance programs. To be eligible for CDBG-DR funds, projects must meet the following criteria:

- Address a disaster-related impact (direct or indirect) in a presidentially declared county for the covered disaster
- Be a CDBG-eligible activity (according to regulations and waivers)
- Meet a national objective.

Incorporating preparedness and mitigation into these actions is encouraged, as the goal is to rebuild in ways that are safer and stronger. CDBG-DR funding is a potential alternative source of funding for actions identified in this plan.

Community Rating System

The CRS is a voluntary program within the NFIP that encourages floodplain management activities that exceed the minimum NFIP requirements. NFIP flood insurance premiums are discounted to reflect the reduced flood risk resulting from community actions meeting the following three goals of the CRS:

- Reduce flood losses.
- Facilitate accurate insurance rating.
- Promote awareness of flood insurance.

For participating communities, flood insurance premium rates are discounted in increments of 5%. For example, a Class 1 community would receive a 45% premium discount, and a Class 9 community would receive a 5% discount. (Class 10 communities are those that do not participate in the CRS; they receive no discount.) CRS classes for local communities are based on 18 creditable activities in the following categories:

- Public information
- Mapping and regulations
- Flood damage reduction
- Flood preparedness.

CRS activities can help to save lives and reduce property damage. Communities participating in the CRS represent a significant portion of the nation's flood risk; over 66% of the NFIP's policy base is located in these communities. Communities receiving premium discounts through the CRS range from small to large and represent a broad mixture of flood risks, including both coastal and riverine flood risks.

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 Assistance grant funds are available to communities. This plan is designed to meet the requirements of DMA, improving eligibility for future hazard mitigation funds.

Emergency Relief for Federally Owned Roads Program

The U.S. Forest Service's Emergency Relief for Federally Owned Roads Program was established to assist federal agencies with repair or reconstruction of tribal transportation facilities, federal lands transportation facilities, and other federally owned roads that are open to public travel and have suffered serious damage by a natural disaster over a wide area or by a catastrophic failure. The program funds both emergency and permanent repairs (Office of Federal Lands Highway, 2016). Eligible activities under this program meet some of the goals and objectives for this plan and the program is a possible funding source for actions identified in this plan.

Emergency Watershed Program

The USDA Natural Resources Conservation Service (NRCS) administers the Emergency Watershed Protection (EWP) Program, which responds to emergencies created by natural disasters. Eligibility for assistance is not dependent on a national emergency declaration. The program is designed to help people and conserve natural resources by relieving imminent hazards to life and property caused by floods, fires, windstorms, and other natural occurrences. EWP is an emergency recovery program. Financial and technical assistance are available for the following activities (Natural Resources Conservation Service, 2016):

- Remove debris from stream channels, road culverts, and bridges
- Reshape and protect eroded banks
- Correct damaged drainage facilities
- Establish cover on critically eroding lands
- Repair levees and structures
- Repair conservation practices.

This federal program could be a possible funding source for actions identified in this plan.

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. It is the enabling legislation for the Convention on International Trade in Endangered Species of Wild Fauna and Flora. Criminal and civil penalties are provided for violations of the ESA and the Convention.

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."

Five sections of the ESA are of critical importance to understanding it:

- Section 4: Listing of a Species—The National Oceanic and Atmospheric Administration Fisheries Service (NOAA Fisheries) is responsible for listing marine species; the U.S. Fish and Wildlife Service is responsible for listing terrestrial and freshwater aquatic species. The agencies may initiate reviews for listings, or citizens may petition for them. A listing must be made "solely on the basis of the best scientific and commercial data available." After a listing has been proposed, agencies receive comment and conduct further scientific reviews for 12 to 18 months, after which they must decide if the listing is warranted. Economic impacts cannot be considered in this decision, but it may include an evaluation of the adequacy of local and state protections. Critical habitat for the species may be designated at the time of listing.
- Section 7: Consultation—Federal agencies must ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of a listed or proposed species or adversely modify its critical habitat. This includes private and public actions that require a federal permit. Once a final listing is made, non-federal actions are subject to the same review, termed a "consultation." If the listing agency finds that an action will "take" a species, it must propose mitigations or "reasonable and prudent" alternatives to the action; if the proponent rejects these, the action cannot proceed.
- Section 9: Prohibition of Take—It is unlawful to "take" an endangered species, including killing or injuring it or modifying its habitat in a way that interferes with essential behavioral patterns, including breeding, feeding or sheltering.
- Section 10: Permitted Take—Through voluntary agreements with the federal government that provide protections to an endangered species, a non-federal applicant may commit a take that would otherwise be prohibited as long as it is incidental to an otherwise lawful activity (such as developing land or building a road). These agreements often take the form of a "Habitat Conservation Plan."
- Section 11: Citizen Lawsuits—Civil actions initiated by any citizen can require the listing agency to enforce the ESA's prohibition of taking or to meet the requirements of the consultation process.

FEMA hazard mitigation project grant applications require full compliance with applicable federal acts. Any action identified in this plan that falls within the scope of this act will need to meet its requirements.

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. More than 3,000 dams 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 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 monitors seismic research and applies it in performing structural analyses of hydroelectric projects. FERC also evaluates the effects of potential and actual large floods on the safety of dams. During and following floods, FERC 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.

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.

Federal Wildfire Management Policy and Healthy Forests Restoration Act

Federal Wildfire Management Policy and Healthy Forests Restoration Act (2003). These documents call for a single comprehensive federal fire policy for the Interior and Agriculture Departments (the agencies using federal fire management resources). They mandate community-based collaboration to reduce risks from wildfire.

National Dam Safety Act

Potential for catastrophic flooding due to dam failures led to passage of the National Dam Inspection Act in 1972, creation of the National Dam Safety Program in 1996, and reauthorization of the program through the Dam Safety Act in 2006. National Dam Safety Program, administered by FEMA requires a periodic engineering analysis of the majority of dams in the country; exceptions include the following:

- Dams under jurisdiction of the Bureau of Reclamation, Tennessee Valley Authority, or International Boundary and Water Commission
- Dams constructed pursuant to licenses issued under the Federal Power Act
- Dams that the Secretary of the Army determines do not pose any threat to human life or property.

The goal of this FEMA-monitored effort is to identify and mitigate the risk of dam failure so as to protect lives and property of the public. The National Dam Safety Program is a partnership among the states, federal agencies, and other stakeholders that encourages individual and community responsibility for dam safety. Under FEMA's leadership, state assistance funds have allowed all participating states to improve their programs through increased inspections, emergency action planning, and purchases of needed equipment. FEMA has also expanded existing and initiated new training programs. Grant assistance from FEMA provides support for improvement of dam safety programs that regulate most of the dams in the United States.

National Environmental Policy Act

The National Environmental Policy Act requires federal agencies to consider the environmental impacts of proposed actions and reasonable alternatives to those actions, alongside technical and economic considerations. The National Environmental Policy Act established the Council on Environmental Quality, whose regulations (40 CFR Parts 1500-1508) set standards for compliance. Consideration and decision-making regarding environmental impacts must be documented in an environmental impact statement or environmental assessment. Environmental impact assessment requires the evaluation of reasonable alternatives to a proposed action, solicitation of input from organizations and individuals that could be affected, and an unbiased presentation of direct, indirect, and cumulative environmental impacts. FEMA hazard mitigation project grant applications require full compliance with applicable federal acts. Any action identified in this plan that falls within the scope of this act will need to meet its requirements.

National Fire Plan (2001)

The 2001 National Fire Plan was developed based on the National Fire Policy. A major aspect of the National Fire Plan is joint risk reduction planning and implementation carried out by federal, state and local agencies and communities. The National Fire Plan presented a comprehensive strategy in five key initiatives:

- Firefighting—Be adequately prepared to fight fires each fire season.
- Rehabilitation and Restoration—Restore landscapes and rebuild communities damaged by wildfires.
- Hazardous Fuel Reduction—Invest in projects to reduce fire risk.
- Community Assistance—Work directly with communities to ensure adequate protection.
- Accountability—Be accountable and establish adequate oversight, coordination, program development, and monitoring for performance.

National Flood Insurance Program

The NFIP makes federally backed flood insurance available to homeowners, renters, and business owners in participating communities. 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%-annual-chance flood and the 0.2%-annual-chance flood. Base flood elevations and the boundaries of the flood hazard areas are shown on Flood Insurance Rate Maps, which are the principle tool for identifying the extent and location of the flood hazard. Flood Insurance Rate Maps are the most detailed and consistent data source available, and for many communities they represent the minimum area of oversight under the local floodplain management program. In recent years, Flood Insurance Rate Maps have been digitized as Digital Flood Insurance Rate Maps, which are more accessible to residents, local governments and stakeholders.

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

- New buildings and those undergoing substantial improvements must, at a minimum, be elevated to protect against damage by the 1%-annual-chance 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.

Full compliance and good standing under the NFIP are application prerequisites for all FEMA grant programs for which participating jurisdictions are eligible under this plan. Chelan County and all cities participate in the NFIP and have adopted and enforced floodplain management regulations that meet or exceed the requirements of the NFIP. At the time of the preparation of this plan, these jurisdictions were in good standing with NFIP requirements.

National Incident Management System

The National Incident Management System (NIMS) is a systematic approach for government, nongovernmental organizations, and the private sector to work together to manage incidents involving hazards. The NIMS provides a flexible but standardized set of incident management practices. Incidents typically begin and end locally, and they are managed at the lowest possible geographical, organizational, and jurisdictional level. In some cases, success depends on the involvement of multiple jurisdictions, levels of government, functional agencies, and emergency responder disciplines. These cases necessitate coordination across a spectrum of organizations. Communities using NIMS follow a comprehensive national approach that improves the effectiveness of emergency management and response personnel across the full spectrum of potential hazards (including natural hazards, technological hazards, and human-caused hazards) regardless of size or complexity.

Although participation is voluntary, federal departments and agencies are required to make adoption of NIMS by local and state jurisdictions a condition to receive federal preparedness grants and awards. The content of this plan is considered to be a viable support tool for any phase of emergency management. The NIMS program is considered as a response function, and information in this hazard mitigation plan can support the implementation and update of all NIMS-compliant plans within the planning area.

National Park Service, North Cascades National Park

The National Park Service (NPS) provides wildland and structure fire protection, and conducts wildfire management within the NPS units. These activities are guided by the National Park Service Fire Management Plan.

Presidential Executive Order 11988, Floodplain Management

Executive Order 11988 requires federal agencies to avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. It requires federal agencies to provide leadership and take action to reduce the risk of flood loss, minimize the impact of floods on human safety, health, and welfare, and restore and preserve the natural and beneficial values of floodplains. The requirements apply to the following activities (FEMA, 2015a):

- Acquiring, managing, and disposing of federal lands and facilities
- Providing federally undertaken, financed, or assisted construction and improvements
- Conducting federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulation, and licensing.

Presidential Executive Order 11990, Protection of Wetlands

Executive Order 11990 requires federal agencies to provide leadership and take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands. The requirements apply to the following activities (National Archives, 2016):

- Acquiring, managing, and disposing of federal lands and facilities
- Providing federally undertaken, financed, or assisted construction and improvements
- Conducting federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulation, and licensing.

All actions identified in this plan will seek full compliance with all applicable presidential executive orders.

U.S. Army Corps of Engineers Dam Safety Program

The U.S. Army Corps of Engineers operates and maintains approximately 700 dams nationwide. It is also 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. The Corps maintains the National Inventory of Dams, which contains information about a dam's location, size, purpose, type, last inspection and regulatory status (U.S. Army Corps of Engineers, 2017).

U.S. Army Corps of Engineers Flood Hazard Management

The U.S. Army Corps of Engineers has several civil works authorities and programs related to flood risk and flood hazard management:

- The Floodplain Management Services program offers 100% federally funded technical services such as development and interpretation of site-specific data related to the extent, duration and frequency of flooding. Special studies may be conducted to help a community understand and respond to flood risk. These may include flood hazard evaluation, flood warning and preparedness, or flood modeling.
- For more extensive studies, the Corps of Engineers offers a cost-shared program called Planning Assistance to States and Tribes. Studies under this program generally range from $25,000 to $100,000 with the local jurisdiction providing 50% of the cost.
- The Corps of Engineers has several cost-shared programs (typically 65% federal and 35% non-federal) aimed at developing, evaluating and implementing structural and non-structural capital projects to address flood risks at specific locations or within a specific watershed:
  - The Continuing Authorities Program for smaller-scale projects includes Section 205 for Flood Control, with a $7 million federal limit and Section 14 for Emergency Streambank Protection with a $1.5 million federal limit. These can be implemented without specific authorization from Congress.
  - Larger scale studies, referred to as General Investigations, and projects for flood risk management, for ecosystem restoration or to address other water resource issues, can be pursued through a specific authorization from Congress and are cost-shared, typically at 65% federal and 35% non-federal.
  - Watershed management planning studies can be specifically authorized and are cost-shared at 50% federal and 50% non-federal.
- The Corps of Engineers provides emergency response assistance during and following natural disasters. Public Law 84-99 enables the Corps to assist state and local authorities in flood fight activities and cost share in the repair of flood protective structures. Assistance is provided in the flowing categories:
  - Preparedness—The Flood Control and Coastal Emergency Act establishes an emergency fund for preparedness for emergency response to natural disasters; for flood fighting and rescue operations; for rehabilitation of flood control and hurricane protection structures. Funding for Corps of Engineers emergency response under this authority is provided by Congress through the annual Energy and Water Development Appropriation Act. Disaster preparedness activities include coordination, planning, training and conduct of response exercises with local, state and federal agencies.

- Response Activities—Public Law 84-99 allows the Corps of Engineers to supplement state and local entities in flood fighting urban and other non-agricultural areas under certain conditions (Engineering Regulation 500-1-1 provides specific details). All flood fight efforts require a project cooperation agreement signed by the public sponsor and the sponsor must remove all flood fight material after the flood has receded. Public Law 84-99 also authorizes emergency water support and drought assistance in certain situations and allows for “advance measures” assistance to prevent or reduce flood damage conditions of imminent threat of unusual flooding.
- Rehabilitation—Under Public Law 84-99, an eligible flood protection system can be rehabilitated if damaged by a flood event. The flood system would be restored to its pre-disaster status at no cost to the federal system owner, and at 20% cost to the eligible non-federal system owner. All systems considered eligible for Public Law 84-99 rehabilitation assistance have to be in the Rehabilitation and Inspection Program prior to the flood event. Acceptable operation and maintenance by the public levee sponsor are verified by levee inspections conducted by the Corps on a regular basis. The Corps has the responsibility to coordinate levee repair issues with interested federal, state, and local agencies following natural disaster events where flood control works are damaged.

All of these authorities and programs are available to the planning partners to support any intersecting mitigation actions.

U.S. Fire Administration

There are federal agencies that provide technical support to fire agencies/organizations. For example, the U.S. Fire Administration, which is a part of FEMA, provides leadership, advocacy, coordination, and support for fire agencies and organizations.

U.S. Fish and Wildlife Service

The U.S. Fish and Wildlife Service fire management strategy employs prescribed fire to maintain early successional fire-adapted grasslands and other ecological communities throughout the National Wildlife Refuge System.

U.S. Forest Service Six Rivers National Forest

The U.S. Forest Service role in wildfire management is primarily focused on National Forest lands. However, Forest Service personnel will respond to wildland and structural fires on adjacent lands through mutual aid agreements when crews and equipment are available. Forest Service fire stations are not staffed outside of fire season.

STATE

Building Code

The Washington State Building Code Council adopted the 2021 editions of national model codes, with some amendments (RCW 19.27.074). The Council also adopted changes to the Washington State Energy Code. Washington’s state-developed codes are mandatory statewide for residential and commercial buildings. The residential code exceeds the 2006 International Energy Conservation Code standards (as amended) for most homes, and the commercial code meets or exceeds standards of the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE 90.1-2004). For residential construction covered by ASHRAE 90.1-2007 (buildings with four or more stories), the state code is more stringent. The 2021 International Building Code went into effect as the Washington model code in March 2024.

The adoption and enforcement of appropriate building codes is a significant component for hazard mitigation loss avoidance. Using the most up to date and relevant codes reduces risk and increases capability.

Comprehensive Emergency Management Planning

Washington's Comprehensive Emergency Management Planning law (RCW 38.52) establishes parameters to ensure that preparations of the state will be adequate to deal with disasters, to ensure the administration of state and federal programs providing disaster relief to individuals, to ensure adequate support for search and rescue operations, to protect the public peace, health and safety, and to preserve the lives and property of the people of the state. It achieves the following:

- Provides for emergency management by the state, and authorizes the creation of local organizations for emergency management in political subdivisions of the state.
- Confers emergency powers upon the governor and upon the executive heads of political subdivisions of the state.
- Provides for the rendering of mutual aid among political subdivisions of the state and with other states and for cooperation with the federal government with respect to the carrying out of emergency management functions.
- Provides a means of compensating emergency management workers who may suffer any injury or death, who suffer economic harm including personal property damage or loss, or who incur expenses for transportation, telephone or other methods of communication, and the use of personal supplies as a result of participation in emergency management activities.
- Provides programs, with intergovernmental cooperation, to educate and train the public to be prepared for emergencies.

It is policy under this law that emergency management functions of the state and its political subdivisions be coordinated to the maximum extent with comparable functions of the federal government and agencies of other states and localities, and of private agencies of every type, to the end that the most effective preparation and use may be made of manpower, resources, and facilities for dealing with disasters.

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's five-year periodic inspection program for dams with high and significant hazard classifications achieves the following purposes (Washington Department of Ecology, 2015a):

- Assess the structural integrity and stability of project elements.
- Identify obvious defects, especially due to aging.
- Assess the stability of the structure under earthquake conditions.
- Determine the adequacy of the spillways to accommodate major floods.
- Evaluate project operation and maintenance.

The inspections, performed by professional engineers from the DSO, consist of the following elements (Washington Department of Ecology, 2015a):

- Review and analysis of available data on the design, construction, operation and maintenance of the dam and its appurtenances
- Visual inspection of the dam and its appurtenances
- Evaluation of the safety of the dam and its appurtenances, which may include an assessment of hydrological and hydraulic capabilities, structural stabilities, seismic stabilities, and any other condition that could constitute a hazard to the integrity of the structure
- Evaluation of the downstream hazard classification
- Evaluation of the operation, maintenance and inspection procedures employed by the owner and/or operator
- Review of the emergency action plan for the dam, including review or update of the dam-breach inundation map.

The DSO provides 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.

Department of Ecology Grants

Washington's first flood control maintenance program, passed in 1951, was called the Flood Control Maintenance Program. In 1984, the state Legislature established the Flood Control Assistance Account Program (FCAAP) to assist local jurisdictions in comprehensive planning and flood control maintenance (RCW 86.26; WAC 173-145). This is one of the few state programs in the country that provides grant funding to local governments for flood hazard management planning and implementation. The account is funded at $4 million per state biennium, unless modified by the Legislature. Projects include comprehensive flood hazard management planning, maintenance projects, feasibility studies, purchase of flood-prone properties, matches for federal projects, and emergency projects. FCAAP grants for non-emergency projects may not exceed $500,000 per county. Due to funding cuts, applications to this program are currently being accepted only for emergency projects.

In 2013, the Legislature authorized $44 million in new funding for integrated projects consistent with Floodplains by Design, an emerging partnership of local, state, federal and private organizations focused on coordinating investment in and strengthening the integrated management of floodplain areas. A similar level of funding was authorized for the 2015-17 and 2017-19 bienniums. The Department of Ecology's Floods and

Floodplain Management Division administers the Floodplains by Design grant program. Ecology awards grants on a competitive basis to eligible entities for collaborative and innovative projects in Washington that support the integration of flood hazard reduction with ecological preservation and restoration. Proposed projects may also address other community needs, such as preservation of agriculture, improvements in water quality, or increased recreational opportunities, provided they are part of a larger strategy to restore ecological functions and reduce flood hazards.

Enhanced Mitigation Plan

The 2013 Washington State Enhanced Hazard Mitigation Plan provides guidance for hazard mitigation throughout Washington (Washington Emergency Management Division, 2013). The plan identifies hazard mitigation goals, objectives and actions for state government to reduce injury and damage from natural hazards. By meeting federal requirements for an enhanced state plan (44 CFR Parts 201.4 and 201.5), the plan allows the state to seek significantly higher funding from the Hazard Mitigation Grant Program following presidential declared disasters (20% of federal disaster expenditures vs. 15% with a standard plan).

The *Chelan County Multi-Jurisdictional Natural Hazard Mitigation Plan* must be consistent with the Washington State Plan. One major example of this is that the Chelan County plan must, at a minimum, address those hazards identified in the state plan as impacting Chelan County.

Environmental Policy Act

The State Environmental Policy Act (SEPA) provides a way to identify possible environmental impacts of governmental decisions. These decisions may be related to issuing permits for private projects, constructing public facilities, or adopting regulations, policies, or plans. Information provided during the SEPA review process helps agency decision-makers, applicants, and the public understand how a proposal will affect the environment. This information can be used to change a proposal to reduce likely impacts, or to condition or deny a proposal when adverse environmental impacts are identified. Actions identified in hazard mitigation plans are frequently subject to SEPA review requirements before implementation (Washington Department of Ecology, 2016).

Floodplain Management Law

Washington’s floodplain management law (Revised Code of Washington (RCW) 86.16, implemented through Washington Administrative Code (WAC) 173-158) states that prevention of flood damage is a matter of statewide public concern and places regulatory control with the Department of Ecology. RCW 86.16 is cited in floodplain management literature, including FEMA’s national assessment, as one of the first and strongest in the nation. A 1978 major challenge to the law—Maple Leaf Investors Inc. v. Department of Ecology—is cited in legal references to flood hazard management issues. The court upheld the law, declaring that denial of a permit to build residential structures in the floodway is a valid exercise of police power and did not constitute a taking. RCW Chapter 86.12 (Flood Control by Counties) authorizes county governments to levy taxes, condemn properties and undertake flood control activities directed toward a public purpose.

Growth Management Act

The 1990 Washington State Growth Management Act (RCW Chapter 36.70A) mandates that local jurisdictions adopt land use ordinances to protect the following critical areas:

- Wetlands

- Critical aquifer recharge areas
- Fish and wildlife habitat conservation areas
- Frequently flooded areas
- Geologically hazardous areas.

The Growth Management Act regulates development in these areas, and therefore has the potential to affect hazard vulnerability and exposure at the local level.

Planning for natural hazards is an integral element of Washington's statewide land use planning program under the Growth Management Act. Other related parts of the planning framework include the Shoreline Master Program rules and guidelines, which now provide for the integration of master programs and comprehensive plans. Natural Hazard Mitigation Elements are an optional element under the Growth Management Act. The continuing challenge faced by local officials and state government is to keep a network of coordinated local plans effective in responding to changing conditions and needs of communities. This is particularly true in the case of planning for natural and technological hazards, where communities must balance development pressures with detailed information on the nature and extent of hazards. Washington's land use program has given its communities and residents a unique opportunity to ensure that natural and technological hazards are addressed in the development and implementation of local comprehensive plans.

Hydraulic Code

Washington's Hydraulic Code states that any person or government agency intending to undertake a hydraulic project shall, before commencing work, secure a Hydraulic Project Approval from the Washington Department of Fish and Wildlife verifying the adequacy of the proposed means for protecting fish (RCW 77.55.021 (1)). The code defines a hydraulic project as work that will use, divert, obstruct, or change the natural flow or bed of any salt or freshwaters of the state. Approval is required for projects at or waterward of the ordinary high water line and for projects landward of the ordinary high water line that are immediately adjacent to waters of the state.

Land and Water Conservation Fund

Congress established the Land and Water Conservation Fund in 1965 and authorized the Secretary of the Interior to provide financial assistance to the states for the acquisition and development of public outdoor recreation areas. The Washington State Recreation and Conservation Office administers the program in Washington. Funding comes from a portion of federal revenue from selling and leasing off-shore oil and gas resources. Eligible projects include land acquisition and development or renovation projects, such as natural areas and open space. The Washington State Recreation and Conservation Office administers the program (Washington State Recreation and Conservation Office, 2016a).

Salmon Recovery Fund

In 1999, the Washington State Legislature created the Salmon Recovery Funding Board. The board provides grants to protect or restore salmon habitat. Funded projects may include activities that protect existing, high quality habitat for salmon or that restore degraded habitat to increase overall habitat health and biological productivity. Funding also is available for feasibility assessments to determine future projects and for other salmon related activities. Projects may include the actual habitat used by salmon and the land and water that support ecosystem functions and processes important to salmon (Washington State Recreation and Conservation Office, 2016b).

Shoreline Management Act

The 1971 Shoreline Management Act (RCW 90.58) was enacted to manage and protect the shorelines of the state by regulating development in the shoreline area. A major goal of the act is to prevent the “inherent harm in an uncoordinated and piecemeal development of the state’s shorelines.” Its jurisdiction includes all water areas of the state, including reservoirs, and their associated shorelands, together with the lands underlying them, except: shorelines of statewide significance; streams upstream of where the mean annual flow is 20 cubic feet per second or less; and lakes smaller than 20 acres.

Shoreline management activities “implement policies and regulations to help protect water quality for our marine waters, lakes and stream systems; increase protection of lives and property from flood and landslide damage; protect critical habitat as well as fish and wildlife; promote recreational opportunities in shoreline areas.” Often these policies and programs complement or are critical in mitigation programs for communities. Shoreline management programs are local capabilities relevant to mitigation activities.

Silver Jackets

The Washington Silver Jackets team was formed in 2010 and is a mix of federal and state agencies that work together to address flood risk priorities in the state. Federal agencies include the Corps of Engineers, which facilitates coordination within the group, FEMA, the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Geological Survey (USGS). Participating state agencies include the Department of Ecology, the Emergency Management Division, and the Department of Transportation. The team’s projects are intended to address state needs and improve flood risk management throughout the full flood life cycle (Silver Jackets, 2016).

Washington Administrative Code 118-30-060(1)

Washington Administrative Code (WAC) 118-30-060 (1) requires each political subdivision to base its comprehensive emergency management plan on a hazard analysis, and makes the following definitions related to hazards:

- Hazards are conditions that can threaten human life as the result of three main factors:
  - Natural conditions, such as weather and seismic activity
  - Human interference with natural processes, such as a levee that displaces the natural flow of floodwaters
  - Human activity and its products, such as homes on a floodplain.
- The definitions for hazard, hazard event, hazard identification, and flood hazard include related concepts:
  - A hazard may be connected to human activity.
  - Hazards are extreme events.

Hazards generally pose a risk of damage, loss, or harm to people and/or their property

Watershed Management Act

Washington’s Watershed Management Act of 1998 encourages local communities to develop plans for protecting local water resources and habitat. Lawmakers wanted local governments and citizens to develop plans since they know their own regions best. WRIA is an acronym for “Water Resource Inventory Area.” WRIAs are watershed planning areas established by the Department of Ecology. Washington State is divided into 62 WRIAs, each loosely drawn around a natural watershed or group of watersheds. A watershed is an area of land that drains into a common river, lake, or the ocean.

C. DETAILED RISK ASSESSMENT RESULTS

EARTHQUAKE

Exposure in the Earthquake Hazard Area

	Estimated Exposure to the Earthquake Hazard[c]				
	Population Exposed[a]	% of Population Exposed	Buildings Exposed	Total Value Exposed (Structure + Contents)[b]	% of Total Value Exposed
Cashmere	3,355	100%	1,316	$1,081,939,050	100%
Chelan	4,470	100%	2,884	$2,222,094,817	100%
Entiat	1,360	100%	822	$446,756,860	100%
Leavenworth	2,590	100%	1,467	$1,169,977,259	100%
Wenatchee	35,850	100%	13,266	$10,347,873,437	100%
Unincorporated County	33,875	100%	26,683	$9,838,451,741	100%
Total	**81,500**	**100%**	**46,438**	**$25,107,093,163**	**100%**

a. Estimated population on April 1, 2023 Population of Cities, Towns, and Counties; from State of Washington, Office of Financial Management, Forecasting and Research Division.
b. Values based on tax parcel data.
c. The entire planning area is exposed to the earthquake hazard, so the exposure estimates are equal to the planning area totals, and are the same for all modeled earthquake scenarios.

Potential Damage in the Earthquake Hazard Area

	Estimated Potential Damage				
	Structure Debris (x 1,000 Tons)[a]	Number of Displaced Households[a]	People Requiring Short-Term Shelter[a]	Total Value Damaged (Structure + Contents) [a]	Damage as % of Total Value
CHELAN M7.2					
Cashmere	2.34	0	0	$42,909,057	4.0%
Chelan	16.06	6	2	$188,649,680	8.5%
Entiat	0.07	0	0	$39,840,766	8.9%
Leavenworth	0.11	0	0	$10,501,405	0.9%
Wenatchee	18.17	0	0	$194,718,083	1.9%
Unincorporated County	16.11	3	1	$252,440,984	2.6%
Total	**52.87**	**9**	**3**	**$729,059,985**	2.9%
CASCADIA SUBDUCTION ZONE M9.0					
Cashmere	0.07	0	0	$1,121,349	0.1%
Chelan	0.02	0	0	$196,559	0.0%
Entiat	0.01	0	0	$358,295	0.1%
Leavenworth	0.08	0	0	$2,105,347	0.2%
Wenatchee	0.23	0	0	$6,919,656	0.1%

	Estimated Potential Damage				
	Structure Debris (x 1,000 Tons)[a]	Number of Displaced Households[a]	People Requiring Short-Term Shelter[a]	Total Value Damaged (Structure + Contents) [a]	Damage as % of Total Value
Unincorporated County	0.29	0	0	$7,418,668	0.1%
Total	**0.71**	**0**	**0**	**$18,119,873**	0.1%

a. Calculated using a Census tract level, general building stock analysis in Hazus 6.1.

FLOOD

Area and Structures Within the 100-Year Floodplain by Municipality

	Area (acres)	Number of Structures							
		Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Cashmere	133	63	26	6	0	0	0	0	**95**
Chelan	80	17	4	0	0	0	0	0	**21**
Entiat	14	0	0	0	0	0	0	0	**0**
Leavenworth	115	2	2	0	0	0	0	0	**4**
Wenatchee	492	659	133	2	9	3	2	0	**799**
Unincorporated County	28,991	424	262	2	9	1	8	0	**706**
Total	**29,825**	**1,165**	**427**	**10**	**0**	**4**	**10**	**0**	**1,625**

Area and Structures Within the 500-Year Floodplain by Municipality

	Area (acres)	Number of Structures							
		Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Cashmere	215	176	45	8	0	0	0	0	**229**
Chelan	83	20	4	0	0	0	0	0	**24**
Entiat	14	0	0	0	0	0	0	0	**0**
Leavenworth	134	3	2	0	0	0	0	0	**5**
Wenatchee	3,391	7,159	1,473	50	33	26	44	33	**8,818**
Unincorporated County	29,778	727	393	5	12	1	8	1	**1,147**
Total	**33,615**	**8,085**	**1,917**	**63**	**45**	**27**	**52**	**34**	**10,223**

Value of Structures in the 100-Year Floodplain by Municipality

	Value Exposed			% of Total Replacement Cost
	Structure	Contents	Total	
Cashmere	$31,019,088	$26,234,238	**$57,253,325**	5.3%
Chelan	$3,960,137	$2,451,271	**$6,411,408**	0.3%
Entiat	$0	$0	**$0**	0.0%
Leavenworth	$2,494,415	$2,156,646	**$4,651,061**	0.4%
Wenatchee	$373,954,086	$280,880,772	**$654,834,858**	6.3%
Unincorporated County	$109,261,392	$72,072,432	**$181,333,824**	1.8%
Total	**$520,689,117**	**$383,795,359**	**$904,484,476**	**3.6%**

1.

Value of Structures in the 500-Year Floodplain by Municipality

	Value Exposed			% of Total
	Structure	Contents	Total	Structure
Cashmere	$53,911,487	$41,402,684	**$95,314,170**	8.8%
Chelan	$4,491,720	$2,717,063	**$7,208,783**	0.3%
Entiat	$0	$0	**$0**	0.0%
Leavenworth	$2,704,230	$2,261,553	**$4,965,784**	0.4%
Wenatchee	$3,582,122,087	$2,618,767,435	**$6,200,889,522**	59.9%
Unincorporated County	$219,416,254	$151,727,552	**$371,143,806**	3.8%
Total	**$3,862,645,777**	**$2,816,876,287**	**$6,679,522,065**	**26.6%**

Estimated Flood Impact on Persons

	100-Year Flood[a]		500-Year Flood[a]	
	Displaced Persons	Persons Requiring Short-Term Shelter[b]	Displaced Persons	Persons Requiring Short-Term Shelter[b]
Cashmere	27	10	177	37
Chelan	1	0	2	0
Entiat	0	0	0	0
Leavenworth	0	0	1	0
Wenatchee	697	90	18,419	1,130
Unincorporated	79	19	211	36
Total	**805**	**119**	**18,809**	**1,203**

2. a. Results shown are not precise, but are estimates of needs that may occur as the result of the modeled flood.
3. b. The number of persons requiring publicly provided shelter is less than the number of displaced persons because not all households will require public assistance to find short-term shelter.

Estimated Flood-Caused Debris

	Debris to Be Removed (tons)[a]	
	100-Year Flood Event	500-Year Flood Event
Cashmere	250	1,365
Chelan	16	20
Entiat	0	0
Leavenworth	162	558
Wenatchee	658	21,467
Unincorporated County	1,536	3,067
Total	**2,622**	**26,477**

4. a. The Hazus flood debris model focuses on building-related debris, and does not address contents removal or additional debris loads such as vegetation and sediment.

Loss Estimates for 100-Year Flood Event

	Structures Impacted[a]	Estimated Loss Associated with Flood			% of Total Replacement Cost
		Structure	Contents	Total	
Cashmere	37	$510,348	$868,566	$1,378,915	0.1%
Chelan	13	$234,178	$105,607	$339,785	0.0%
Entiat	0	$0	$0	$0	0.0%
Leavenworth	1	$1,363	$17,724	$19,088	0.0%
Wenatchee	127	$7,787,836	$13,767,170	$21,255,005	0.2%
Unincorporated County	382	$7,862,634	$10,054,588	$17,917,222	0.2%
Total	**560**	**$16,396,360**	**$24,813,655**	**$41,210,015**	**0.2%**

5. a. Impacted structures are those structures with finished floor elevations below the Hazus-estimated 100-year water surface elevation. These structures are the most likely to receive damage in a 100-year flood event
6. Notes: Values in this table are only for purposes of comparison among results.

Loss Estimates for 500-Year Flood Event

	Structures Impacted[a]	Estimated Loss Associated with Flood			% of Total Replacement Cost
		Structure	Contents	Total	
Cashmere	176	$9,912,188	$13,300,870	$23,213,058	2.1%
Chelan	16	$314,280	$136,218	$450,498	0.0%
Entiat	0	$0	$0	$0	0.0%
Leavenworth	3	$38,962	$107,045	$146,045	0.0%
Wenatchee	2,759	$233,544,647	$333,096,341	$566,640,988	5.5%
Unincorporated County	682	$17,095,574	$18,884,878	$35,980,451	0.4%
Total	**2,636**	**$260,905,652**	**$365,525,352**	**$626,431,003**	**2.5%**

7. a. Impacted structures are those structures with finished floor elevations below the Hazus-estimated 500-year water surface elevation. These structures are the most likely to receive damage in a 500-year flood event
8. Notes: Values in this table are only for purposes of comparison among results.

LANDSLIDE

Exposure in the Landslide Hazard Area

	Estimated Exposure in the Landslide Hazard Area						
	Population Exposed	% of Population Exposed	Buildings Exposed	Structure Value Exposed	Contents Value Exposed	Total Value Exposed (Structure + Contents)	% of Total Value Exposed
Cashmere	0	0.00%	0	$0	$0	$0	0.00%
Chelan	0	0.00%	0	$0	$0	$0	0.00%
Entiat	0	0.00%	0	$0	$0	$0	0.00%
Leavenworth	0	0.00%	0	$0	$0	$0	0.00%
Wenatchee	110	.3%	37	$10,819,201	$5,509,632	$16,328,833	0.2%
Unincorporated County	2,923	8.6%	2,363	$518,251,738	$359,333,110	$877,584,847	8.9%

	Estimated Exposure in the Landslide Hazard Area						
	Population Exposed	% of Population Exposed	Buildings Exposed	Structure Value Exposed	Contents Value Exposed	Total Value Exposed (Structure + Contents)	% of Total Value Exposed
Total	**3,032**	**3.7%**	**2,400**	**$529,070,939**	**$364,842,742**	**$893,913,680**	**3.6%**

Structures in the Landslide Hazard Area

	Number of Structures within the Landslide Hazard Area							
	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Cashmere	0	0	0	0	0	0	0	0
Chelan	0	0	0	0	0	0	0	0
Entiat	0	0	0	0	0	0	0	0
Leavenworth	0	0	0	0	0	0	0	0
Wenatchee	33	4	0	0	0	0	0	37
Unincorporated County	1,533	716	19	90	1	4	0	2,363
Total	**1,566**	**720**	**19**	**90**	**1**	**4**	**0**	**2,400**

D. Adoption Documents

TO BE PROVIDED WITH FINAL PLAN