LEWIS COUNTY EMERGENCY MANAGEMENT

PREVENTION –MITIGATION
PREPAREDNESS
RECOVERY
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LEWIS COUNTY
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DRAFT

LEWIS COUNTY
HAZARD MITIGATION PLAN

Volume 1 Planning-Area-Wide Elements

2024

PERTEET

DRAFT

LEWIS COUNTY HAZARD MITIGATION PLAN UPDATE

VOLUME 1: PLANNING-AREA-WIDE ELEMENTS

March 2024

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The cost of developing this Plan has been graciously provided by Lewis County government for the protection of all Lewis County residents.

Lewis County Hazard Mitigation Plan Update
Volume 1: Planning-Area-Wide Elements

PART 1 – THE PLANNING PROCESS

CHAPTER 1. INTRODUCTION TO HAZARD MITIGATION PLANNING

1.1 About Hazard Mitigation?

1.1.1 What is It?

According to the Stafford Act (44 CFR 206:401) hazard mitigation is defined as "any action taken to reduce or eliminate the long- term risk to human life and property from natural disasters." These hazards may include flooding, wildfires, earthquakes, and storms. Each disaster can cause the loss of life, damage buildings, facilities, infrastructure, and have devastating consequences for a jurisdiction's economic and social well-being. Hazard mitigation is the process of implementing planning, policy changes, programs, projects, and other activities that can mitigate the impact of these hazards to lessen their burdens on communities. In addition, hazard mitigation can lessen the economic hardship and costly cycle of repeated damage and rebuilding by taking a proactive approach to these hazards.

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. Multi-jurisdictional planning can lead to many benefits including improved communication, reduced risk, maximized economic effectiveness, and concise efforts.

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 Hazard Mitigation for Lewis County

The Lewis County Emergency Management Council (EMC) led the development of the initial Lewis County Natural Hazard Mitigation Plan in 2005 and again led the development of an update in both 2010. The City of Centralia, Lewis County Community Development, and Lewis County Department of

Emergency Management led the update process in 2015. In 2023 Lewis County Emergency Management led the update process. The Lewis County Natural Hazards Mitigation Plan is multi-jurisdictional and satisfies the DMA's natural hazard mitigation planning requirements for Lewis County and 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.

The main purpose of the plan is to identify risks posed by hazards and to present strategies to reduce the impact of hazard events. The plan also meets 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 Lewis 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 Who Will Benefit from This Plan?

All stakeholders will benefit from this plan, including residents and businesses of Lewis County. 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 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.

1.4 How to Use This Plan

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 initiatives, and a plan maintenance strategy.
- **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 established by the Steering Committee, as well as instructions and templates that the partners used to complete their annexes. Volume 2 also includes "linkage" procedures for eligible jurisdictions that did not participate in development of this plan but wish to adopt it in the future.

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.

The following appendices provided at the end of Volume 1 include information or explanations to support the main content of the plan:

- Appendix A—A glossary of acronyms and definitions
- Appendix B—Public outreach information, including the hazard mitigation questionnaire and summary and documentation of public meetings
- Appendix C—A template for progress reports to be completed as this plan is implemented
- Appendix D—Plan Adoption Resolutions from Planning Partners

CHAPTER 2. PLAN UPDATE – WHAT HAS CHANGED

2.1 The Previous Plan

The Lewis County EMC developed the initial *Lewis County Multi-Jurisdictional Natural Hazard Mitigation Plan* in 2005. The plan was updated in 2010 and 2015.

Each update was written using the best available information at the time of the update. The 2015 multi-jurisdictional plan referenced information from existing plans, studies, reports, technical data, internet databases, local publications, and scholarly journals.

The plan allowed the participating agencies to identify and update critical facilities, inventory vulnerable buildings and structures by specific hazards, and to estimate potential losses by using the Hazus-MH program. In addition, the updated plan provided greater detail about identified hazards, risk assessment, and mitigation strategies. The 2015 plan included GIS maps that identify critical facilities, hazards, and land uses.

Through a risk assessment utilizing input and information from surveys, the steering committee, planning team, stakeholders, and research, the 2015 update found that communities in Lewis County are subject to a wide array of hazards including: avalanche, dam failure, debris flows, earthquake, extreme heat, flooding, landslide, levee failure, severe windstorm, severe winter storm, volcano, and wildfire.

2.2 Why Update?

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 The Updated Plan—What Is Different?

The updated plan differs from the initial plan in a variety of ways, as shown in Table 2-1.

Table 2-1. Summary of Plan Changes.

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, academi0,a 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 2015 plan allowed the public to participate in surveys, review goals and objectives, and invited adjacent communities, agencies, non-profits, and other interested parties to participate in the updating process.	The 2023 plan allowed the public to participate in surveys, review goals and objectives, and invited adjacent communities, agencies, non-profits, and agencies that represent socially vulnerable populations, and other interested parties to participate in the updating process.
§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 2015 plan provides a characteristic assessment of eight identified hazards of concern.	The County and its jurisdictions utilized Hazus, when applicable, and GIS analysis to determine hazard vulnerability and impacts. Information from the UW Climate Impacts Group was used to determine climate change impacts.
§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.	The characteristic assessment of the 8 hazards of concern in the 2015 plan did discuss the extent and location of each hazard qualitatively. Stakeholders were able to estimate potential loss by individual hazard and utilize the HAZUZ-MH program.	All natural hazards occurring since the last plan update were included in this plan update. The plan discusses previous occurrences of hazard events in the "Hazard Profile" section of each hazard. The probability of future hazard events is discussed in the "Probability" section of each hazard chapter.
§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 subjectively assessed and described for all hazards of concern. The 2015 plan utilized the HAZUZ-MH program to estimate potential losses for flood and earthquake events.	Each hazard of concern was profiled and updated with current information, utilizing the best available science in its profile and risk development. Additionally, Hazus was utilized to acquire hazard-specific information.

44 CFR Requirement	Previous Plan	Updated Plan
§201.6(c)(2)(ii): [The risk assessment] must also address National Flood Insurance Program insured structures that have been repetitively damaged floods	The 2015 plan included a section on the NFIP, developing new mitigation strategies direction related to repetitive loss properties.	NFIP information was provided, including repetitive loss information. The plan includes general FIRM information and FEMA flood data was also used for mapping.
§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.	The 2015 plan does not include specific vulnerability information.	The risk assessment included an assessment of people, buildings, and systems structures county wide. The risk assessment used data from the National Risk Index to assess impacts to vulnerable populations.
§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.	The 2015 plan does not include loss estimation values.	Loss estimations were included within each hazard profile. The methodology used for the various hazard assessments are included both in the general overview and within the hazard profiles.
§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 some discussion of future development trends as they pertain to each hazard of concern.	Hazard profiles provided information with respect to land use and development trends, and the inclusion of the risk assessment information into future planning efforts. The capabilities matrix also provides information concerning integration of the risk assessment into other planning mechanisms, such as GMA, IBC, etc.
§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.	Section 5 in the 2015 plan includes a mitigation strategy.	The capabilities matrix defined the existing authorities and capabilities in place within the county and its jurisdictions and defines the inclusion of the risk data as it relates to other planning initiatives throughout the county.
§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.	There is a description of goals and objectives in section 5.	Goals and objectives were included in Chapter 5.
§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.	The plan includes mitigation actions in property protection, natural resource protection, emergency services, structural projects, and public information activities.	The plan includes mitigation initiatives in several categories. Planning partners considered new and existing infrastructure in their mitigation strategy.

44 CFR Requirement	Previous Plan	Updated Plan
§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 to adopt the State's Model Floodplain Ordinance to prohibit/regulate future development in the floodplain.	The flood profile includes information concerning the County and its jurisdictions' involvement in the NFIP, and relates insurance information, claim information and enrollment information.
§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 recommended action was prioritized using a points system based on the objectives the project will meet.	Planning partners based their decisions based on information collected through the risk assessment and prioritize based on maximum benefits.
§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 section describes the method and schedule of monitoring, evaluating, and updating the plan	Plan maintenance section delineated a plan evaluation and update schedule with action steps to be taken within a five-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.	The plan did not discuss integration.	Each annex in Volume 2 discusses the integration of planning mechanisms throughout the County and their relationship and integration with the hazards of concern.
§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 plan describes how the community will continue to participate in the plan maintenance through public meetings, hearing, surveys, and press releases. In addition, a website will be maintained that will post materials.	The public involvement strategy was included in the plan maintenance process. The plan was available for review through the Lewis County webpage, periodic press releases, Facebook posts, and through Local Emergency Planning Committee meetings and events. The plan maintence strategy includes a process for involving community-based organizations.

44 CFR Requirement	Previous Plan	Updated Plan
§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).	Documentation of plan adoption was included in Volume 1, Appendix E.	Documentation of plan adoption was included in Volume 1, Appendix D upon plan approval.

CHAPTER 3. PLAN METHODOLOGY

3.1 Formation of The Core Planning Team

Lewis County hired Perteet Inc. and Tetra Tech, Inc. to assist with development and implementation of the plan. The Perteet project manager assumed the role of the lead planner, reporting directly to a County-designated project manager. A planning team was formed to lead the planning effort, made up of the following members:

- Christina Wollman, Lead Planner, Perteet
- Kirk Holmes, Director of Emergency Preparedness, Perteet
- Samantha Criner, Planner, Perteet
- Rob Flaner, Risk Assessment Lead, Tetra Tech
- Erika Katt, Lewis County Emergency Management
- Ross McDowell, Lewis County Emergency Management
- Josh Metcalf, Lewis County Public Works
- Mindy Brooks, Lewis County Community Development
- Lee Napier, Lewis County Community Development

3.2 Establishment of the Planning Partnership

Lewis County opened this planning effort to all eligible local governments within the County. The planning team invited all eligible planning partners to a kickoff meeting on March 25, 2022. Key meeting topics were as follows:

- Provide an overview of the Disaster Mitigation Act.
- Describe the reasons for a plan update.
- Outline the County work plan.
- Outline planning partner expectations.
- Seek commitment to the planning partnership.
- Seek volunteers for the Steering Committee.

Each jurisdiction wishing to join the planning partnership was asked to provide a “letter of intent to participate” that designated a 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 Lewis County plan in the future. The planning partners covered under this Plan are shown in Table 3-1.

Table 3-1. Planning Partners.

Jurisdiction	Point of Contact	Title
Lewis County	Lee Napier	Community Development Director
City of Chehalis	Celest Wilder, CFM	Engineer Technician II
City of Centralia	Emil Pierson	Community Development Director
City of Morton	Ander Pollman	Public Works Superintendent
City of Mossyrock	Randall Sasser	Mayor
City of Napavine	Terry Lopex	Administrative Assistant
City of Vader	Lisa Huckleberry	Clerk/Treasurer
City of Winlock	Brandon Svenson	Mayor
Cemetery District 4	Peggy Hurte-Uhlorn	Lead Commissioner
Lewis County Fire District #1	Brad Flexhaug	Chief
Lewis County Fire District #2	Mike Dorothy	Chief
Lewis County Fire District #3	Doug Fosburg	Chief
Lewis County Fire District #4	Bill Reynolds	Chief
Lewis County Fire District #6	Paul Patterson	Chief
Lewis County Fire District #8	Duran McDaniel	Chief
Lewis County Fire District #10	Lonnie Goble	Chief
Lewis County Fire District #14	Jeff Jaques	Chief
Lewis County Fire District #15	Rich Underdahl	Chief
Cowlitz-Lewis Fire District #20	Rich Underdahl	Chief
Lewis County PUD	Bryan Watt	Operations Manager
Lewis County Water District #2	Amie Smith	District Manager
Port of Chehalis	Bill Teitzel	Operations Manager
Providence Centralia Hospital	Scott Smitherman	Emergency Preparedness Manager
Thurston PUD	Kim Gubbe	Director of Planning and Compliance
Timberland Library	Cheryl Heywood	Executive Director

3.3 Defining the Planning Area

The planning area consists of all of Lewis County. All partners to this plan have jurisdictional authority within this planning area.

3.4 The Steering Committee

Hazard mitigation planning enhances collaboration and support among diverse parties whose interests can be affected by hazard losses. A steering committee was formed to oversee all phases of the plan. 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 partnership confirmed a committee of 15 members plus several alternates. Table 3-2. Steering Committee Members. Table 3-2 lists the steering committee members and their attendance. Members with an (A) indicate alternates.

Table 3-2. Steering Committee Members.

		Attendance								
Name	Jurisdiction/ Agency	4/19	5/25	7/19	9/27	1/17	3/21	5/16	6/27	7/18
Ross McDowell	Lewis County EM	○	○	○	○	○	○		○	

Josh Metcalf	Lewis County Public Works		○							
Mindy Brooks	Lewis County Planning	○	○	○	○	○	○	○	○	
Erika Katt (A)	Lewis County	○	○	○	○	○	○	○	○	○
Lee Napier (A)	Lewis County	○	○	○	○	○	○		○	○
Emil Pierson	Centralia	○	○		○		○	○	○	○
Hillary Hoke	Centralia		○			○	○	○	○	○
Andy Caldwell (A)	Centralia	○		○						
Celeste Wilder	Chehalis		○	○	○		○		○	○
Brandon Rakes	Chehalis	○	○	○	○	○	○	○	○	
Bill Teitzel	Port of Chehalis	○		○	○	○	○	○	○	○
Amie Smith	LCWD #2	○	○	○	○	○	○	○	○	○
John Hannah	Morton School District	○		○						
Cheryl Haywood	Timberland Regional Library	○	○	○	○	○	○	○		○
Gregg Peterson	Fire District									
Shane Moore	Citizen	○		○	○					
Ryan Thode	Farm Bureau	○	○	○						○
Bob Amrine	LC Conservation District			○			○		○	○
Nikki Atkins (A)	LC Conservation District	○								

Leadership roles and ground rules were established during the steering committee's kickoff meeting on April 19, 2022. The steering committee agreed to meet monthly or as needed throughout the course of the plan's development beginning on May 25, 2022. The planning team facilitated each steering committee meeting, which addressed a set of objectives based on the work plan established for the plan. All meetings were open to the public and the meeting agendas and meeting summaries were posted on the project website.

3.5 Coordination with Other Agencies

44CFR requires that opportunities for involvement in the planning process be provided to neighboring communities, local and regional agencies involved in hazard mitigation, agencies with authority to regulate development, businesses, academia, and other private and nonprofit interests (Section 201.6.b.2). This task was accomplished by the planning team as follows:

- **Steering Committee Involvement**—Agency representatives were invited to participate on the Steering Committee.
- **Agency Notification**—The following agencies were invited to participate in the plan development process from the beginning:
    - Lewis County Departments
    - Incorporated Municipalities of Lewis County, including the City of Centralia, Chehalis, Morton, Mossyrock, Napavine, Pe Ell, Toledo, Vader, and Winlock.
    - Special Purpose Districts within Lewis County (Lewis County Fire District [LCFD] #1, 2, 3,

4, 5, 6, 8, 10, 13, 14, 15, 17, 20, Riverside Fire Authority, Lewis County Water District #2, Lewis County Public Utility District, Thurston Public Utility District, Morton School District, Mossyrock School District, Toledo School District, Cemetery District #4, 6, 7, Port of Chehalis, Providence Hospital, Timberland Regional Library).

  - The Confederated Tribes of the Chehalis Reservation and the Cowlitz Indian Tribe
  - Private sector representation

  These agencies received meeting announcements, meeting agendas, and meeting minutes by e-mail throughout the plan development process. Agencies that participated in the Steering Committee supported the effort by attending meetings or providing feedback on issues. Several participating agencies provide support to vulnerable populations, including the Timberland Library, Providence Hospital, and schools. There was not active participation from private sectors or non-profit organizations. The agencies that did not participate in the planning process, such as private sectors and non-profit organizations that support underserved and socially vulnerable populations will be invited to participate in future plan updates and in this current plan through the plan maintenance process described in Chapter 7.

- **Pre-Adoption Review**—All the agencies listed above were provided an opportunity to review and comment on this plan. Each agency was sent an e-mail message informing them that draft portions of the plan were available forreview. The complete draft plan was sent to the Washington State Military Department, Emergency Management Division for a pre-adoption review to ensure program compliance. The County conducted a SEPA analysis and issued a Determination of Non-Significance (DNS). The DNS and an invitation to review the plan was sent to the following agencies in addition to those listed above:
  - Lewis County Conservation District
  - Department of Agriculture
  - Department of Archaeology and Historic Preservation
  - Department of Commerce
  - Department of Corrections
  - Department of Ecology
  - Energy Facility Site Evaluation Council
  - Department of Health
  - Department of Natural Resources
  - Parks and Recreation Commission
  - Puget Sound Partnership
  - Puget Sound Regional Council
  - Department of Social and Health Services
  - Department of Transportation
  - Department of Fish and Wildlife
  - Thurston County
  - Pierce County
  - Grays Harbor County
  - Pacific County
  - Wahkiakum County

- Cowlitz County
- Skamania County
- Yakima County

3.7 Review of Existing Programs

44CFR states that hazard mitigation planning must include review and incorporation, if appropriate, of existing plans, studies, reports, and technical information (Section 201.6.b(3)). Volume 1, Chapter 9 of this plan provides a review of laws and ordinances in effect within the planning area that can affect hazard mitigation initiatives and in the jurisdictional annexes within Volume 2.

An assessment of all planning partners' regulatory, technical, and financial capabilities to implement hazard mitigation initiatives is presented in the individual jurisdiction-specific annexes in Volume 2. Many of these relevant plans, studies and regulations are cited in the capability assessment. Information on the following plans, studies, reports, and technical information is incorporated, as appropriate, into the mitigation plan.

- **State Hazard Mitigation Plan**—The State Hazard Mitigation Plan was reviewed for recent updates on state-wide hazard events and hazard information.
- **Lewis County Comprehensive Emergency Management Plan** – The CEMP defines the roles and responsibilities for emergency response.
- **Chehalis River Basin CFHMP**—The Chehalis River Basin Comprehensive Flood Hazard Mitigation Plan was utilized to collect pertinent information on flood risk within Lewis County's Chehalis River basin.
- **National Risk Index Map**—The National Risk Index Map was utilized to collect information on socially vulnerable populations within Lewis County by individual hazards.
- **Assessor's Data**—Assessor's Data was utilized during the risk assessment to identify areas prone to specific hazards (such as floodplains). In addition, this data was used to inform the vulnerability assessment and identify which buildings, infrastructure, and populations are most vulnerable to hazards.
- **Weather History**—Weather History collected from a variety of sources included FEMA Presidentially declared disasters and NOAA was utilized to determine past events, frequency, and probability.
- **Fire History Data** – Fire history data was used to determine frequency and severity of fire within the County.
- **Lewis County Comprehensive Plan**—General Plan demographics and land use were cross-referenced for inclusion into this Plan as part of the overall community profile.
- **Shoreline Management Program** – The SMP provided habitat information that was used to determine environmental vulnerability and impacts.
- **Additional Resources and Technical Information**—A complete listing of technical reports, research materials, and articles used during development of this Plan is found in the References section.

3.8 Plan Development Chronology/Milestones

Table 3-3 summarizes important milestones in the development of the plan.

Table 3-3. Plan Development Milestones.

Date	Event	Description
County submits grant application, seeking funding for plan development process. County receives notice of grant award.		
		2022
	RFP advertised and consultant selected	County initiates contractor procurement process to select consultant to facilitate planning process.
	Contracting completed	Contract with Perteet Inc. and Tetra Tech, Inc signed.
March 24	Internal kickoff meeting	Perteet and initial county project manager met to kick off the project.
April 19	Planning Partnership and Steering Committee kickoff meeting	All eligible planning partners were invited to attend the kickoff meeting to learn about the planning process, benefits, and expectations. Planning partners were asked to be part of the Steering Committee process. The committee was formed and the stakeholders agreed on ground rules and discussed the hazards of concern, current plan goals/objectives, and the guiding principle.
May 24	Steering Committee Meeting #2	• Reviewed LOIs • Confirmed a vision statement • Discussed, identified, and revised goals • Defined Critical Facilities
July 19	Steering Committee Meeting #3	• Confirmed Goals • Discussed Objectives
September 27	Steering Committee Meeting #4	• Confirmed Objectives • Discussed the Plan Maintenance Strategy • Held Phase 1 Annex workshop
		2023
January 17th	Steering Committee Meeting #5	• Reviewed risk assessment • Held Phase 2 Annex workshop
March 21	Steering Committee Meeting #6	• Reviewed seismic vulnerability results • Discussed public outreach plans
May 3-4	Public Outreach #1	• HMP Presentation • 25 attendees at public meeting at 4 different locations over the course 2 days
May 21	Steering Committee Meeting #7	• Reviewed risk assessment • Discussed social vulnerability, National Risk Index (NRI) map and the Social Vulnerability Index (SVI) map
June 27	Steering Committee Meeting #8	• Social vulnerability assessment • SWOO Exercise
July 18	Steering Committee Meeting #9	• Social vulnerability results presentation • Actions workshop • Introduction to Phase 3 Annex Workshop

Date	Event	Description
August 2	Steering Committee Meeting #10	• In-person Phase 3 Annex Workshop
November 28	Steering Committee Meeting #11	• Draft Plan Review Volume 1 and 2 • Discuss next steps and approval
DATE	Public Comment Period Begins	• Advertised in
DATE	Public Outreach #2	• Presented plan at County Commissioners Meeting
DATE	Plan Review	• Plan was sent to EMD and FEMA
DATE	Received Approval Pending Adoptions (APA) from FEMA	•
DATE	Received FEMA Approval	•

CHAPTER 4. PUBLIC INVOLVEMENT

Broad public participation in the planning process helps ensure that diverse points of view about the planning area's needs are considered and addressed. 44CFR requires that the public have opportunities to comment on disaster mitigation plans during the drafting stages and prior to plan approval (Section 201.6.b.1). The Community Rating System expands on these requirements by making CRS credits available for optional public involvement activities.

4.1 Public Involvement Strategy

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

- Use of a questionnaire to determine the public's perception via the Lewis County Emergency Management webpage.
- Attempt to reach as many planning area citizens as possible, through both in-person and virtual outreach.
- Identify and involve planning area stakeholders.
- Create and utilize a Story Map to educate the public on hazard risk within Lewis County and address the public survey.

4.1.1 Stakeholder 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. The effort to include stakeholders in this process included stakeholder participation on the Steering Committee. The group had representation from special purpose districts, county departments, and the local jurisdictions for Lewis County. All meetings were open the public.

4.1.2 Hazard Mitigation Plan Website

The planning team developed a Story Map that provided information about the planning process, details about each hazard, and a hazard mapper. The Story Map also included links to the previous plan and the survey. The Story Map will remain live after the planning process ends to continue to provide information on local natural hazards to the community. A printout of the Story Map is in Appendix B and a link is: https://arcg.is/Xu49m. See Figure 4-1 and Figure 4-2 for excerpts from the Story Map.

Figure 4-1. Lewis County HMP Story Map Home Page.

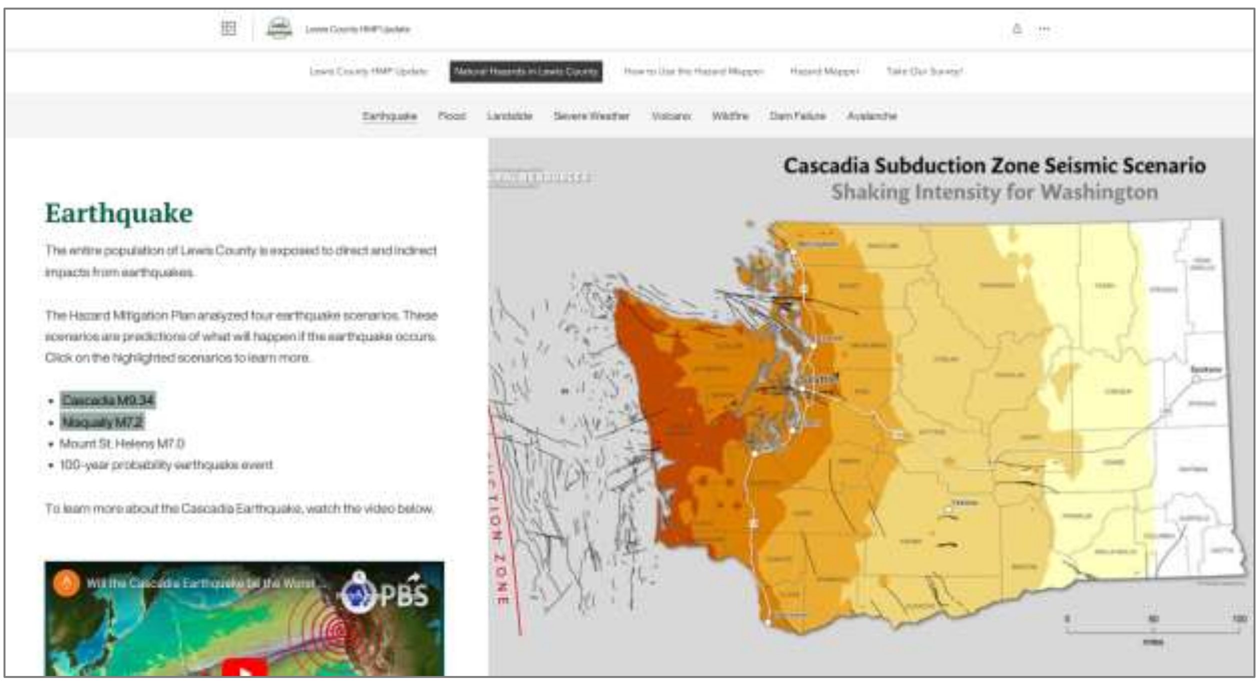


Figure 4-2. Lewis County HMP Story Map – Earthquake Hazard.

4.1.3 Hazard Mitigation Survey

The Hazard Mitigation Survey went live in April of 2023 and received 60 responses. The survey asked a variety of questions to determine the experience and preparedness of community members in Lewis County. This survey was utilized throughout the planning process to better understand and gauge need within the community and the strengths and weaknesses of response to natural hazards. The survey results are in Appendix B.

Of the 60 responses, 97% of respondents live in Lewis County and 3% work in the county. Roughly 16% of respondents live in the unincorporated county, 16% live in Chehalis and 13% live in Centralia. 95% of respondents own their home and 32% have a gross household income of $100,000 or more. When asked which hazards have been experienced in their household in the past 20 years, 77% stated that they have experienced severe weather (excessive heat/cold, wind, lightening, snowstorms, etc.) and 56% have experienced flooding. 67% believe that the most useful information has come from personal experience with one or more natural hazards or disasters.

In terms of preparedness, most respondents (53%) believe that they are somewhat prepared to deal with a natural hazard event. In addition, 70% or more respondents have installed smoke detectors on each level of their home and stored food, water, flashlights, batteries, a fire extinguisher, and medical supplies to prepare for a natural disaster.

When asked how concerned residents were about each hazard in Lewis County, wildland fire received the highest weighted average (2.85 out of 4), then earthquake (2.70), and then flood (2.68). 73% of respondents selected that social media is the most effective method for providing hazard and disaster information.

4.1.4 Public Meetings

The planning team held four public meetings on May 3rd and 4th to review the results of the risk assessment with the community. The meetings were held throughout the county as a way to encourage participation from a diversity of stakeholders. Meeting notices were posted on Facebook, sent to the Lewis County newspaper of record, and posted on community bulletin boards. The format allowed attendees to examine the plan, maps, and have direct conversations with project staff. Reasons for planning and information generated for the risk assessment were shared with attendees. Each attendee was given the opportunity to comment on the plan and talk about all hazards within the county.

County staff also presented information at a Rotary meeting on May 10, 2023.

[ADD INFO ABOUT PUBLIC OUTREACH DURING PUBLIC COMMENT PERIOD]

4.1.5 Public Comment Period

[DESCRIBE PUBLIC COMMENT PERIOD]

4.2 Public Involvement Results

By engaging the public through the public involvement strategy, the concept of mitigation was introduced to the public, and the Steering Committee received feedback that was used in developing the components of the plan. Details of attendance and comments received are summarized in Table 4-1.

Table 4-1. Public Involvement Results.

Date	Location	Number of Citizens in Attendance	Number of Questions Received
May 3, 2023	Winlock	1	0
May 3, 2023	Chehalis	3	0

May 4, 2023	Packwood	13	0
May 4, 2023	Mossyrock	8	0
May 10, 2023	Rotary Club Presentation	10	0
March X-X, 2024	Public Comment Period	N/A	
March 2 2024	Public Meeting Presentation		

Lewis County Emergency Management
1d ·

LEWIS COUNTY
DIVISION OF EMERGENCY MANAGEMENT
351 NW. North Street, Chehalis, WA 98532
DEM@lewiscountywa.gov • Phone: (360) 740-1151 • Fax: (360) 740-1471
Follow us on Twitter @LCDEM or on Facebook at Lewis County Emergency Management

PUBLIC INVITED TO ATTEND MEETINGS TO LEARN ABOUT THE LEWIS COUNTY HAZARD MITIGATION PLAN UPDATE

Lewis County Emergency Management is inviting the public to attend meetings to learn about the Lewis County Multi-Jurisdictional Hazard Mitigation Plan (HMP) update. During the meetings, the HMP project team will share the result of the risk assessment and provide information about natural hazards that pose a risk to Lewis County. There will be four meetings held throughout the County. The same information will be presented at each meeting.

The public can also learn more about the hazards within Lewis County by visiting the project's story map. The story map provides information about the plan update and each of the natural hazards in the area, plus a hazard mapper that identifies areas that are exposed to those hazards. The public's input will help the project team develop mitigation strategies to reduce the county's vulnerability to natural hazards: https://lewiscountywa.gov/departments/emergency-management/2023-lewis-county-hazard-mitigation-plan-update/. The County also requests the public take a survey, which can be accessed from the story map.

An HMP looks at how the County can become more resilient to natural hazards such as flooding, earthquakes, volcanoes, wildfires, and severe storms. The HMP will provide an overall strategy of programs, projects, and measures aimed at reducing the adverse impacts of natural hazards on the communities within Lewis County. The agencies participating in the planning process will use hazard data to identify specific projects that can mitigate against the risk of natural hazards, such as retrofitting water and sewer systems, adding generators to critical facilities, or elevating structures above flood levels.

The public meetings will be held on May 3rd and 4th.

- May 3rd, 1:00 pm to 2:30 pm
  Winlock Community Building
  607 NW Kerron St, Winlock, WA 98596
- May 3rd, 5:30 pm to 7:00 pm
  Lewis County Courthouse basement
  275 W Main St, Chehalis, WA 98532
- May 4th, 12:00 pm to 1:00 pm
  Packwood Community Hall
  12935 US Highway 12, Packwood, WA 98361
- May 4th, 4:00 pm to 5:30 pm
  Mossyrock Community Center
  219 E State St, Mossyrock, WA 98564

The update is being led by Erika Katt and Ross McDowell from Lewis County Emergency Management. There are over 30 cities and special districts participating in the planning process with the County.

For questions, please contact Lewis County Emergency Management at: (360) 740-1151.

2 8 shares

Like Comment Share

Figure 4-3. Facebook Post Advertising Public Meetings.

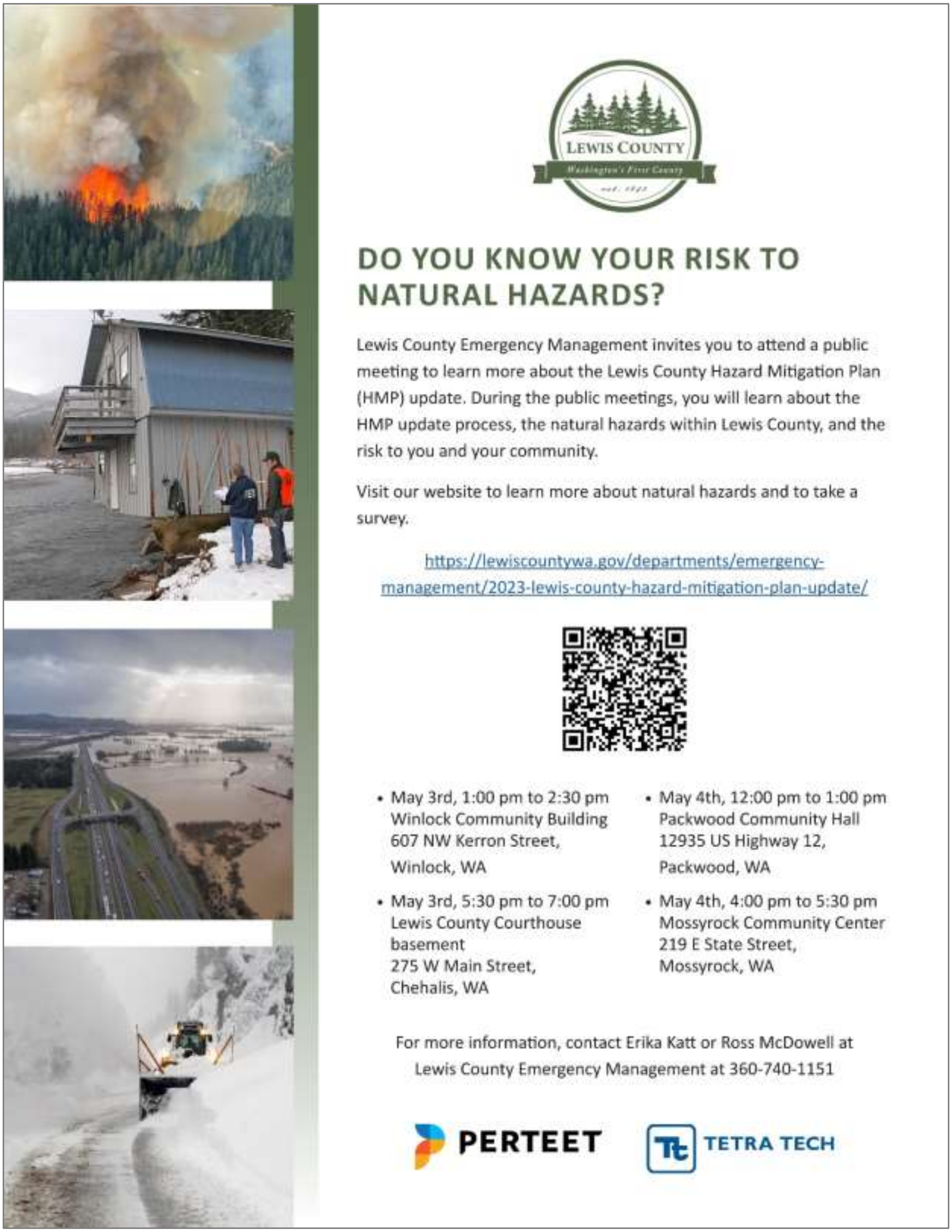


Figure 4-4. Flyer posted online and at community bulletin boards.

Figure 4-5. Public Comment Period Press Release.

CHAPTER 5. IDENTIFIED HAZARDS OF CONCERN AND EVALUATION METHODOLOGY

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

- Hazard identification—Use all available information to determine what types of disasters may affect a jurisdiction, how often they can occur, and their potential severity.
- Vulnerability identification—Determine the impact of natural hazard events on the people, property, environment, economy, and lands of the region.
- Damage estimates—Estimate the cost of potential damage or cost that can be avoided by mitigation.
- Impacts evaluation – Evaluate the impacts of the hazards on vulnerable assets.

The risk assessment for this hazard mitigation plan update evaluates the risk of natural hazards prevalent in Lewis County and meets requirements of the DMA (44 CFR, Section 201.6(c)(2)).

5.1 Identified Hazards of Concern

For this plan, the Steering Committee considered the full range of natural hazards that could impact the planning area and then listed hazards that present the greatest concern. The process incorporated review of state and local hazard planning documents, as well as information on the frequency, magnitude, and costs associated with hazards that have impacted or could impact the planning area. Anecdotal information regarding natural hazards and the perceived vulnerability of the planning area's assets to them was also used. Based on the review, this plan addresses the following hazards of concern:

- Avalanche
- Dam/Levee failure
- Earthquake
- Flood
- Landslide
- Severe Storms
- Volcano
- Wildfire

This hazard mitigation plan update addresses climate change as a secondary impact for some identified hazards. Those hazard chapters include a section with a qualitative discussion on the probable impacts of climate change for that hazard. Although specific models have not been developed for Lewis County, regional predictions are available for several hazards.

5.2 Methodology Overview

The risk assessments in Chapter 10 through Chapter 17 describe the risks associated with each identified natural hazard of concern. Each chapter describes the hazard, the planning area's vulnerabilities, and probable event scenarios. The following steps were used to define the risk of each hazard:

- Identify and profile each hazard—The following information is given for each hazard:
  - Geographic areas most affected by the hazard
  - Event frequency estimates
  - Severity estimates
  - Warning time likely to be available for response
- Determine vulnerability to each hazard—Vulnerability was determined by overlaying hazard maps with an inventory of structures, facilities, and systems. The vulnerability was also assessed for people, natural, historic, and cultural resources, and activities that have value to the community.
- Assess impact of the hazard—The impact of the hazard on people, structures, systems, natural, historic, and cultural resources, and activities that have value to the community was determined by interpreting the probability of occurrence of each event and assessing structures, facilities, and systems that are exposed to each hazard. Tools such as GIS and FEMA's hazard-modeling program called Hazus-MH were used to perform this assessment for the flood, dam failure and earthquake hazards.

5.3 Risk Assessment Tools for Natural Hazards

5.3.1 GIS Mapping

National, state, county, and city databases were reviewed to locate spatially based data that is relevant to this planning effort and that represents the best science currently available. Maps were produced using geographic information system (GIS) software to show the spatial extent and location of hazards when such datasets were available. The maps are included in the hazard profile chapters.

5.3.2 Hazus Modeling

Overview

In 1997, FEMA developed the standardized Hazards US, or Hazus, model to estimate losses caused by earthquakes and identify areas that face the highest risk and potential for loss. Hazus was later expanded into a multi-hazard methodology, Hazus-MH, with new models for estimating potential losses from hurricanes and floods.

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

- Provides a consistent methodology for assessing risk across geographic and political entities.
- Provides a way to save data so that it can readily be updated as population, inventory, and other factors change and as mitigation planning efforts evolve.
- Facilitates the review of mitigation plans because it helps to ensure that FEMA methodologies are incorporated.

- Supports grant applications by calculating benefits using FEMA definitions and terminology.
- Produces hazard data and loss estimates that can be used in communication with local stakeholders.
- Is administered by the local government and can be used to manage and update a hazard mitigation plan throughout its implementation.

For flood-related hazards, Hazus calculates losses to structures due to inundation by looking at depth of flooding and type of structure. Using historical flood insurance claim data, Hazus estimates the percentage of damage to structures and their contents by applying established damage functions to an inventory. The Hazus analysis also estimates the quantity of debris that would be caused by the flooding.

For earthquake, once the location and size of a hypothetical earthquake are identified, Hazus estimates the intensity of the ground shaking, the number of buildings damaged, the number of casualties, the damage to transportation systems and utilities, the number of people displaced from their homes, and the estimated cost of repair and clean up.

Levels of Detail for Evaluation

Hazus-MH provides default data for inventory, vulnerability, and hazards; this default data can be supplemented with local data to provide a more refined analysis. 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.

5.3.3 Climate Change Predictions

To evaluate the effects of climate change on certain hazards, the planning team used data from the University of Washington Climate Impacts Group Climate Mapping for Resilient Washington web map. This data provided a qualitative assessment of changes in two climate change scenarios and various timeframes. The data was used to provide a qualitative assessment of potential impacts to the community. For flooding, the planning team used a model developed for the Office of the Chehalis (OCB) Basin by the same climate impacts group which was evaluated in Hazus.

5.3.4 Local Knowledge

The available wildfire data was determined to not accurately portray the actual risk from wildfire. Local knowledge gathered during meetings with the fire chiefs was used to identify the highest risk areas within the County.

5.4 Vulnerability Assessment

5.4.1 Flood, Dam Failure, Volcano, Landslide, and Wildfire

During a vulnerability assessment, asset inventory data (critical facilities, general building stock, and population) is selected within the spatial boundaries of the individual hazard area. The people and structures that fall within the hazard area are considered vulnerable. Community vulnerability was evaluated for the following mapped hazard areas:

- **Flood**—1-percent-annual-chance and 0.2-percent-annual-chance flood events, mid-century, moderate scenario, 1-percent-chance climate change model
- **Dam Failure—**combined inundation areas for high hazard dams
- **Volcano**—Lahar hazard areas for Mt. Adams and Mt. Rainier
- **Landslide—**Steep Slope (15 to 35 percent slope and >35 percent slope) and NEHRP Soils (Class D and E)
- **Wildfire—**Wildland urban interface, wildland urban intermix, wildfire risk burn probability, and local knowledge of wildfire risk

5.4.2 All Other Assessed Hazards

Historical datasets were not adequate to map the remaining hazards of concern. These other hazards were generally assumed to present equal exposure over the entire planning area.

5.5 Impacts Assessment

5.5.1 Flood, Dam Failure, and Earthquake

The risk assessment used Hazus to determine impacts of the following hazards to the planning area:

- **Flood**— A Level 2 user-defined analysis was performed for general building stock in flood zones and for critical facilities. Current flood mapping for the planning area was used to delineate flood hazard areas and estimate potential losses from the 1-percent-annual-chance and 0.2-percent-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.
- **Dam Failure**— A Level 2 user-defined analysis was performed for general building stock and critical facilities located in the dam failure hazard areas for probable maximum flood (PMF) scenarios. A composite depth grid was generated from the dam failure inundation areas of all high hazard dams with the potential to impact the planning area. The composite was uploaded into the Hazus riverine flood model. By inputting 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 four scenario events:
    - Cascadia M9.34 scenario event

- Nisqually M7.2 historic event
- Mount St. Helens M7.0 historic event
- 100-year probabilistic earthquake

5.5.2 Avalanche, Landslide, Severe Storms, Volcano, and Wildfire

Historical datasets were not adequate to model future losses for the remaining hazards of concern. A qualitative analysis was conducted for those hazards using the best available data and professional judgment.

5.6 Sources of Data Used

5.6.1 Building and Cost Data

Replacement cost values and detailed structure information derived from parcel and tax assessor data provided by Lewis County were loaded into Hazus. When available, an updated inventory was used in place of the Hazus defaults for critical facilities.

5.6.2 Hazus Data Inputs

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

- **Flood**—The preliminary Digital Flood Insurance Rate Map (DFIRM) for the Nisqually River, effective DFIRM, Watershed Science and Engineering 2022 Depth Grids for the Cowlitz River and Tributaries near Packwood, and Chehalis Basin 100-year flood hazard area model from the Office of the Chehalis Basin were used to delineate flood hazard areas and estimate potential losses from the 1-percent-annual-chance and 0.2-percent-annual-chance flood events. Using a composite dataset of the floodplain boundaries, base flood elevation information, and 3-foot LiDAR digital elevation model data (DEM), flood depth grids were generated and integrated into the Hazus model.
- **Dam Failure**—The Skookumchuck dam failure inundation area data was provided by TransAlta. The Cowlitz Sequential (Mossyrock and Mayfield dams) dam failure inundation area data was provided by Tacoma Public Utilities. Using the dam failure inundation area boundaries, and 3-foot LiDAR DEM data, depth grids were generated and integrated into the Hazus model.
- **Earthquake**—Earthquake ShakeMaps prepared by the USGS were used for the analysis of this hazard.

5.6.3 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:

- **Landslide**—A compilation of existing landslide areas was provided by the Washington Department of Natural Resources (DNR). Additionally, areas of slope between 15 and 35 percent and areas of slope greater than 35 percent were generated by Tetra Tech from the 3-foot LiDAR DEM.

- **Volcano/Lahar—**Volcanic hazard data, including lahar inundation zones, was provided by DNR and the USGS Cascades Volcano Observatory.
- **Wildfire**—Wildland urban interface data and wildland urban intermix area data were provided by DNR. Burn probability data was compiled from the USDA Wildfire Risk to Communities dataset. Fire history data was gathered from various sources. Local knowledge identified the areas of highest risk.

5.7 Data Source Summary

The data sources used in this risk assessment are summarized in Table 5-1.

Table 5-1. Data Sources.

Data	Source	Date	Format
Assessor's Residential Property Table	Lewis County	2022	Digital (tabular)
Parcels	Lewis County	2022	Digital (GIS)
Building Footprints	Microsoft/Bing	2019-2020	Digital (GIS)
Building replacement (square foot) costs	RS Means	2022	Digital (pdf)
Skookumchuck Dam PMF Inundation, Polygon Data (Skookumchuck EAP Maps)	TransAlta Centralia Generation, LLC	2018	Digital (GIS)
Cowlitz, Mossyrock & Mayfield PMF Sequential Dam Failure Flood Inundation	Tacoma Public Utilities	Unknown	Digital (GIS)
ShakeMap – Cascadia Subduction Zone M9.34	USGS	2017	Digital (GIS)
ShakeMap – Nisqually M7.2	USGS	Unknown	Digital (GIS)
ShakeMap – St. Helens M7.0	USGS	Unknown	Digital (GIS)
Seismic Site Class (NEHRP Soils)	DNR	2010	Digital (GIS)
Liquefaction Susceptibility	DNR	2010	Digital (GIS)
Digital Flood Insurance Rate Map (DFIRM) – partial unincorporated County effective 7/17/2006; latest LOMR effective 12/18/2015	FEMA	2015	Digital (GIS)
Digital Flood Insurance Rate Map (DFIRM) – Chehalis effective 7/17/2006	FEMA	2006	Digital (GIS)
Digital Flood Insurance Rate Map (DFIRM) – Napavine effective 7/17/2006; latest LOMR effective 12/18/2015	FEMA	2015	Digital (GIS)
Preliminary Digital Flood Insurance Rate Map (DFIRM) – Unincorporated County, issued 6/25/2021	FEMA	2021	Digital (GIS)
Landslide Compilation – GIS data	DNR	2020	Digital (GIS)
Volcanic hazards, adapted from US Geological Survey – GIS data	DNR	2016	Digital (GIS)
Wildland-Urban Interface	DNR	2019	Digital (GIS)
Burn Probability	Wildfirerisk.org	2023	Digital (GIS)
Risk to Structures	Wildfirerisk.org	2023	Digital (GIS)
Wildfire highest risk areas	Local knowledge	2024	Map
LiDAR Digital Elevation Model (3ft-resolution mosaic of 2017 and 2021 data)	DNR LiDAR Portal	2017/2021	Digital (GIS)
Airports	WSDOT	Unknown	Digital (GIS)

Data	Source	Date	Format
Cell Tower	Washington Open Data Portal	2023	Digital (GIS)
Dams	WSDOT	Unknown	Digital (GIS)
Dental Clinics	Washington Department of Health	Unknown	Digital (GIS)
Kidney Dialysis Centers	Washington Department of Health	Unknown	Digital (GIS)
Electric Power	EIA 860	Unknown	Digital (GIS)
Emergency Medical Service	Washington Department of Health	Unknown	Digital (GIS)
Fire Station	Washington Open Data Portal	2023	Digital (GIS)
WSDOT Bridge Structures	WSDOT	2020	Digital (GIS)
Hospice	Washington DSHS	Unknown	Digital (GIS)
Hospital	Washington Department of Health	Unknown	Digital (GIS)
Nursing Home	Washington DSHS	Unknown	Digital (GIS)
Oil Wells		Unknown	Digital (GIS)
Pharmacy	Washington Department of Health	Unknown	Digital (GIS)
Police Station	HIFLD, USDJ	Unknown	Digital (GIS)
Primary Care	Washington Department of Health	Unknown	Digital (GIS)
Radio Tower	Washington Open Data Portal	2023	Digital (GIS)
Schools	Washington OSPI	Unknown	Digital (GIS)
WIC Clinic	Washington OSPI	Unknown	Digital (GIS)

5.8 Limitations

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

- Approximations and simplifications necessary to conduct a study.
- Incomplete or outdated inventory, demographic, and/or 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.

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.

5.9 Risk Assessment Tools for Socially Vulnerable Populations

5.9.1 Overview

Social vulnerability for this plan was calculated using the National Risk Index (NRI) map for all hazards except flooding. The map utilizes the Social Vulnerability Index, the Expected Annual Loss, and Community Resilience to calculate an overall risk index score. Social Vulnerability Index (SVI) is published by the Centers of Disease Control and is defined as a consequence enhancing risk component and community risk factor that represents the susceptibility of social groups to the adverse impacts of natural hazards.

This score is divided by Community Resilience. Community Resilience is measured using the Baseline Resilience Indicators for Communities (HVRI BRIC) published by the University of South Carolina's Hazards and Vulnerability Institute (HVRI). Community Resilience is defined as the ability of a community to prepare for anticipated natural hazards, adapt to changing conditions, and withstand and recover rapidly from disruptions.

The Social Vulnerability score divided by the Community Resilience Score is then categorized as the Community Risk Factor; this score is then multiplied by the Expected Annual Loss, which represents the average economic loss in dollars resulting from natural hazards each year. The overall score is the Risk Index.

5.9.2 Limitations

The NRI map is a Census tract level map. Due to the nature of examining data in Census tracts, risk may not be accurately stated for specific communities. Larger Census tracts may reduce accuracy, overstating or understating risk. In addition, the information provided by the NRI is only as accurate as the input data available.

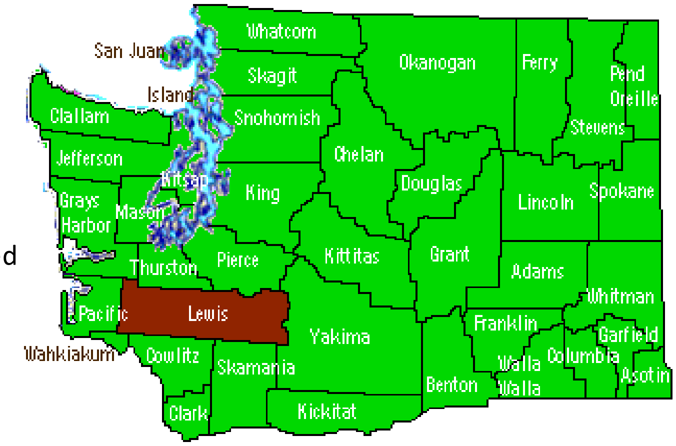
5.9.3 Application in Plan

For each natural hazard applicable to Lewis County, socially vulnerable populations were considered utilizing the data from the NRI map. Each hazard examined socially vulnerable populations in consideration with the overall risk index score (Social Vulnerability divided by Community Resilience, multiplied by Expected Annual Loss) and the Expected Annual Loss score.

5.9.4 Social Vulnerability to Flooding

The NRI appeared to greatly underestimate the impact of flooding on vulnerable communities. Actual events have shown that most all of the communities in Lewis County are highly vulnerable to flooding and for many of the communities, flooding is the highest risk natural hazard. The NRI map showed that most of Lewis County has a lower risk index for flooding. Instead of the NRI results, the planning team identified the highest risk flooding areas (as described in Section 8.3.1) and compared to the SVI and HVRI BRIC determinations. The results did not consider the expected annual losses; therefore, the results for flooding cannot be directly compared to the results for other hazards.

CHAPTER 6. LEWIS COUNTY PROFILE



Lewis County is located in the southwest region of Washington State. Lewis County contains many rivers, lakes, and outdoor attractions including the Chehalis River, Cowlitz River, and Cascade Mountains. With an area of 2,436 square miles, it is the sixth largest of Washington's 39 counties. There are eight incorporated municipalities in the county: Centralia, Chehalis, Morton, Mossyrock, Napavine, Toledo, Vader, Winlock, and Pe Ell. Centralia is the largest city and Chehalis is the county seat.

6.1 Jurisdictions and Attractions

Lewis County is known for its abundance of outdoor recreational opportunities, including the Pacific Crest Trail, Goat Rocks Wilderness, and access to nearby Mt. St. Helens and Mt. Rainer. The County offers a number of secluded lakes for paddle boarding, fishing, and swimming. The Gifford Pinchot National Forest is another attraction of Lewis County that can be accessed by horseback, off-road vehicles, mountain bike, or foot.

Centralia is the largest incorporated city in Lewis County with a population of 18,183 (US Census, 2020). Centralia was founded as a railroad town and was dependent on extractive industries such as coal, lumber, and agriculture. The current economy still relies on light industrial areas and the core business district in the historic downtown.

Chehalis, with a population of 7,439, shifted from a logging and railroad town towards farming in the mid-20th century (US Census, 2020). Similar to Centralia, Chehalis maintains a robust historic downtown, with 11 locations on the list of National Register of Historic Places.

Mossyrock is located centrally in Lewis County, with a population of 768 residents (US Census, 2020). Mossyrock is known for many outdoor recreational opportunities. In addition, the fertile soil of the Klickitat Creek drainage basin lends itself to both large and small-scale farming.

The town of Napavine was first incorporated in 1913. Napavine grew to include six sawmills, a shingle mill and two column factories; the population of Napavine grew to a population of 1,500 between 1900 to 1925. Onalaska, an unincorporated community, was similar to Napavine and known for its wood products production. Napavine is located in west-central Lewis County and was originally built around the inland mill established by the Carlisle Lumber Company in 1909. Today Onalaska has a population of 657 and Napavine has a population of 1,888 (US Census, 2020). The town of Pe Ell was incorporated in 1906 and had a population of roughly 1,000 people in 1907—larger than it is today, at 642 (US Census, 2020). Pe Ell was known for its rich agriculture and timber resources.

6.2 Historical Overview

Prior to the European settlement of what is now Lewis County, the Meshall and Chehalis Tribes occupied and lived along the bank of the Chehalis River. The tribes relied on annual runs of salmon and collecting berries and nuts from the land to survive. These tribes used horses to trade with the tribes east of the Cascades. Due to the plentiful rivers and creeks, most villages were located along their mouths (Wilma, 2005).

Later, during European settlement of this land, communities alongside the Columbia River and Puget Sound that followed the Cowlitz trail developed first. Cowlitz Landing, which later became Toledo, was the hub of activity. Travelers gathered at the hotel and store before beginning their journey through the rivers, forests, and prairies (Wilma, 2005).

In 1855 the Quinault Treaty with United States Government went into effect. Coastal tribes signed the treaty, exchanging southwest Washington for reservation land. Although no member of the Chehalis tribe signed the treaty, they have since claimed rights under the treaty as affiliates. Currently, the Confederated Chehalis Tribes govern what is left of tribal lands (Wilma, 2005).

Originally, half of present-day Washington and British Columbia was included in Lewis County's borders, it was first named after George Vancouver. Lewis County was later renamed after Meriwether Lewis in 1849. The county took its final form in 1854, measuring 26 miles by 96 miles (Wilma, 2006).

In 1871 the city of Morton was settled. The city was known for its abundant revenue of logging and mining for cinnabar. Morton was once known as the "tie mill capital of the world" in the 1950s. The Northern Pacific Railroad reached the Chehalis River in 1872. By 1874 the line was providing regular service between the river and Tacoma. When the railroad bypassed the county seat, Claquato, the county commissioners moved to make Saudersville (Chehalis) the county seat in August of 1874. The railroad allowed the county to exploit its major resource—timber. Lumbering became the primary industry in the region, attracting immigrants to new communities (Wilma, 2006). In fact, the longest railroad tie dock in the world ran along the railroad tracks east of Morton.

By 1900, the county officials were focused on building schools, churches, granges, and roads that connected to the eastern side of the Cascades. Post-war the county completed the White Pass Highway over the Cascades and the Pacific Highway that links Portland to Seattle—this would later become Interstate 5.

6.3 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, 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. Review of these events helps identify targets for risk reduction and ways to increase a community's capability to avoid large-scale events in the future. Still, many natural hazard events do not trigger federal disaster declaration protocol but have significant impacts on their communities. These events are also important to consider in establishing recurrence intervals for hazards of concern.

Lewis County has experienced 30 events since 1964 for which presidential disaster declarations were issued. These events are listed in Table 6-1.

Table 6-1. Presidential Disaster Declarations for Hazard Events in Lewis County.

Event	Federal Disaster Number	Year
Severe Winter Storm, Winds, Flooding, Land and Mudslides	4650	2022
Severe Storms, Winds, Flooding, Land and Mudslides	4635	2022
Severe Winter Storm, Winds, Flooding, Land and Mudslides	4593	2021
COVID-19	3427, 4481	2020
Severe Winter Storm, Flooding, Land and Mudslides	4309	2017
Severe Winter Storm, Winds, Flooding, Land and Mudslides	4253	2016
Severe Winter Storm, Winds, Flooding, Land and Mudslides	4249	2016
Severe Winter Storm, Flooding, Land and Mudslides	4056	2012
Severe Winter Storm, Flooding, Land and Mudslides	1963	2011
Severe Winter Storm, Land and Mudslides	1817	2009
Severe Winter Storm and Record Snow	1825	2009
Severe Winter Storm, Land and Mudslides	1682	2007
Severe Storms, Land and Mudslides	1734	2007
Severe Storms, Flooding, Land and Mudslides	1671	2006
Earthquake	1361	2001
Severe Winter Storm, Land and Mudslide, Flooding	1159	1997
Severe Storms, High Wind, and Flooding	1079	1996
High Winds, Severe Storms, and Flooding	1100	1996
Severe Storms and High Winds	981	1993
Severe Storms and High Tides	896	1991
Severe Storms and Flooding	883	1990
Severe Storms and Flooding	852	1990
Severe Storms and Flooding	784	1986
Volcanic Eruption, Mt. St. Helens	623	1980
Severe Storms, Mudslides, and Flooding	545	1977
Severe Storms and Flooding	492	1975
Severe Storms, Snowmelt, Flooding	414	1974
Severe Storms and Flooding	322	1972
Heavy Rains, Melting Snow, and Flooding	300	1971
Heavy Rains and Flooding	185	1964

6.4 Physical Setting

6.4.1 Geology

Lewis County is bounded on the east by the crest of the Cascade Mountain Range and extends west to the Willapa and Doty Hills. The County crosses three physiographic provinces: the Cascade Range, the Puget-Willamette Lowlands, and the Pacific Coast Range.

The Chehalis River valley occupies most of the western parts of the County, and the Cowlitz River valley occupies most of the central and eastern parts. A small portion of the mountainous north central part of the County contains the Nisqually and Deschutes watersheds. The uplands of the eastern County are composed of rugged mountainous and alpine topography, modified by glacial activity, and drained by rivers that flow generally westward. The landscape is characterized by long, steep slopes and relatively straight, parallel drainages. Ridge tops have an average elevation of approximately 4,000 feet.

The geology of Lewis County is composed primarily of igneous and sedimentary bedrock of the Tertiary Period, and unconsolidated glacial sediments of the Pleistocene Epoch. After formation of the bedrock, between 7 and 55 million years ago, the surface of the area underwent geologic uplift, raising the volcanic and sedimentary rocks above sea level. Deformation, in the form of faulting and folding, accompanied the uplift. Landslides and erosion followed in the western part of the County; glaciation, glaciofluvial deposition, erosion, and recent volcanic activity followed in the eastern half of the County.

6.4.2 Watersheds

The County includes watersheds associated with four major rivers: the Chehalis River, Cowlitz River, Deschutes River, and Nisqually River. The Chehalis watershed is the most vulnerable watershed in the County. Not only does it flood with the greatest frequency, but it is also the county’s population center with significant residential, commercial, and industrial development located within the expansive floodplain.

Chehalis River – WRIA 23

The Chehalis River originates in the Cascade foothills surrounding the Cities of Centralia and Chehalis, and eventually flows into Grays Harbor at Aberdeen. The river basin, located at the southern end of the Puget Trough, has a total drainage area, including tributaries, of approximately 2,114 square-miles. The valley is characterized by a broad, well-developed floodplain, and low terraces surrounded by highly dissected uplands of low to moderate relief, that have broad, rounded ridges. Many perennial streams drain these ridges. Elevations within the basin range from 170 feet at Chehalis to over 5,000 feet at the headwaters. Most uplands in the basin average 300 to 600 feet in elevation. A low divide occurs between the Chehalis River basin and the Cowlitz watershed to the south a few miles south of Chehalis, between the communities of Napavine and Winlock. At their closest point, the Chehalis and Cowlitz Rivers, the two largest rivers in southwestern Washington, are only 16 miles apart.

The Chehalis River valley is characterized by the Willapa Hills in the west and by the Cascade foothills in the east, with broad, developed floodplains downstream of its confluence with the south fork of the Chehalis River. The river gradient from its source to the floodplain is steep with an average gradient of 16 feet per mile. The Chehalis River uplands are undergoing tectonic uplifting. This lowering and lifting of the Chehalis River valley changes the gradients of streams and other waterbodies. The tectonic action, along with the heavier precipitation and sedimentary rock in the Chehalis-Centralia floodplain, generates bed load material that must be moved from the river channel. Sedimentary rock is usually weaker and easier to erode, and this process is hastened by high peak flows. A river channel with a low gradient tends to form meanders as a way to remove heavy bed material. The change in channel gradient from tectonic activity can compound this meandering action.

The Chehalis River, in the Centralia-Chehalis valley, has a meandering channel that occupies a uniform floodplain averaging over one mile wide. Most of the valley is inundated during a severe flood such as the January 1990 flood. Tributaries to the Chehalis River in the Chehalis-Centralia valley include Dillenbaugh Creek, Newaukum River, Salzer Creek, Coal Creek, China Creek, Skookumchuck River, and Coffee Creek (Lewis County, 2008).

The Skookumchuck River, one of the major Chehalis River tributaries, joins the Chehalis River, and is approximately 41 miles in length. Three developments are notable within the Skookumchuck River system:

1. The City of Centralia occupies several square miles at the lower end of the basin.
2. Skookumchuck Dam is located about 20 miles upstream from Centralia and operated by PacifiCorp. Skookumchuck Dam was completed in 1971 and has been considered several times for flood control use.
3. Centralia Steam Generating Plant on Hanaford Creek, authority has been granted for this coal-fired facility to divert up to 54 cubic feet per second (cfs) of water from the Skookumchuck River. However, in 2011 Governor Christine Gregoire signed the TransAlta Energy Transition Bill. This resulted in one coal boiler being shut down in 2020. The other boiler is set to be shut down by the end of 2025.

Nisqually River – WRIA 11
The Nisqually River runs approximately 81 miles from its source at the Nisqually Glacier on the southern slopes of Mount Rainier to its mouth at Puget Sound. The Nisqually River serves as the county boundary between Lewis County and Pierce County. Flooding is a frequent concern for communities along the Nisqually River, particularly during winter months when heavy rainfall and melting snow can cause the river to swell. The Nisqually River Basin is highly susceptible to flooding. The chance of flooding can vary depending on several factors including the amount and intensity of precipitation, snowpack levels, and the conditions of the river's levees and dams (Department of Ecology).

The Nisqually River Basin is known for its diverse landscape and wide variety of plant and animal species. Several threatened and endangered species such as chinook salmon, steelhead trout, and bull trout call the river home. The Nisqually River is an important resource for both people and wildlife. The river and its tributaries provide the essential habitat for fish and other aquatic species, as well as a source of water for irrigation, industrial uses, and residential consumption. In addition, the basin also provides recreational opportunities, such as fishing, hiking, and wildfire viewing.

Deschutes River – WRIA 13
The Deschutes River originates in the southern Cascade Range and flows for approximately 50 miles before emptying into the southern end of Budd Inlet in the Puget Sound. Only a small portion of the watershed's headwaters are in Lewis County. The majority of the watershed is in Thurston County. There is no development within the Deschutes watershed in Lewis County as the land is owned either by the US Forest Service or by timber companies.

Cowlitz River – WRIA 26
The Cowlitz River in Lewis County is a major waterway, flowing approximately 105 miles. The river is an important source of water for the region, providing irrigation for agriculture and supporting fisheries and recreational activities. The risk of flooding on the Cowlitz River is especially high during periods of heavy rainfall or snowmelt. In recent years, the risk of flooding on the Cowlitz River has been mitigated through the construction of levees and other flood control structures. The Cowlitz River has three major hydroelectric dams, including the Cowlitz Falls Project, Mossyrock Dam, and the Mayfield Dam.

The Cowlitz Falls Project was built in the 1990s, producing an average 260 GWh annually for Lewis County Public Utility District. Its reservoir, Lake Scanewa, is located at the confluence of the Cowlitz and Cispus River. Mossyrock Dam is a concrete arch-gravity dam that was constructed on the Cowlitz River near Mossyrock beginning in 1965. By 1968, the dam began generating power for Tacoma City Light. The dam creates Riffe Lake and is 606 feet tall, which is the highest dam in the Pacific Northwest. Mayfield

Dam began producing electricity in 1963. The dam contains a tunnel that connects the reservoir to the powerhouse. The dam sits at 185 feet high and creates Mayfield Lake.

6.4.3 Climate

Lewis County has a mixture of climates, which changes from east to west. The eastern portion of Lewis County has a predominately marine climate characterized by mild temperatures both summer and winter. Extreme temperatures are unusual for the area because prevailing westerly winds bring maritime air over the basin and provide a moderating influence throughout the year. During the spring and summer, high-pressure centers predominate over the northeastern Pacific, sending a northwesterly flow of dry, warm air over the basin. The dry season extends from late spring to midsummer, with precipitation frequently limited to a few light showers; however, the dry season has been lengthening due to climate change.

The western portion of the County experiences more temperature extremes. As the elevation rises towards the crest of the Cascade Mountains, the area experiences lower wintertime temperatures than the west. See Table 6-2 for a comparison between eastern and western Lewis County.

Occasionally, hot, dry easterly winds cross the Cascade Mountains and raise daytime temperatures into the 90s or higher. The hot, windy days are high fire danger days and are becoming more frequent. In winter, the Aleutian low-pressure center normally predominates during the winter, causing a counterclockwise circulation of cool, moist air over the basin and prevailing southwesterly winds.

Virtually every fall and winter, strong winds and heavy precipitation occur throughout the County. Storms are frequent and may continue for several days. Successive secondary weather fronts with variable rainfall, wind, and temperatures may move onshore at daily intervals or less. The abundance of rainfall during this period is due to the frequent storm systems that pass over Western Washington.

Precipitation in the County is affected by distance from the Pacific Ocean, elevation, and seasonal conditions. In Lewis County, the Willapa Hills in the southwest receives the most rainfall, averaging 120 inches each year. Most rainfall occurs between the months of October and March. Heavy rainfall is often carried into the region in an atmospheric river, a band of moisture in the sky that resembles a river, bringing heavy rain or snowfall that can last for days. Many atmospheric rivers are characterized by warm rain and temperatures, which can increase snow melt that contributes to flooding. Over the past 40 years, atmospheric rivers have caused more than 80% of flood damage along the west coast (NASA, 2021). The 2007 flood was caused by an atmospheric river, which brought 12 to 26 inches over a four-day period (WA Ecology, 2016).

Snowfall in most of the county is not heavy, but potential does exist for extremely large amounts on occasion in the lower elevations. The average annual snowfall in lower elevations is approximately nine inches with higher populated elevations averaging 50 inches per year. The White Pass area, at the eastern boundary of Lewis County, averages 350 inches per year. Snowfall occurs occasionally at Chehalis and Centralia, but warm temperatures typically limit any snow accumulation over prolonged periods. Most of the snow occurs above 1,000 feet in communities like Morton, Mineral, Randle, and Packwood.

Winds in the region rarely exceed 30 mph; winds of this speed usually only occur during the fall and winter months in conjunction with rainstorms and/or thunderstorms that pass through the vicinity.

Approximately 10% of the winds between the months of November and February have speeds between 15 and 30 mph, compared with approximately two% of the winds for the other months. The rest of the wind speeds typically range between zero and 15 mph, about 90% of the time. Wind speeds have been measured in excess of 70 mph during the winter months. The majority of the highest wind speeds measured have originated from the south and southwest directions (City of Centralia, 2008). The most recent significant wind event occurred in November, 2022 in Packwood with gusts of up to 41mph.

Table 6-2. Climate averages and extremes.

	Temperature Extremes (F)		Average Winter Temperature (F)		Average Summer Temperature (F)		Average Rainfall (in)	Average Snowfall (in)
Jurisdiction	Low	High	Low	High	Low	High		
Centralia	-4 (1930)	107 (2021)	36	49	52	75	41	<10
Packwood	-23	108 (2021)	24	45	50	75	56	30

Source: NOAA, 2023

6.5 Developmental Profile

6.5.1 Land Use

Lewis County lies in southwestern Washington with a total landmass of 2,452 square-miles, and measures about 90 miles (east to west) by 25 miles (north to south).

Incorporated and unincorporated urban growth areas are designated and zoned for urban levels of development. Incorporated cities plan for, and designate land uses within their corporate boundaries consistent with adopted comprehensive plans and development regulations. Unincorporated UGAs, areas adjacent to incorporated cities, were designated consistent with the GMA and are intended for urban development. UGAs represent about 0.7% of the County. Such areas are expected to develop at higher intensities and eventually be annexed into the cities and zoned for residential, commercial, and industrial uses. For a full discussion of land use within incorporated cities, refer to each city’s comprehensive plan.

Unincorporated Lewis County land use is regulated consistent with historic and traditional land use patterns and at intensities consistent with rural levels of public services. For example, more than three-quarters is designated for federal, state, and private resource uses. 72 percent is devoted to forest resource uses and 6% is devoted to agricultural land. In addition, approximately one-third of Lewis County is designated as national forest.

Two percent of the land lies within urban areas, with 1% located in cities and 1% located in UGAs. One percent of the County land is classified as “Limited Areas of More Intensive Rural Development” (LAMIRDs). LAMIRDs are unincorporate areas that often have density of development similar to incorporated small towns. Examples of LAMIRDs are Adna, Salkum, Glenoma, Randle and Packwood. LAMIRDs have zoning designations and development regulations that allow for new development and redevelopment at densities similar to the historic densities. For example, Packwood has a population of roughly 900 people living on small single family lots and a wide variety of services and retail including a hotels, motels, gas stations, grocery store, restaurants, etc. Rural land, not including LAMIRDs, encompasses 19% of the total land area.

Open space land is designated in the County Comprehensive Plan and includes parks, wilderness areas, resource lands (forest, farm, and mineral), and corridors. The open space designation overlays other zoning and makes up about 75% of the County. Open space corridors follow stream and river valleys and are comprised of steep slopes, agricultural resource land, and flood hazard areas. Unlike park and recreation areas, open space lands may be either public or private ownership and are often not available for public access. Privately owned lands in flood hazard areas (over 40,000 acres) and lands currently managed by Tacoma City Light under conservation easements (over 15,000 acres) are part of this latter category.

Figure 6-1 demonstrates the land use designations in Lewis County as outlined in the 2016 Comprehensive Plan.

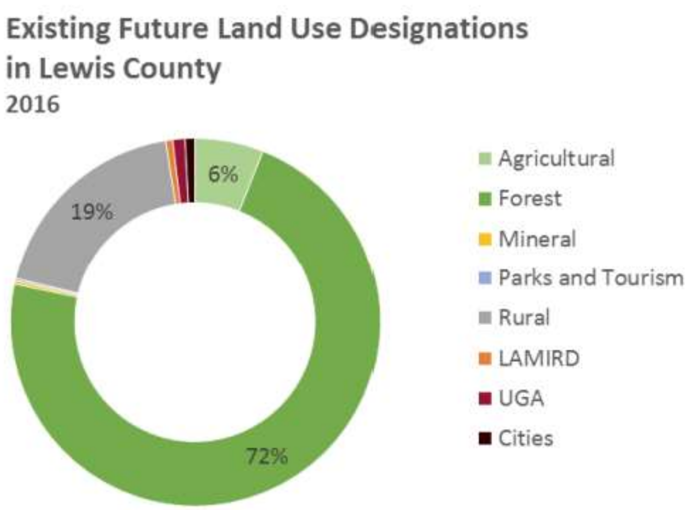


Figure 6-1. Future Land Use in Lewis County.

6.5.2 Critical Facilities and Infrastructure

A critical facility is a 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, the following categories of lifelines are defined as critical facilities:

- Safety and Security—Law enforcement/security, search and rescue, fire services, government service, responder safety, and imminent hazard mitigation
- Food, Water and Shelter—Evacuations, schools, food/potable water, shelter, durable goods, water infrastructure and agriculture
- Health and Medical—Medical care (hospitals), patient movement, public health, fatality management, health care and supply chain
- Energy—Power (grid), temporary power and fuel
- Communications—Infrastructure, alerts, warnings, messages, 911 and dispatch, responder communications and financial services
- Transportation—Highway/roadway, mass transit, railway, aviation, maritime and pipeline
- Hazardous Materials—Facilities, hazardous debris, pollutants, and contaminants

Table 6-3 lists the number of critical facilities within Lewis County. Due to the sensitivity of this information, a detailed list of facilities is not provided. The list is on file with Lewis County. Figure 6-2 and Figure 6-3 show the locations of critical facilities. All critical facilities and infrastructure were analyzed to help identify the risk and mitigation actions.

Table 6-3. Critical Facilities within Lewis County.

Jurisdiction	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health and Medical	Safety and Security	Transportation	Total
Centralia	2	0	9	0	48	4	40	**103**
Centralia UGA	6	0	1	0	6	0	6	**19**
Chehalis	4	0	8	0	21	5	19	**57**
Chehalis UGA	0	1	0	0	1	1	8	**11**
Morton	0	0	2	0	11	2	2	**17**
Morton UGA	0	0	0	0	0	1	0	**1**
Mossyrock	0	0	3	0	2	2	1	**8**
Mossyrock UGA	0	0	0	0	0	0	1	**1**
Napavine	0	0	2	0	5	2	6	**15**
Napavine UGA	0	0	0	0	0	0	1	**1**
Pe Ell	0	0	2	0	3	2	2	**9**
Pe Ell UGA	0	0	0	0	0	0	0	**0**
Toledo	0	0	3	0	2	5	0	**10**
Toledo UGA	0	0	1	0	0	0	0	**1**
Vader	0	0	0	0	1	2	0	**3**
Vader UGA	0	0	0	0	1	0	2	**3**
Winlock	0	0	2	0	4	2	4	**12**
Winlock UGA	0	0	2	0	2	1	2	**7**
Unincorporated	30	206	9	0	26	95	327	**684**
Total	**42**	**207**	**0**	**0**	**133**	**159**	**421**	**962**

Road Transportation

The road system in Lewis County is made up of local public and private roads, interstate, US highways, and state routes. There are over 1,888 miles of public and private roads within the County. The County maintains 1,065 miles of roadways, 196 bridges, and 5,110 culverts. The nine cities (Centralia, Chehalis, Morton, Mossyrock, Napavine, Pe Ell, Toledo, Vader, and Winlock) are responsible for their own roadways within their city limits. Unless there is an agreement between the County and the cities, the County currently maintains the roadways in the unincorporated UGAs.

The Chehalis-Centralia area lies 85 miles midway between the metropolitan areas of Seattle, Washington, and Portland, Oregon. The primary north-south transportation corridor passing through Lewis County and the Cities of Centralia and Chehalis is Interstate 5. Interstate 5 passes through the Chehalis River floodplain and is affected by flooding. The roadway was closed for four days in 1996 and 2007, and two days in 2009, causing millions of dollars of freight delays (WA Ecology, 2020). More recently, in January of 2022 after heavy rain and snow fell throughout the state, I-5 was closed south of Chehalis due to flooding. During this flood event, local first responders conducted 21 water rescues on the first day of flooding (KOIN, 2022).

US Highway 12 traverses Lewis County from east to west and crosses the Cascade Mountains at White Pass. White Pass is the only major all-season route south of Seattle and north of the Columbia River allowing access to eastern Washington. During snow events that close Snoqualmie Pass (I-90) and Stevens Pass (US 2), significant commercial truck traffic is diverted to White Pass. This can effect the mobility of local traffic, as Highway 12 is the only winter transportation route to and from Packwood, Randle and Glenoma.

Railroad Transportation

Several rail lines are located within Lewis County. The mainline BNSF Railway Company railroad crosses through Lewis County. Amtrak provides passenger railway service to Centralia along the BNSF rail line. There are also rail lines operated by the Puget Sound and Pacific Railroad, the Union Pacific Railroad, and Tacoma Rail.

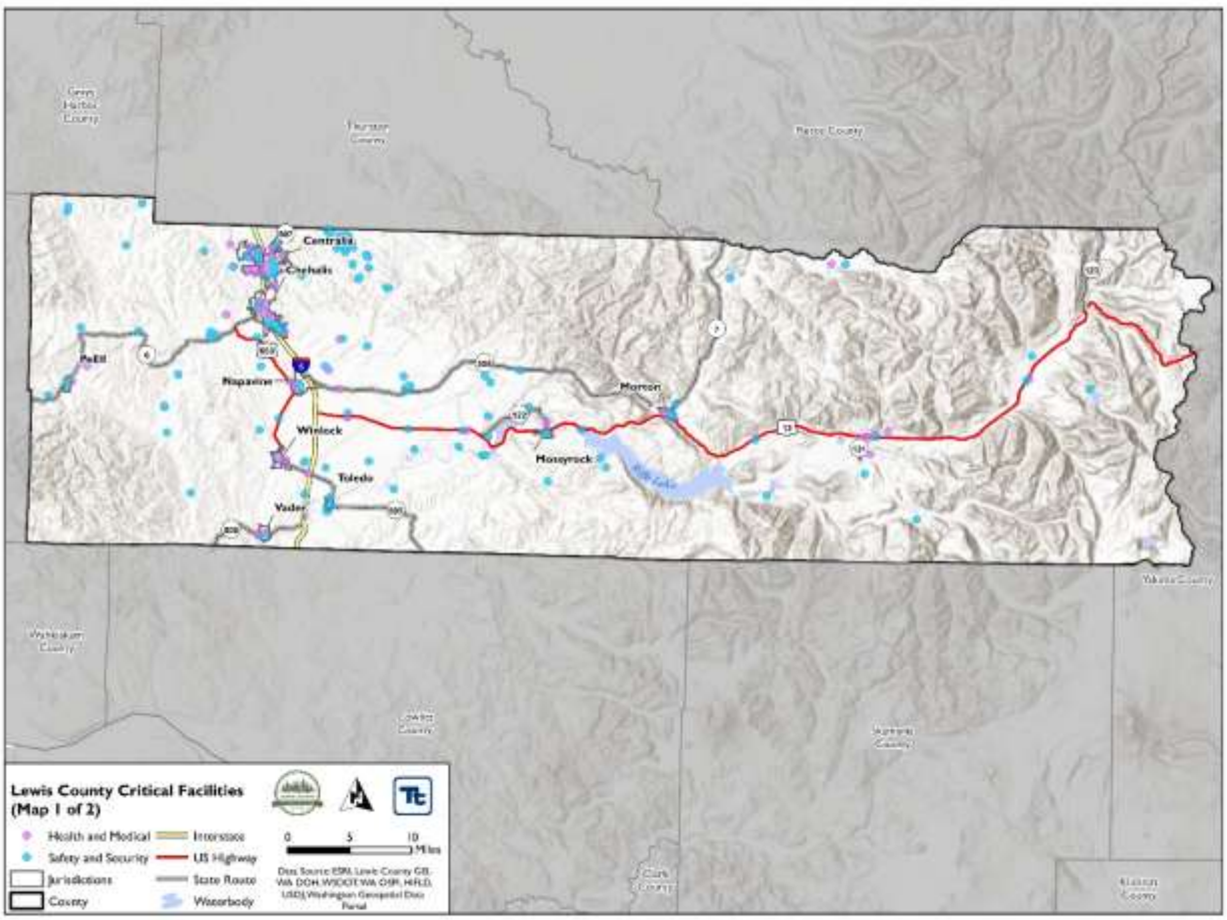


Figure 6-2. Critical Facilities – Health, Medical, Safety, and Security.

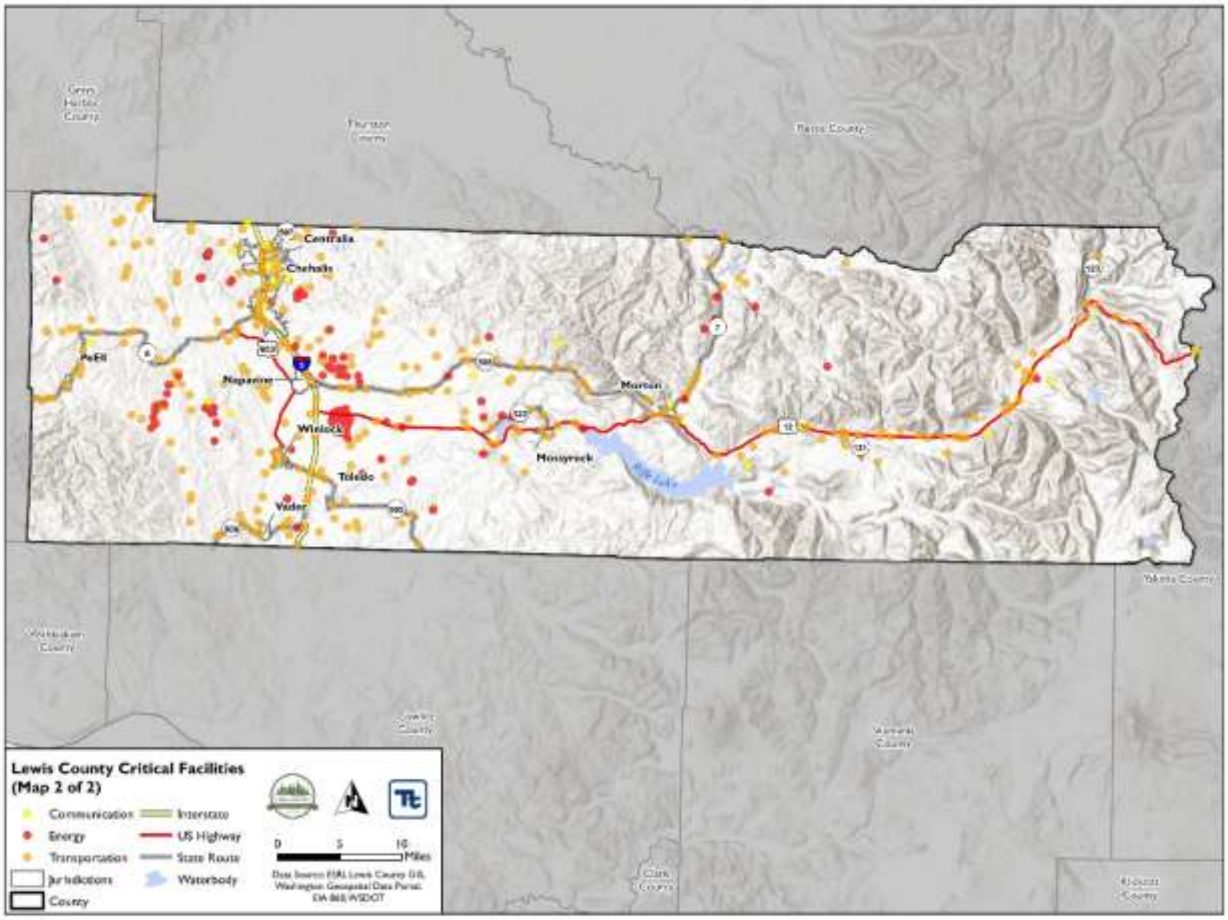


Figure 6-3. Critical Facilities – Communication, Energy, Transportation.

Air Transportation

There are three airports located within Lewis County. The Chehalis-Centralia airport is located within Chehalis city limits and provides regional services. The airport is owned by the City of Chehalis. The Ed Carlson Memorial Field- South Lewis County Airport was originally known as the Toledo-Winlock County Airport when the municipalities and Lewis County had joint ownership. In 2001, Toledo and Winlock released their ownership and Lewis County took over full ownership, eventually renaming the airport. The Packwood Airport is in the unincorporated community of Packwood and is owned by Lewis County. Originally the airport was developed as an unpaved emergency air strip in 1949, but over time the runway has transitioned to a wide paved runway with medium intensity runway lighting. The Packwood Airport is considered under the Federal Aviation Administration a Basic General Aviation Airport that provides a link to the national airport system. The Packwood Airport is important for aviation activities such as emergency response (e.g., wildfire), air ambulance service, flight training, and personal flying.

6.6 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. Section 6.9 describes socially vulnerable populations within Lewis County and their location.

6.6.1 Lewis County 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 the population of Lewis County at 84,075 in 2023 (OFM, 2023).

Population changes are useful socio-economic indicators. A growing population generally indicates a growing economy, while a decreasing population signifies economic decline. Table 6-4 shows recent population growth in the County. Figure 6-4 shows the Lewis County population change from 1990 to 2019 compared to that of the State of Washington (Washington OFM, 2021). The County grew faster than the statewide average through the early-to-mid 1990s but has since had a growth rate somewhat below, and mirroring, that of the state.

Table 6-4. Lewis County Population Growth.

Year	Lewis County Population	Year	Lewis County Population	Year	Lewis County Population
2005	71,600	2012	76,300	2019	79,480
2006	72,900	2013	76,200	2020	82,140
2007	74,100	2014	76,300	2021	82,700
2008	74,700	2014	76,300	2022	83,400
2009	75,200	2016	76,890	2023	84,075 (est)
2010	75,455	2017	77,440	2045	104,951 (est)
2011	76,000	2018	78,380		

Source: OFM, 2023.

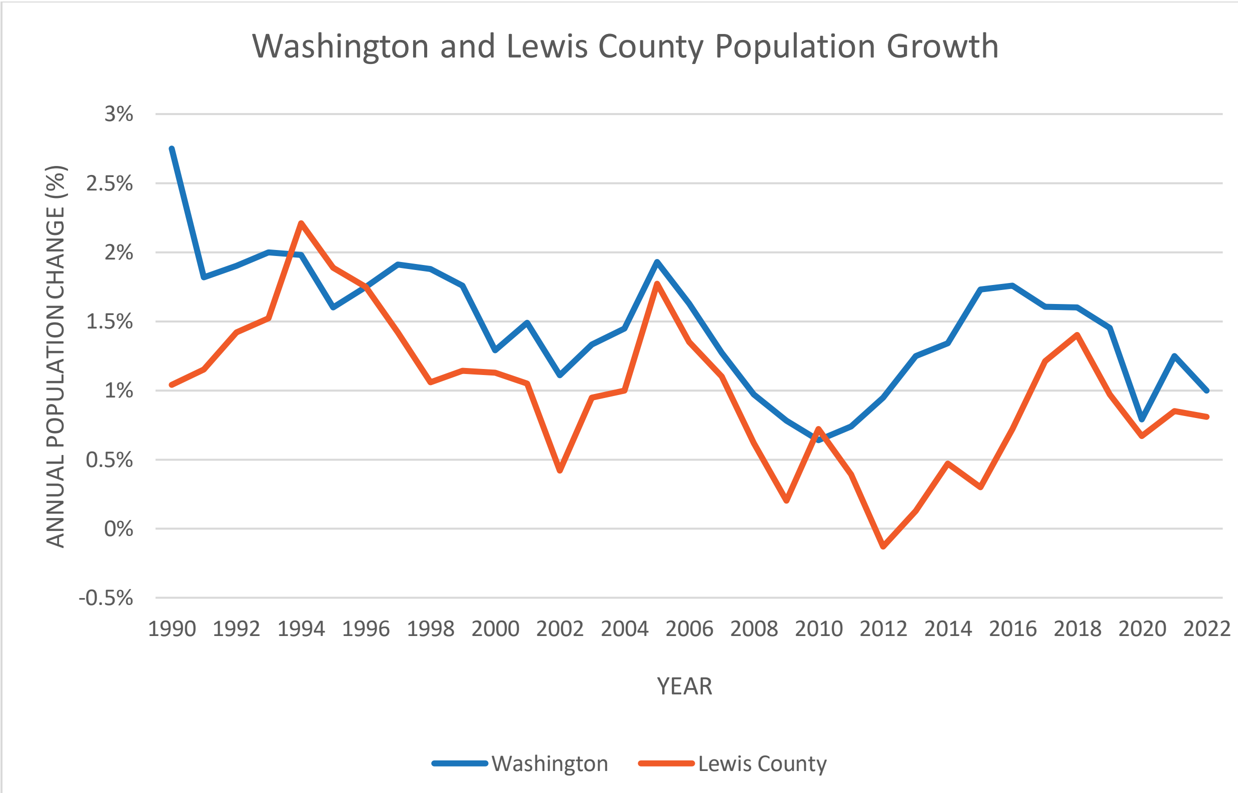


Figure 6-4. Washington and Lewis County Population Change. Source: OFM, 2023.

6.6.2 Age Distribution

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 who live in adult family homes that do not accept Medicare or Medicaid may be more vulnerable because 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.

Children under 14 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 hazards.

The overall age distribution for the planning area is illustrated in Figure 6-5. Based on the most recent data from the US Census Bureau’s American Community Survey conducted in 2020, 21.1% of the planning area’s population is 65 or older, compared to the state average of 16.2%. The county’s population includes 27.6% who are 18 or younger, compared to the state percentage of 27.3%. In eastern Lewis County, about 30% of the population is over 65. This about 10% higher than western Lewis County (US Census, 2020).

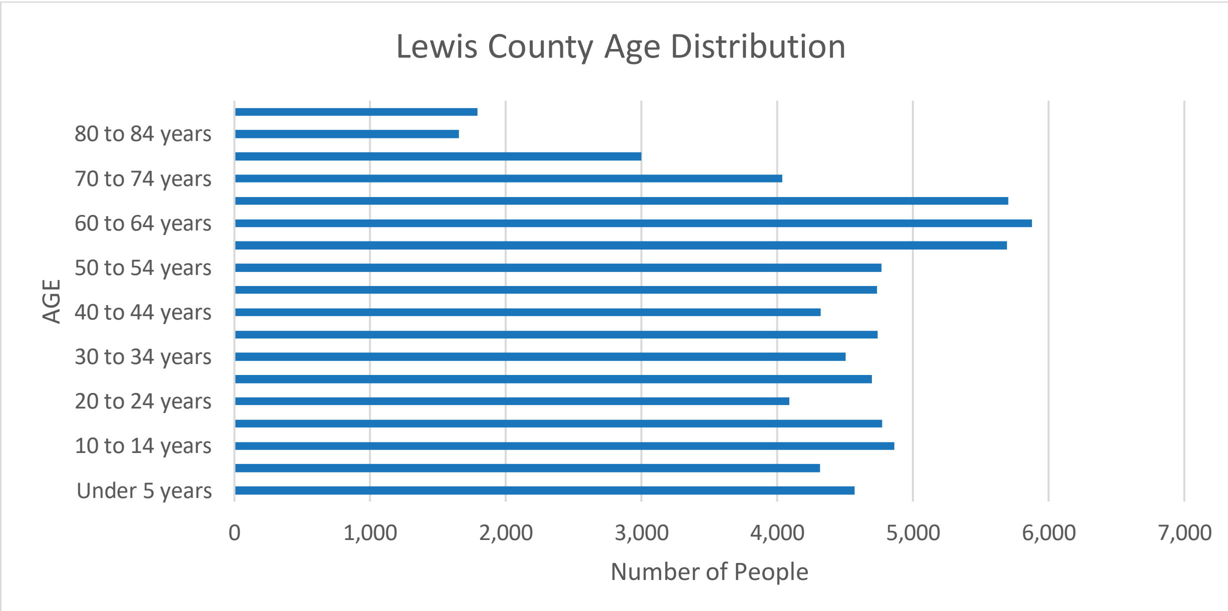


Figure 6-5. Lewis County Age Distribution.

6.6.3 Race, Ethnicity, and Language

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.

According to the most recent data from the US Census Bureau's American Community Survey in 2023, the racial composition of the planning area is predominantly white, at 81.3%.Those identifying as Hispanic or Latino, of any race, make up 11.7% of the population. This population is concentrated in the Centralia-Chehalis area and along the I-5 corridor.

The planning area has a 5% foreign-born population. Other than English, the most commonly spoken language in the planning area is Spanish, with 7% of the population speaking Spanish at home. The Census estimates that 3.6% of the residents speak English "less than very well" (US Census, 2020).

6.6.4 Individuals with Disabilities or with Access and Functional Needs

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.

According to the 2022 American Community Survey data, there are almost 17,000 individuals living in Lewis County with some form of disability, representing 20% of the total population. Of the 20%, 50% of the population with a disability are under the age of 65 (US Census, 2022).

6.7 Economy

6.7.1 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 and severe storms 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 data from the US Census Bureau's American Community Survey per capita income per person in Lewis County is $32,800, and the median income is estimated to be $67,247. The incomes in Lewis County are much lower than Washington state's per capita and median incomes of $48,685 and $90,325 (US Census, 2022). Census Bureau estimates that in Lewis County, 11.7% of the population in the planning area lives below the poverty level, which is higher than Washington state's 10.0% (US Census, 2020).

6.7.2 Industry, Businesses, and Institutions

The planning area's economy is strongly based in health care/assistance industry (13% of employment), retail trade (13.2%), and manufacturing (9.2%). Figure 6-6 demonstrates the breakdown of industry types in Lewis County.

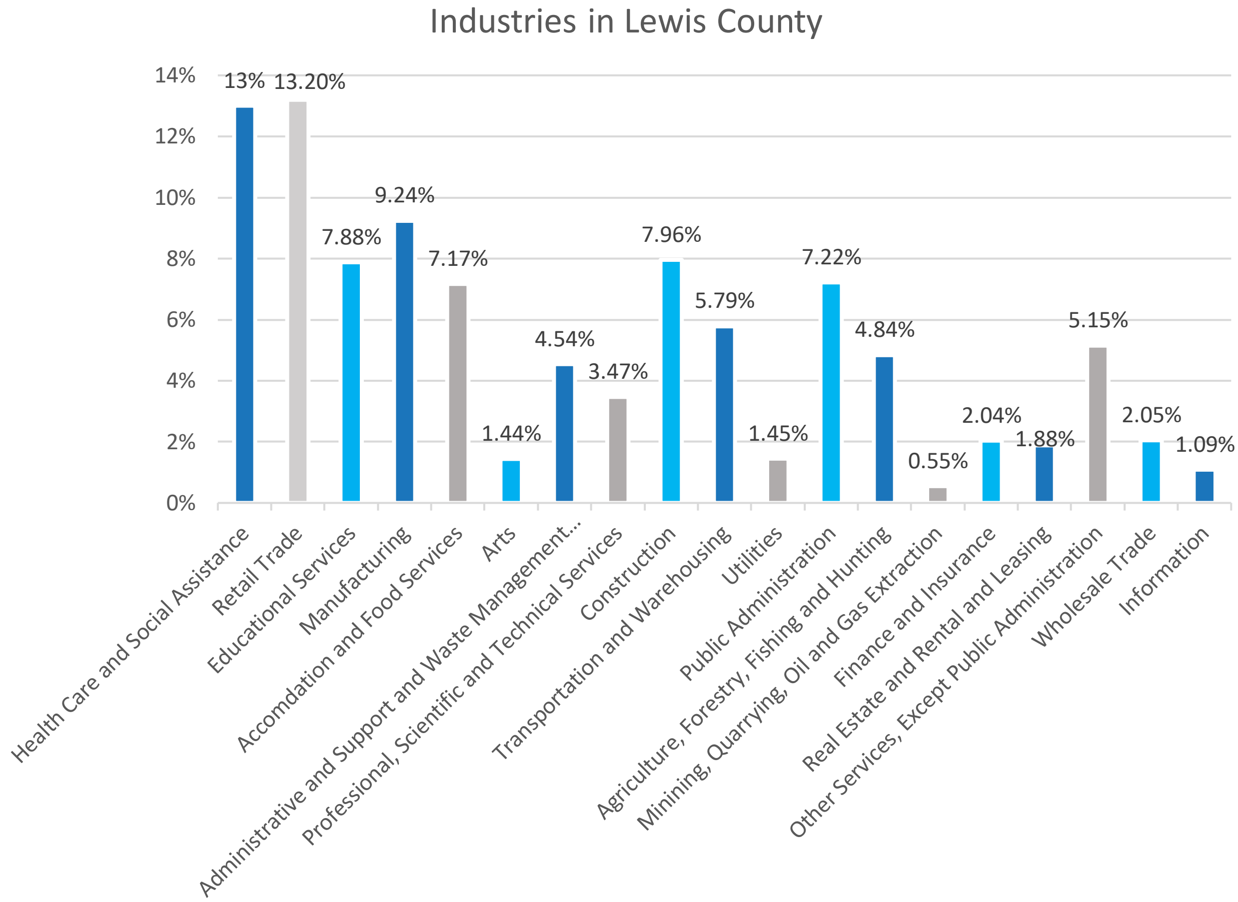


Figure 6-6. Lewis County Industries.

6.7.3 Employment Trends and Occupations

According to the 2017-2021 five-year American Community Survey, 54.6% of Lewis County's population 16-years old or older is in the labor force, including 49.7% of women in that age range (US Census, 2021).

Figure 6-7 compares unemployment trends from 1990 through 2023 for the United States, Washington, and Lewis County, based on data from the state Employment Security Department (Washington ESD, 2021). Lewis County's unemployment rate has been declining since 2009 when it reached its peak of 13.3%. The unemployment rate was at its pre-COVID lowest in 2019 at 6.3%. However, due to the onset of the COVID-19 Pandemic in the United States in March 2020, the unemployment rate for Lewis County, the State of Washington, and the United States as a whole, increased sharply. By 2023, the unemployment rate has reached its lowest level since 1990, 5.4%.

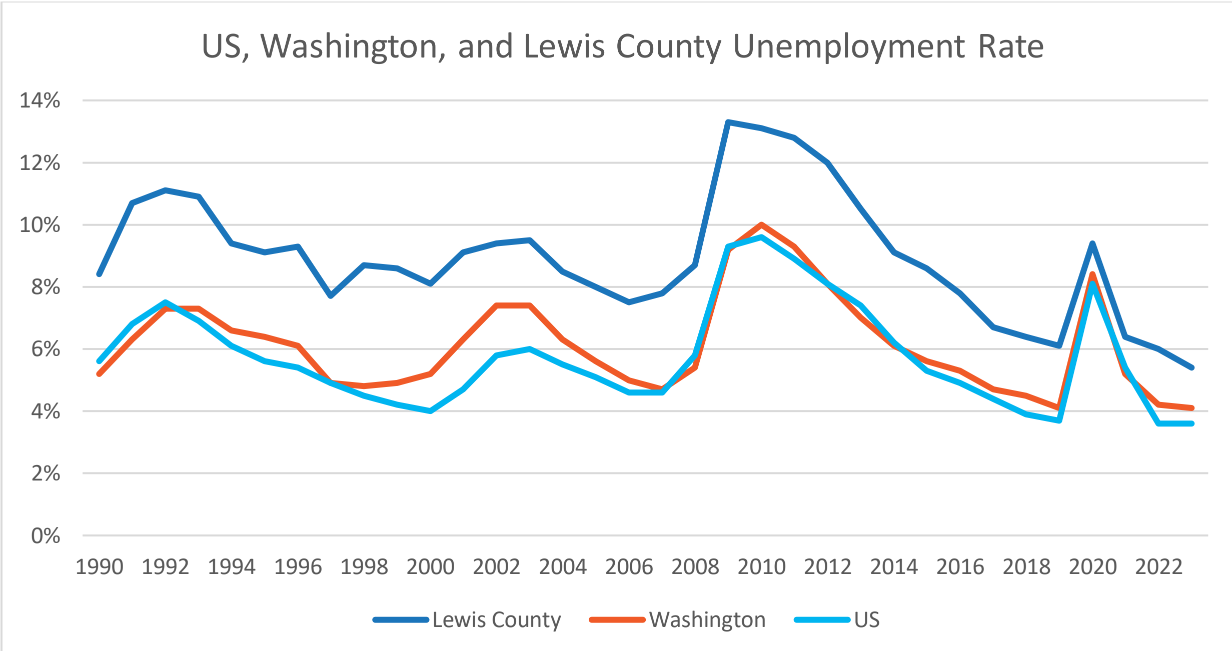


Figure 6-7. US, Washington, and Lewis County Unemployment Rate.

6.8 Future Trends in Development

The County and its cities and towns have adopted comprehensive plans that govern land use decisions and policy making their jurisdictions. Decisions on land use will be 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 Lewis County.

Each comprehensive plan includes a land capacity analysis that determine how many residences and businesses the land can support given the existing zoning designations and development regulations. Cities and counties are required to demonstrate that there is sufficient capacity to support the next 20-years of population growth. In June 2023, Lewis County adopted the 2045 population forecast of 104,951 people, which is an increase of 21,505 people over the current population. Cities and the county will be updating their respective comprehensive plans to demonstrate how they will accommodate that growth through changes to zoning designations and development regulations, as well as how those people will be served by things like water, sewer, transportation, police, EMS, fire protection, etc.

All municipal planning partners will incorporate by reference the updated Lewis County Hazard Mitigation Plan in their comprehensive plans during the current periodic update process. This will ensure 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.

6.9 Social Vulnerability

Socially vulnerable populations were considered for each of the natural hazards that impact Lewis County. Social vulnerability was evaluated using the National Risk Index map (NRI), as described in

Chapter 5 Section 5.9. The overall County social vulnerability, community resilience, and expected annual loss is summarized below.

Social vulnerability for Lewis County is demonstrated in Figure 6-8. 10.7% of the area within Lewis County has a very high social vulnerability classification, in total 259.75 square miles. The largest portion of very high social vulnerability is in south central Lewis County along Highway 12. This area encompasses 219.8 square miles but has a relatively low population density of 13 people per square mile. Other areas of very high social vulnerability are in the northwest area of the county near Centralia and Chehalis and have a much higher population density. The highest population density with a very high vulnerability classification is located directly south of Centralia. The census tract is 0.48 square miles and contains 4,625 people per square mile. In addition, 5.5% of Lewis County is classified as relatively high social vulnerability. There is a small section located to the west of Centralia and Chehalis and the other areas are along I-5 in the southern portion of the county.

Figure 6-9 demonstrates the community resilience within Lewis County. The entire County is classified as having a relatively low community resilience, meaning that the communities within Lewis County are anticipated to have a relatively low ability to prepare for natural hazards, adapt to changing conditions, and withstand and recover rapidly from disruptions when compared to the rest of the United States. Lewis County is in the 10th percentile within Washington State for community resilience.

The high social vulnerability and low community resilience in Lewis County may be due to several factors. According to the Census, 13.5% of the population in Lewis County is in poverty, compared to the 11.6% nation average. In addition, 21.5% of the population is over the age of 65, 13.5% of residents under the age of 65 have a disability, and in 8.3% of homes a language other than English is spoken. All of these factors may contribute to a community's ability to communicate information effectively and respond to and recover from hazards efficiently.

Figure 6-10 demonstrates the expected annual loss. Eight percent of the County is classified as very high expected annual loss. The areas classified as a very high risk are near Centralia and Chehalis and encompass over 19 acres. Within those 19 acres reside 10.4% of the County's population. 61.2% of the County is classified as having a relatively high risk and encompasses 1,492 acres. Most of the land mass classified as relatively high is in the eastern portion of the County. 52.8% of the population is classified as residing in relatively high-risk areas.

After dividing the social vulnerability score by community resilience and then multiplying the expecting annual loss, an overall risk score was calculated. Three census tracts near Centralia and Chehalis were identified as being very high risk. These areas total 1% of the County's total land and contain 17.2% of the County's population. Areas of relatively high risk are in the eastern section of the County and the Census tracts surrounding Centralia and Chehalis and to the south along I-5. The areas identified as relatively high-risk total 61% of the County's total land and 51% of the population.

Figure 6-8. Social Vulnerability in Lewis County.

Figure 6-9. Community Resilience in Lewis County.

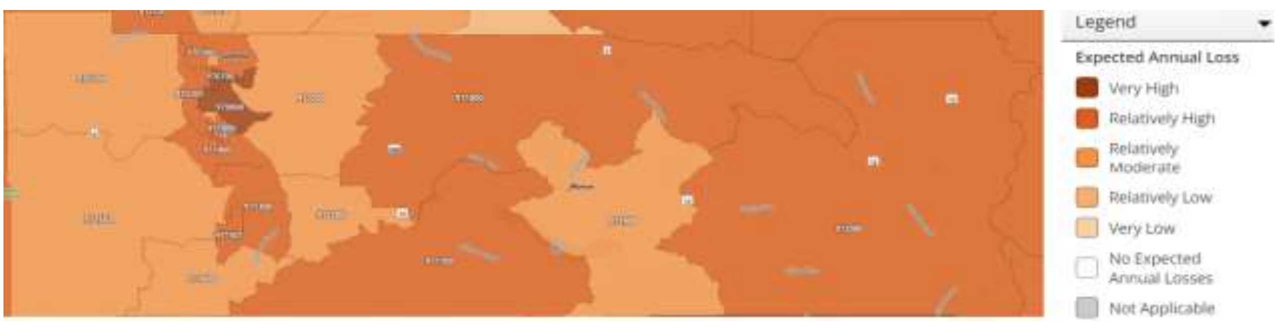


Figure 6-10. Expected Annual Loss in Lewis County, All Hazards.

Lewis County Hazard Mitigation Plan Update Volume 1: Planning-Area-Wide Elements

PART 2 – NATURAL HAZARD PROFILES

CHAPTER 7. AVALANCHE

7.1 General Background

7.1.1 Causes

An avalanche occurs when a layer of snow loses its grip on a slope and slides downhill. The primary factors that contribute to an avalanche formation may include snowpack conditions, snowfall and precipitation, temperature and weather changes, slope steepness, human activities, and natural triggers. The structure and stability of the snowpack plays a vital role; when the snowpack develops weak layers, it becomes prone to instability, increasing the likelihood of avalanches. Temperature and weather changes can contribute to the weakening of the snowpack, such as sudden warming after a cold period. In addition, rain on snow can destabilize the snowpack, creating weak layers. In addition, avalanches are more likely to occur on slopes with steeper gradients. Skiers, snowboarders, snowmobilers, and other backcountry recreationists can trigger avalanches by adding additional stress on the snowpack. Not only can human trigger avalanches but so can natural triggers such as rock falls.

Avalanches have killed more than 190 people in the past century in Washington State, exceeding deaths from any other natural hazard (Washington State Emergency Management Division Hazard Mitigation Plan, October 2013). Avalanches kill one to two people, on average, every year in Washington, although many more are involved in avalanche accidents that do not result in fatalities. Most current avalanche victims are participating in recreational activities in the backcountry where there is no avalanche control. Only one-tenth of one percent of avalanche fatalities occurs on open runs at ski areas or on highways.

Avalanches occur in four mountain ranges in the state – the Cascade Range, which divides the state east and west, the Olympic Mountains in northwest Washington, the Blue Mountains in southeast Washington, and the Selkirk Mountains in northeast Washington.

The avalanche season begins in November and continues until early summer for all mountain areas of the state. In the high alpine areas of the Cascades and Olympics, the avalanche season continues year-round.

7.1.2 Types

There are several types of avalanches. The avalanche type is determined by the physical attributes, formation environments, and travel. Some avalanches can be two or more types. See Figure 7-1 for type of avalanches that may occur.

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. Loose avalanches can be wet or dry, depending on the weather

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 produced through 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.

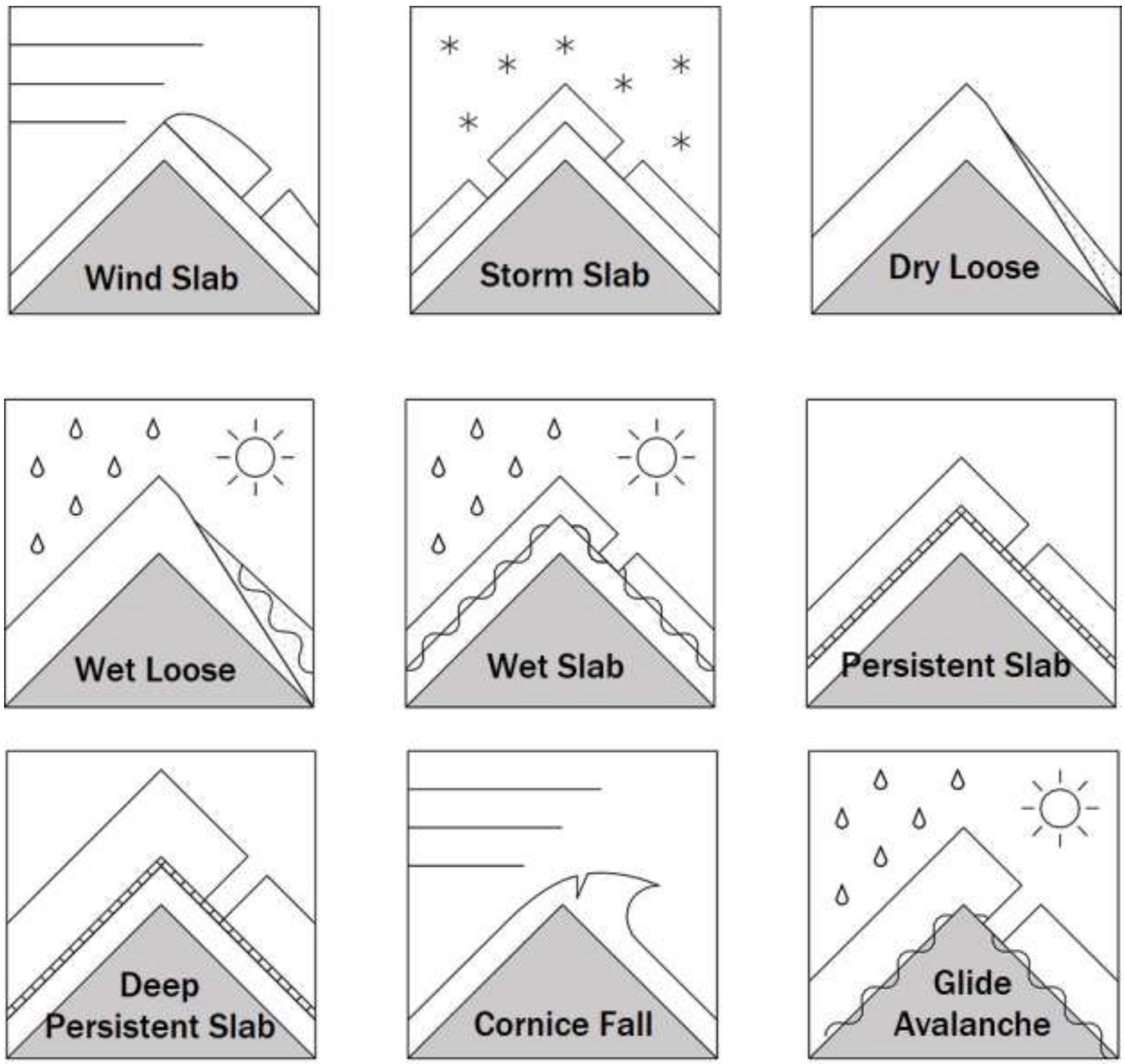


Figure 7-1. Avalanche Types.

7.1.3 Zones

Avalanche paths contain three major zones: starting zone, track zone, and run-out zone. Figure 7-2 demonstrates the avalanche paths. Avalanches can grow to speeds of 200 mph and are strong enough to cause severe damage to structures, even uprooting them.

1. Starting Zone--Top of a ridge, bowl, or canyon, with steep slopes of 25 to 50 degrees.
2. Track Zone-- Mild slopes of 15 to 30 degrees. This is the area where the avalanche will reach its maximum velocity and mass.
3. Run-Out Zone—Slopes of 5 to 15 degrees at the base of the path, where the avalanche will decelerate, and massive snow/debris deposition occurs.

Figure 7-2. Avalanche Paths.

7.2 Hazard Profile

7.2.1 Past Events

Avalanches occur every year in Lewis County. However, most avalanches are insignificant due to no impact to people or the built-environment. In 2022, a week of heavy rain and snow caused widespread flooding and avalanches in western Washington. During this time, a 20-mile stretch of Interstate 5 in Lewis County was closed due to flooding (New York Post, 2022). In addition, in 2022 a weather system caused US Route 12 White Pass to close due to high avalanche danger (KIRO 7, 2022). In 2016, a back-county skier died in an avalanche west of White Pass ski area, located at the summit of White Pass that connects Lewis County on the west and Yakima County on the east, while skiing out of the designated boundaries of the ski area.

7.2.2 Location

The eastern portion of Lewis County has areas that may be impacted by avalanches. Major highways including US Route 12 White Pass and State Routes 410 Chinook Pass and 123 Cayuse Pass can experience closure due to avalanches during the winter months. With better equipment allowing more people to explore further into the wilderness skiers, snowshoers, snowboarders, climbers, and snowmobilers are able to access back country areas outside developed ski resorts that have a higher risk of avalanche. Figure 7-3 shows avalanche hazard areas in Washington. Avalanche season can extend from November to early summer in alpine areas.

The only areas with high risk of avalanche in Lewis County are the unincorporated areas. There have been no reported instances of avalanche in any of the participating jurisdictions, and it is unlikely that an avalanche event would occur in the future, due to the nature of avalanches and where they are generally located.

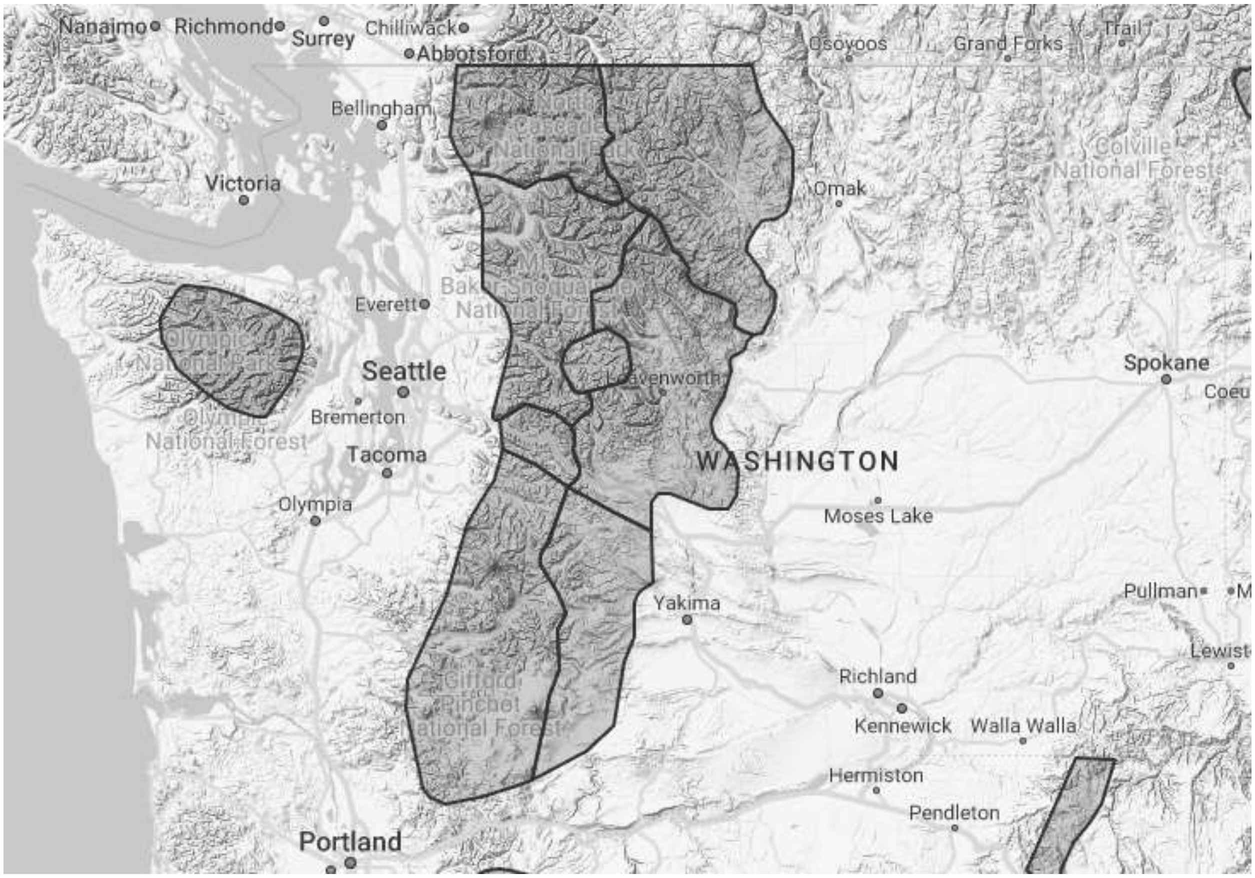


Figure 7-3. Avalanche Risk Areas in Washington State.

7.2.3 Severity

Avalanche severity depends on snowpack conditions and terrain. 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.

7.2.4 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 warnings 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 snowpack, which can change rapidly during a day and particularly during rainfall. Winter sports can also cause avalanches. However, despite forecasts, an avalanche can occur with little or no warning time, making them particularly deadly.

7.3 Probability

7.3.1 Future Events

Although avalanches occur annually, the probability of a significant avalanche occurring is dependent on snowpack, climate, seasonal conditions, and the presence of vulnerable assets. Predicating the probability of avalanches occurring in the future involves monitoring weather conditions and analyzing snowpack characteristics and terrain. Assessing avalanche likelihood and raising public awareness about avalanche safety is essential to minimize the impacts of any future events. Avalanche predicating is inherently uncertain; therefore, safety precautions, proper training, and reliable information are of the upmost importance when entering avalanche-prone regions.

7.3.2 Climate Change Impacts

Climate change can impact avalanche conditions by altering snowpack conditions. According to the UW Climate Mapping for a Resilient Washington, areas in eastern Lewis County can expect a reduced snowpack of -68% in the next 30 years. A shallower snowpack may cause smaller avalanches because there is less snow to displace, however, the snowpack may be more sensitive to triggers such as human activities or a natural event, such as rapid temperature change. This potential change in snowpack may decrease the volume of avalanches but increase the frequency.

Rising temperatures and changing precipitation patterns are altering the stability of snowpack and increasing the frequency and severity of avalanches in many parts of the world. Rising temperatures can cause snow to melt earlier in the season, resulting in a thinner and weaker snowpack. This can make it more prone to collapsing, which can trigger an avalanche. In addition, warmer temperatures can cause snow to melt and refreeze, creating a weak layer in the snowpack that can increase the likelihood of avalanches. Climate change can also impact the frequency of avalanches by altering weather patterns. For example, midwinter rains can cause slick ice layers, which can destabilize the snowpack (Scientific American, 2021). With heavier and more intense snowfall from climate change, the risk of avalanches increases.

7.3.3 Future Trends in Development

At this time, no significant future development is anticipated in the mountainous areas along White Pass that are known to be avalanche prone. Most of the avalanche prone areas are public lands that is protected from development. Therefore, the probability, vulnerability, or impacts of a significant avalanche is not anticipated to increase due to changes in land use, development, and population.

7.4 Vulnerability and Impacts

7.4.1 People

The overall direct vulnerability and impact to human life is extremely low. People who are in avalanche risk areas are the most vulnerable assets. With the increased interest in the pursuit of backcountry recreational activities such as skiing, snowshoeing, and snowmobiling, more people may become vulnerable to avalanche and maybe impacted by potential of loss of life or serious injuries may increase. People recreating in avalanche risk areas can reduce impacts by carrying avalanche beacons, airbags, and other devices which can increase the survivability if they are caught in an avalanche.

In addition, first responders to an avalanche scenario may face secondary avalanches in the response area causing injury or death or reducing their ability to respond. This risk increases when people chose to recreate during the time of year when rapid warming follows heavy, wet snowfall. Additional vulnerability occurs to people travelling on roads in areas with an avalanche risk.

Using the National Risk Index, three census tracts in Lewis County were identified as relatively high-risk for avalanche. The areas are in eastern Lewis County and total 1,383.56 square miles, roughly 57% of the total County land. However, these areas in eastern county are not densely populated; only roughly 15.3% of the population (12,568) reside in the areas designated as high-risk index. The western portion of Lewis County has no identified avalanche risk. Table 7-1 provides a breakdown of the risk factor for avalanche in Lewis County. See section 5.9 for a detailed description of the components of the NRI.

Table 7-1. NRI Scoring for Avalanche in Lewis County.

Expected Annual Loss	Social Vulnerability	Community Resilience	Community Risk Factor	Risk Value	Risk Index Score
$1,632,740	Relatively High	Relatively Moderate	1.34	$638,015	93.8

7.4.2 Structures

There are no specific structures identified as being exposed or vulnerable to avalanche. Most areas in Lewis County that experience avalanches are undeveloped, except for roads. However, any structure within an avalanche area is at risk of being damaged. For example, and avalanche could move a building off its foundation. In addition, the accumulation of snow and debris on a roof or against the walls of a structure during an avalanche could overload its structural capacity, causing roof collapse or wall damage.

7.4.3 Critical Facilities and Systems

Mountain highways, such as White Pass US 12 and State Route 410 and 123, are vulnerable to avalanches. Utilities located along these routes or in other avalanche risk areas are also vulnerable to damage.

Infrastructure and systems may be damaged or temporarily impacted by an avalanche. There is a potential for infrastructure damage to the at-risk highways. The likelihood of road damage is minimized because the roads have been designed and built to withstand extreme weather conditions. However, an avalanche occurring along the highway has the potential to block the roadway and delay travel and emergency response.

7.4.4 Natural, Historic, Cultural Resources, and Valued Activities

Avalanches occur in mountainous areas with natural resources, which may include vegetation, wildlife habitat, and waterways. Historic and cultural resources that are vulnerable to avalanche may include historic buildings and archaeological sites. However, since avalanche risk in Lewis County is isolated to high mountain areas, this vulnerability is greatly reduced. There are no known historic buildings within high-risk areas for avalanche.

Avalanches are a natural event, but they can negatively affect the environment. Avalanches can uproot trees, destroy vegetation, and disrupt ecosystems. Large avalanches may lead to habitat loss for wildlife. 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. In addition, avalanches have the possibility to impact waterways through soil erosion and the altering of stream or river flow. The massive redistribution of snow can cause a flash flood, impacting surrounding areas and waterbodies (All Tracks Academy). Avalanches can bury or damage archaeological sites, potentially erasing important historic information. Furthermore, avalanches can impact a community's ability to access cultural amenities during the winter.

Activities of value to communities in avalanche prone areas are vulnerable to avalanche due to their potential to disrupt various aspects of community life. These activities, such as tourism, outdoor recreation, transportation, and emergency services are impacted after an avalanche. They face risks of closures, damages, and economic setbacks when avalanches occur. Community efforts, including avalanche forecasting and mitigation measures are critical to minimize the vulnerability of these valued activities.

7.5 Secondary Hazards

Avalanches can cause blocked roads, which can isolate residents and businesses and delay commercial, public, and private transportation and make it challenging for emergency services to reach affected areas. Other potential problems resulting from avalanches are power and communication failures. Avalanches also can damage or block rivers or streams, potentially causing temporary dams and flash flooding, or harming water quality, fisheries, and spawning habitat.

7.6 Scenario

In a worst-case scenario, an avalanche would occur in the Cascade Mountains along White Pass after a series of storms. The avalanche may cause serious injury or loss of life and would shut down travel along White Pass, leading to a delay in shipping goods, limiting access, and potentially blocking travelers. 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.

7.7 Issues

Avalanches pose a threat to recreational users and property and can disrupt the east-west transportation network. Land managers, such as the state, US Forest Service, or ski resort operators, posts warning signs and beacon test stations in key locations warning recreation users of avalanche dangers, and resources are available that track avalanche risk. New technology allows individual users to reduce their risk if they trigger an avalanche, such as avalanche beacons and avalanche airbag packs. 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 back country. 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 the internet and cell phone apps.

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.

CHAPTER 8. DAM OR LEVEE FAILURE

8.1 General Background

8.1.1 Dams

Dam failures in the United States typically occur in one of four ways:

1. Overtopping of the primary dam structure, which accounts for 34 percent of all dam failures, can occur due to inadequate spillway design, settlement of the dam crest, blockage of spillways, and other factors.
2. Foundation defects due to differential settlement, slides, slope instability, uplift pressures, and foundation seepage can also cause dam failure. These account for 30 percent of all dam failures.
3. Failure due to piping and seepage accounts for 20 percent of all failures. These are caused by internal erosion due to piping and seepage, erosion along hydraulic structures such as spillways, erosion due to animal burrows, and cracks in the dam structure.
4. Failure due to problems with conduits and valves, typically caused by the piping of embankment material into conduits through joints or cracks, constitutes 10 percent of all failures.

The remaining six percent of US dam failures are due to miscellaneous causes (USACE, 2022). Many dam failures in the United States have been secondary results of other disasters. The prominent causes are earthquakes, landslides, extreme storms, massive snowmelt, equipment malfunction, structural damage, foundation failures, and sabotage. The most likely disaster-related causes of dam failure in Lewis County are flood and sabotage. Presently, Lewis County has 53 dams.

Poor construction, lack of maintenance and repair, and deficient operational procedures are preventable or correctable by a program of regular inspections. Terrorism and vandalism are serious concerns that all operators of public facilities must plan for; these threats are under continuous review by public safety agencies.

8.1.2 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

DEFINITIONS

Dam— An artificial barrier that has the ability to impound water, wastewater, or any liquid-borne material, for the purpose of storage or control of water.

Dam Failure—An uncontrolled release of impounded water due to structural deficiencies in dam.

Emergency Action Plan—A document that identifies potential emergency conditions at a dam and specifies actions to be followed to minimize property damage and loss of life. The plan specifies actions the dam owner should take to alleviate problems at a dam. It contains procedures and information to assist the dam owner in issuing early warning and notification messages to responsible downstream emergency management authorities of the emergency situation. It also contains inundation maps to show emergency management authorities the critical areas for action in case of an emergency. (FEMA 64)

High Hazard Dam—Dams where failure or operational error will probably cause loss of human life. (FEMA 333)

Significant Hazard Dam—Dams where failure or operational error will result in no probable loss of human life but can cause economic loss, environmental damage or disruption of lifeline facilities, or can impact other concerns. Significant hazard dams are often located in rural or agricultural areas but could be located in areas with population and significant infrastructure. (FEMA 333)

High Hazard Potential Dams— Dams must meet one of the following criteria: Downstream flooding would likely result in the loss of human life or downstream flooding would likely results in the disruption of access to critical facilities, damage to public and private facilities, and require difficult mitigation efforts. To be eligible for HHPD grants, a state must have an existing state/territory dam safety program and a FEMA approved hazard mitigation plan that includes dam risk.

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.

Even with a well-maintained levee, there is still a residual flood risk. 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.

8.1.3 Regulatory Oversight

Washington Department of Ecology Dam Safety Guidelines
Under Washington State law, the Department of Ecology (Ecology) is responsible for regulating dams that capture and store at least 10 acre-feet (about 3.2 million gallons) of water or watery materials such as mine tailings, sewage, and manure waste. The Department currently regulates nearly 1,157 water storage dams throughout the state. All statutory sized dams must be inspected by the Department. However, according to the Department of Ecology, with the current dam safety staffing, it is anticipated that high hazard dam inspections will occur on a 6-year cycle, while inspections on significant hazard dams will occur on a 12-year cycle. These inspection periods are longer than what federal dam safety guidelines recommend.

The first dam safety law in Washington was passed as part of the state water code in 1917 (RCW 90.03.350) This law required that engineering plans for any dam that could impound 10 or more acre-feet had to be reviewed and approved by the state before construction could begin. Over the years, the Department of Conservation and Development, then the Department of Water Resources performed this function. In 1970, responsibility transferred to the new Department of Ecology.

In Washington, besides regulating dams that meet the NID requirements, there are over 370 dams which do not meet one of the four criteria above but do fall under the 10 acre-foot jurisdictional level. Ecology’s Dam Safety Office currently oversees 996 of the 1,125 dams across the state. Through plan reviews and construction inspections, the agency helps ensure these facilities are properly designed and constructed. To reasonably secure the safety of human life and property, Ecology also conducts inspections of existing dams to assure proper operation and maintenance. The ages of dams in Washington vary from 11 dams constructed pre-1900, to more than 50 dams being completed since 2000. The age of a dam is also a factor in the stability, as many dams are constructed for a specified number of years, as well as the integrity of the materials used to construct the dam may deteriorate over time.

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

Federal Energy Regulatory Commission Dam Safety Program
The Federal Energy Regulatory Commission (FERC) has the largest dam safety program in the United

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

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

Every five years, an independent consulting engineer, approved by the FERC, must inspect and evaluate projects with dams higher than 32.8 feet, or with a total storage capacity of more than 2,000 acre-feet. FERC staff monitors and evaluates seismic research in geographic areas where there are concerns about seismic activity. This information is applied in investigating and performing structural analyses of hydroelectric projects in these areas. FERC staff also evaluates the effects of potential and actual large floods on the safety of dams. During and following floods, FERC staff visits dams and licensed projects, determines the extent of damage, if any, and directs any necessary studies or remedial measures the licensee must undertake. The FERC publication *Engineering Guidelines for the Evaluation of Hydropower Projects* guides the FERC engineering staff and licensees in evaluating dam safety. The publication is frequently revised to reflect current information and methodologies.

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

US Army Corps of Engineers Levee Safety Program and Levee Rehabilitation Program

The USACE Levee Safety program was established to assess and manage the safety of levees across the United States. The primary goals of this program are to identify potential risks associated with levees, develop risk reduction measures, and ensure that communities protected by levees are aware of their risk. The USACE Levee Rehabilitation Program focuses on repairing, upgrading, or enhancing existing levee systems to meet modern safety standards. Both programs play a critical role in protecting communities from flooding and reducing risks associated with levees.

8.2 Hazard Profile

8.2.1 Past Events

Dams

Since 1918, 18 dam failures have occurred within Washington State, the latest occurring in 2010 in Snohomish County when a waste pond failed. The two most severe of these dam failures took the lives of 9 people total. The first incident occurred in 1932 near North Bend, when a slide caused water to back up, and the second failure happened in 1976 near Auburn when a surge in flow caused by increased discharge from Mud Mountain Dam and removal of flashboards at Diversion Dam killed two children playing in the White River.

The only historical occurrence of dam failure within the planning area was Seminary Hill Reservoir, owned by the City of Centralia, in October 1991. There was a failure along a weak rock zone in the hillside that caused a massive slide which breached a reservoir. Three million gallons of water drained from reservoir in three minutes destroying two homes and damaging many others. There was approximately three million dollars in damage.

Levee

Any community that has levees or dikes within the planning area has the chance to have the levee or dike fail. There have been 3 instances of levee failure within the Planning Area:

- Centralia/Chehalis Airport Levee – December 2007
- Cowlitz River Dike – November 2006
- Skookumchuck Dike – 1996

8.2.2 Location

Dams

According to Washington's Dam Safety Program, there are 53 Dams in Lewis County. The dams classified as hazardous dams are listed in Table 8-1. Section 8.2.4 explains the hazard category ranking system. Skookumchuck dam is located in Thurston County, but is significant for purposes of Lewis County's hazard mitigation planning because if it failed it would affect thousands of people in the City of Centralia and its Urban Growth Area.

Levees

The levees in the planning area that are a part of the National Levee Database maintained by the Army Corps of Engineers are listed in Table 8-2.

Table 8-1. Lewis County Hazardous Dams.

Dam Name	Dam Type	Purpose	Normal Storage Qty in Acre-Ft	Maximum Storage Qty in Acre-ft	Hazard Category
Mayfield Dam	Concrete Gravity, Concrete Single Arch	Hydroelectric, Recreation	133,718	178,000	1A
Mossyrock Dam	Concrete Single Arch	Flood Control and Storm Water Management, Hydroelectric, Recreation	1,326,300	1,790,000	1A
Skookumchuck Dam*	Earth Fill	Hydroelectric, Water Supply	35,000	60,000	1A
Carlisle Lake Dam	Earth Fill	Tailings	150	300	1B
Cowlitz Fall Dam	Concrete, Concrete Gravity	Hydroelectric	10,000	15,000	1C
Koppert Pond	Earth Fill	Recreation	66	96	1C
Centralia Coal Mine Dam No 3B	Earth Fill	Tailings	5,500	7,750	2D
Centralia Coal Mine No 3C East Tr	Earth Fill	Tailing	2,000	5,000	2D

Dam Name	Dam Type	Purpose	Normal Storage Qty in Acre-Ft	Maximum Storage Qty in Acre-ft	Hazard Category
Centralia Coal Mine No 3C North South Hanaford Creek	Earth Fill	Tailings	1,000	2,000	2D
Centralia Coal Mine Dam No 3C South Tr	Earth Fill	Tailings	6,000	9,6000	2D
Centralia Coal Mine Pond 46 Dam Unnamed Tr	Earth Fill	Flood Control and Storm Water Management, Water Quality	10	16	2D
Centralia Coal Mine Pond 46A Dam Unnamed Tr	Earth Fill	Flood Control and Storm Water Management, Water Quality	48	68	2D
Packwood Dam	Rock Fill, Concrete Gravity	Hydroelectric, Recreation	1,700	4,200	2D
Thode Dam	Earth Fill	Water Quality	14	24	2D
Burnt Ridge Surface Impoundment	Earth Fill	Tailings	9	10	2E
Chehalis Regional Water Reclamation Pond	Earth Fill	Water Quality	8	11	2E

*Located in Thurston County but would have significant impact on planning area

Source: Washington Department of Ecology Dam Inventory, 2020

Table 8-2. Levee Profiles.

Levee Segment Name	Length (feet)	Property Value Protected	Level of Protection (% chance of exceedance)	PL 84-99 Status
Skookumchuck	.81 mi	$181 M	.02% chance	Active
Skookumchuck River Levee	.51 mi	N/A	N/A	Not Enrolled
Salzer Creek Levee	.44 mi	$3.58 M	.02% chance	Active
Newaukum River Levee	.45 mi	$16 M	N/A	Not Enrolled
Long Road Levee	1.64 mi	$41.6 M	5% chance	Active
Chehalis-Centralia Airport Levee	2.17 mi	$49.3 M	.02% chance	Active
Chehalis River Levee	.56 mi	N/A	N/A	Not Enrolled
Elbe Levee	.47 mi	$2.2 M	N/A	Inactive

Source: Army Corps of Engineers National Levee Database, 2023

8.2.3 Severity

Dam Failure

Dam failure can be catastrophic to all life and property downstream. The Washington Dam Safety Program classifies dams and reservoirs in a three-tier hazard rating system (High, Significant, and Low) based solely on the potential consequences to downstream life and property that would result from a failure of the dam and sudden release of water (ECY, 2019). Table 8-3 describes the Army Corps of Engineers classification of hazardous dams. An alpha-numeric code is used as an index of potential consequences in the downstream valley if a dam were to fail and release the reservoir:

- **High Hazard**—A high-hazard means that if failure were to occur, the consequences likely would be a direct loss of human life and extensive property damage. All high- hazard dams must be properly designed and at all times responsibly maintained and operated. An up-to-date Emergency Action Plan is a requirement for all owners of high-hazard dams. The Department of Ecology assigns three alpha-numeric codes to the High Hazard category with the following impact considered sufficient reason for assigning the high-hazard rating:

- 1A = Greater than 300 lives at risk;
- 1B = From 31-300 lives at risk;
- 1C = From 7 to 30 lives at risk.

As of 2020, Lewis County has 2 dams rated as 1A, 1 dam rated as 1B, and 2 dams rated as 1C. See Table 8-1.

- **Significant Hazard**—Significant hazard dams are those whose failure would result in significant risk. The alpha-numeric code assigned to this hazard class is:
  - 2 or 2D = From 1 to 6 lives at risk;
  - 2E = no lives at risk, but significant economic and/or environmental risk.

  As of 2020, Lewis County has 8 dams rated as 2D and 2 dams rated as 2E. See Table 8-1.

- **Low Hazard**—Low hazard dams typically are located in sparsely populated areas that would be largely unaffected by a breach of the dam. Although the dam and appurtenant works may be totally destroyed, damages to downstream property would be restricted to undeveloped land with minimal impacts to existing infrastructure. The Department of Ecology assigns the alpha-numeric hazard rating of:
  - 3 = No lives at risk.

High Hazard Potential Dams

The State's Dam Safety Office also classifies dams as High Hazard Potential, which are dams that meet certain criteria and qualify for FEMA's High Hazard Potential Dam Grant program. No dams in Lewis County meet the criteria to be considered High Hazard Potential, which requires the dam to have an unacceptable risk to the public among other factors. An unacceptable risk to the public is when a dam poses a risk to downstream lives and requires remediation or risk reduction measures due to inadequate design, construction methods, lack of maintenance, or poor operations.

Levee Failure

Severity of levee failure can be rated based on the extent of damage and the impacts it has on the surrounding areas. Currently, there is not a statewide system specifically dedicated to rating levees. However, through actively being involved in flood risk management and levee safety, Lewis County can significantly reduce the probability and severity of a levee failure.

Table 8-3. Army Corps of Engineers Hazard Potential Classification.

Hazard Category[a]	Direct Loss of Life[b]	Lifeline Losses[c]	Property Losses[d]	Environmental Losses[e]
Low	None (rural location, no permanent structures for human habitation)	No disruption of services (cosmetic or rapidly repairable damage)	Private agricultural lands, equipment, and isolated buildings	Minimal incremental damage

Significant	Rural location, only transient or day-use facilities	Disruption of essential facilities and access	Major public and private facilities	Major mitigation required
High	Certain (one or more) extensive residential, commercial, or industrial development	Disruption of essential facilities and access	Extensive public and private facilities	Extensive mitigation cost or impossible to mitigate

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

Source: US Army Corps of Engineers, 1995

8.2.4 Warning Time

Dam Failure

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 for residents immediately downstream of the dam. 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 (U.S. Army Corps of Engineers, 1997). Most high hazards dams have an emergency plan that includes an estimate of the time for inundations waters to reach downstream locations, which can be used in an emergent situation.

Levee Failure

The warning time for levee failure can vary widely depending on the cause and location of the failure, as well the warning systems and procedures in place. In some cases, there may be little or no warning before a levee failure, particularly if the failure is caused by a sudden and unexpected event such as an earthquake. In addition, sometime water seeps underneath the levee, weakening the levee's overall stability, which can be hard to detect in advance (FEMA). Through utilizing monitoring systems such as sensors or gauges, early warning of potential levee failure can be detected.

8.3 Probability

8.3.1 Future Events

Dam Failure

Dam failure events are low probability and low frequency, high consequence events and often coincide with other hazard events that cause them, such as earthquakes, landslides and excessive rainfall and snowmelt. The probability of any type of dam failure is low in today's dam safety oversight environment.

However, 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.

Levees
Levee failure can have significant consequences, including property damage, loss of life, and economic impacts. However, through taking preventative measures in the design and construction process and providing regular inspection and maintenance, the risk is greatly diminished. The frequency of levee failure depends on an array of factors including location, construction quality, maintenance, and occurrence of extreme weather events.

8.3.2 Climate Change Impacts

Dams and levees 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 or levee. According to the UW Climate Mapping for a Resilient Washington, Lewis County’s percent change in the magnitude of a 2-year storm is 7%. If the hygrograph changes, it is conceivable that a dam or levee 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. Throughout the west, communities downstream of dams are already seeing increases in stream flows from earlier releases from dams.

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. Although climate change will not increase the probability of catastrophic dam failure, it may increase the probability of design failures.

Climate change can result in more frequent and intense rainfall events. Excessive rainfall can increase water levels in rivers and raise hydraulic pressure against levees. This heightened stress can weaken levee structures. In addition, recent research found that extreme weather events associated with climate change are causing cumulative structural damage to the nation’s levee system. The type of damage that is occurring due to repeated flood events is invisible to the naked eye and therefore goes unrepaired (NC State, 2021).

8.3.3 Future Trends in Development

Land use in the planning area is directed by land use plans adopted under Washington’s Growth Management Act and general planning laws specific to each jurisdiction. In general, land use changes can modify natural hydrology patterns. Increased impervious surfaces, such as roads and buildings, can lead to faster runoff, which may strain the dam’s or levee’s capacity and increase the risk of failure. As populations grow and urban development continues to expand, more communities and infrastructure are located downstream of dams or protected by levees. This will lead to an increase in the exposure of people and property to potential dam failure. In addition, population growth can drive changes in water demand and usage. These changes may modify the reservoir’s storage capacity, which can impact the dam’s stability.

Each dam has a Dam Safety Plan on file with the State and County. However, dam failure is currently not addressed as a hazard in critical areas ordinances, but flooding is. The municipal planning partners have established comprehensive policies regarding sound land use in identified flood hazard areas. Most of the areas vulnerable to the more severe impacts from dam failure intersect the mapped flood hazard areas. Flood-related policies in the general plans will help to reduce the risk associated with the dam failure hazard for all future development in the planning area.

8.4 Vulnerability

8.4.1 People

Vulnerable populations are all populations downstream from dam failures or within the levee's area of protection. Socially vulnerable populations include the very young, the elderly, and those experiencing poverty. These socially vulnerable populations are most susceptible based on many factors, including their physical and financial ability to react or respond during a hazard and the ability to be self-sustaining for prolonged periods of time after an incident because of limited ability to stockpile supplies. Vulnerable populations may also lack adequate warning from television, radio emergency warning systems, or alert and warning messages released on social media due to a lack of access to these tools caused by disparities in economic opportunity and socioeconomic status. They may be incapable of escaping the area within the allowable time frame due to mobility challenges or lack of a vehicle. The potential for loss of life is affected by the capacity and number of evacuation routes available to populations living in areas of potential inundation.

An especially vulnerable population is found among those experiencing homelessness. Not only do those experiencing homelessness face an inequitable lack of access to resources and basic needs, they also face an exceptional risk of injury due to common shelter locations. Those experiencing homelessness often set up shelter under bridges near or along waterways, presenting an exceptional threat to their lives in the event of dam failure and subsequent flooding.

Table 8-4 summarizes the planning area population exposed to dam failure using Hazus to model the effects of three dam failure scenarios:

- Skookumchuck Dam will affect the Centralia and Chehalis area
- Mossyrock and Mayfield Dams will affect communities along the Cowlitz River

Twenty-six percent of the total County population lives in at least one of the three dam failure inundation areas. In Toledo, 98.9% of the population is vulnerable to dam failure and in Mossyrock, 99.7% of the population is vulnerable.

The people most vulnerable to flooding are those that live in the 100-year floodplain below levees, which is described in Chapter 10.

See Appendix E Table 8-4 for a detailed breakdown of vulnerable population.

Table 8-4. Population Vulnerable to Dam Failure.

Jurisdiction	Estimated Population	Population Exposed	% of Population Exposed

Lewis County	**82,036**	**21,823**	**26.6%**

8.4.2 Structures

Vulnerable structures are those within the dam and levee inundation area. These properties would experience the largest, most destructive surge of water. Low-lying areas are also vulnerable since they are where the inundation waters would collect. Table 8-5 summarizes the number of structures within the planning area that are vulnerable to dam failure, including the value of the structure and contents. See Appendix E Table 8-5 for a detailed breakdown of values of structures and content. Mossyrock has the highest percentage of exposure, with 99.8% of total building value in city limits exposed to dam failure and 100% of the total value exposed in the UGA. Table 8-6 summarizes the number and types of building that are vulnerable to dam failure. See Appendix E Table 8-6 for a detailed breakdown of the number and types of vulnerable structures.

Structures vulnerable to levee failure are the same structures that are vulnerable to flooding, described in Chapter 13.

Table 8-5. Structure and Content Values Vulnerable to Dam Failure.

Jurisdiction	Value of Structure Exposed	Value of Contents Exposed	Value (Structure and Contents)	% of Total Value
Lewis County	**$3,421,991,172**	**$2,651,211,698**	**$6,073,202,870**	**28.4%**

Table 8-6. Number of Structures in Dam Inundation Area.

Jurisdiction	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Lewis County	**7,845**	**710**	**64**	**17**	**79**	**37**	**44**	**8,796**

8.4.3 Critical Facilities and Systems

A number of critical facilities and systems are vulnerable to dam failure. Table 8-7 summarizes the number of systems vulnerable to dam failure. The systems that are vulnerable to levee failure are the same as those impacted by flooding described in Chapter 10. See Appendix E Table 8-7 for a detailed breakdown of the number systems vulnerable to dam failure.

Table 8-7. Systems Vulnerable to Dam Failure.

Jurisdiction	Communications	Energy	Hazardous Material	Health & Medical	Safety & Security	Schools	Transportation	Total
Lewis County	**3**	**7**	**0**	**38**	**20**	**13**	**106**	**187**

8.4.4 Natural, Historic, Cultural Resources, and Valued Activities

Natural, historic, and cultural resources and values activities vulnerable to dam and levee failure are those located within the inundation areas. These include the natural ecosystem, cultural sites located along the rivers, and any historic structures in the area.

8.5 Impacts

8.5.1 People

Dam or levee failure can cause a wide range of impacts on people, ranging from death to destruction of their property to temporary displacement.

According to the Hazus results, 16,071 people in Lewis County are at risk of being displaced by a dam failure, with 710 requiring short-term shelter. 12,175 of those displaced are from Centralia/Centralia area as a result of the Skookumchuck Dam. Table 8-8 describes the displaced population and those requiring short-term shelter for a dam failure event. See Appendix E Table 8-8 for a detailed breakdown of the displaced population and those requiring short-term shelter for a dam failure event.

Table 8-8. Displaced Population, and Short-Term Shelter.

Jurisdiction	Displaced Population	People Requiring Short-Term Shelter
Lewis County	**16,071**	**710**

8.5.2 Structures

All structures within dam inundation or levee failure areas may be impacted by flood waters. They would experience damage similar to flooding, but with potentially more damage due to higher water levels or greater flooding extents. Properties in dam inundation zones or levee protected areas that are built to the National Flood Insurance Program (NFIP) minimum construction standards may have some level of protection against flooding, depending on the velocity and elevation of inundation water. In addition, these properties are more likely to have flood insurance, which will help the property owners to recover more quickly. Table 11-9 summarizes the estimated damage to the structures and content in the dam inundation areas in the planning area. See Appendix E Table 8-9 for a detailed breakdown of the structures and content values impacted by dam failure.

Table 8-9. Structure and Content Values Impacted by Dam Failure.

Jurisdiction	Value of Structure Exposed	Value of Contents Exposed	Value (Structure and Contents)	% of Total Value
Lewis County	**$1,025,631,532**	**$1,038,024,633**	**$2,063,656,166**	**9.6%**

8.5.3 Critical Facilities and Systems

Transportation routes are vulnerable to dam inundation and have the potential to be damaged or washed away, creating isolation issues. This includes all roads, railroads, and bridges in the path of the dam inundation. Those that will be most affected are those that are already in poor condition and would not be able to withstand a large water surge, or low-lying roads next to the rivers. Utilities such as overhead power lines, cable and phone lines could also be affected. Loss of these utilities could create additional isolation issues for the inundation areas.

Table 8-10. Systems Exposed Dam Failure.

Type of System	Number of Facilities Affected	Average % of Total Value Damaged	
		Structure	Content
Total/Average	**112**	**43.9%**	**66.7%**

8.5.4 Natural, Historic, Cultural Resources, and Valued Activities

The environment would be impacted in a number of ways in the event of dam or levee 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 Coho salmon. The inundation could cause erosion which could damage streambanks and historic and cultural sites. Table 8-11 provides the estimated tons of debris that would need to be removed after a dam failure for the planning area. See Appendix E Table 8-11 for a detailed breakdown of the estimated tons of debris due to dam failure for each jurisdiction.

Table 8-11. Estimate Tons of Debris Due to Dam Failure.

Jurisdiction	Debris (tons)
Lewis County	**201,266**

8.6 Secondary Hazards

Dam failure and levee failure can cause severe 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 rivers, and destruction of downstream habitat. In addition, the floodwaters from a dam or levee failure can carry debris, such as tress, rocks, and other materials which can cause damage to homes and infrastructure downstream.

8.7 Scenario

An earthquake in the region could lead to liquefaction of soils around a dam or levee. 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 or levee that impacts the planning area. While the probability of dam or levee 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 and levee designs are developed based on hydrographs with historical record. If these hydrographs experience significant changes over time due to the impacts of climate change, the design and operations may no longer be valid for the changed condition. This could have significant impacts on dams and levees 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, thus increasing the probability and severity of flooding.

8.8 Issues

The most significant issue associated with dam or levee failure involves the properties and populations in the inundation zones. Flooding as a result of a dam or levee failure would significantly impact these areas. There is often limited warning time for dam or levee failure. These 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 or levee failure hazards include the following:

- Federally regulated dams have an adequate level of oversight and sophistication in the development of emergency action plans for public notification in the unlikely event of failure. However, the protocol for notification of downstream citizens of imminent failure needs to be tied to local emergency response planning.
- Mapping for federally regulated dams is already required and available; however, mapping for non-federal-regulated dams that estimates inundation depths is needed to better assess the risk associated with dam failure from these facilities.
- Most dam failure mapping required at 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 illustrate areas potentially impacted by more frequent events to support emergency response and preparedness.
- The concept of residual risk associated with structural flood control projects should be considered in the design of capital projects and the application of land use regulations.
- Addressing security concerns and the need to inform the public of the risk associated with dam failure is a challenge for public officials.
- Increased precipitation due to climate change could reduce the level of protection of levees.

CHAPTER 9. EARTHQUAKE

9.1 General Background

9.1.1 How Earthquakes Happen

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.

Earthquake—The shaking of the ground caused by an abrupt shift of rock along a fracture in the earth or a contact zone between tectonic plates.

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

Fault—A fracture in the earth's crust along which two blocks of the crust have slipped with respect to each other.

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

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

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.

Earthquakes in the Pacific Northwest have been studied extensively. It is generally agreed that three source zones exist for Pacific Northwest quakes: a shallow (crustal) zone; the Cascadia Subduction Zone; and a deep, intraplate "Benioff" zone. These are shown on Figure 9-1. More than 90 percent of Pacific Northwest earthquakes occur along the boundary between the Juan de Fuca plate and the North American plate.

Geologists classify faults by their relative hazards. Active faults, which represent the highest hazard, are those that have ruptured to the ground surface during the Holocene period (about the last 11,000 years). Potentially active faults are those that displaced layers of rock from the Quaternary period (the last 1,800,000 years). Determining if a fault is "active" or "potentially active" depends on geologic evidence, which may not be available for every fault. Although there are probably still some unrecognized active faults, nearly all the movement between the two plates, and therefore the majority of the seismic hazards, are on the well-known active faults.

Faults are more likely to have earthquakes on them if they have more rapid rates of movement, have had recent earthquakes along them, experience greater total displacements, and are aligned so that movement can relieve accumulating tectonic stresses. A direct relationship exists between a fault's length and location and its ability to generate damaging ground motion at a given site. In some areas, smaller, local faults produce lower magnitude quakes, but ground shaking can be strong, and damage can be significant as a result of the fault's proximity to the area. In contrast, large regional faults can generate great magnitudes but, because of their distance and depth, may result in only moderate shaking in the area.

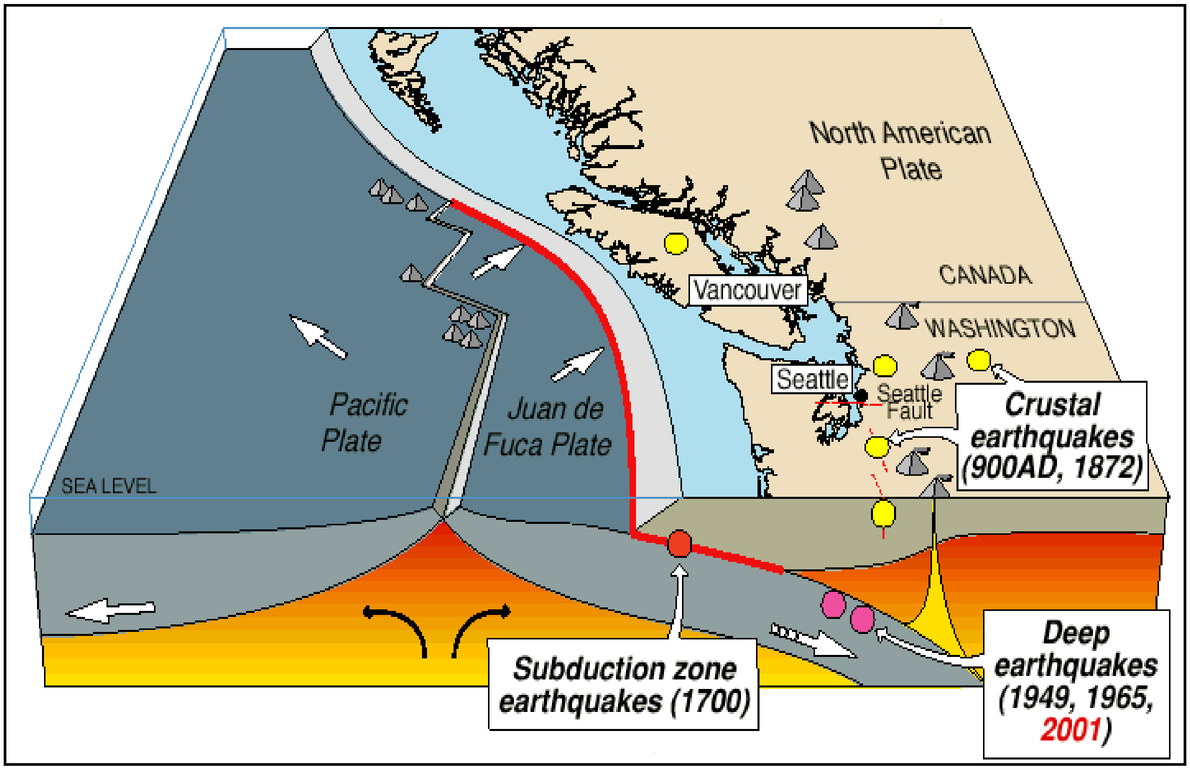


Figure 9-1. Earthquake Zones and History in the Pacific Northwest.

9.1.2 Types of Earthquakes

Earthquakes are classified according to the amount of energy released as measured by magnitude or intensity scales. Currently the most commonly used scales are the moment magnitude (Mw) scale, and the modified Mercalli intensity scale. 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. Table 9-1 presents a classification of earthquakes according to their magnitude.

Table 9-1. Magnitude Class.

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

Table 9-2 compares the moment magnitude scale to the modified Mercalli intensity scale.

Table 9-2. Earthquake Magnitude and Intensity.

Magnitude (Mw)	Intensity (Modified Mercalli)	Description
1.0 – 3.0	I	1. Not felt except by a very few under especially favorable conditions
3.0 – 3.9	II – III	2. Felt only by a few persons at rest, especially on upper floors of buildings. 3. Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
4.0 – 4.9	IV – V	4. Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like a heavy truck striking building. Standing cars rocked noticeably. 5. Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
5.0 – 5.9	VI – VII	6. Felt by all; many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight. 7. Damage negligible in buildings of good design and construction; slight in well-build ordinary structures; considerable in poorly built or badly designed structures. Some chimneys broken.
6.0 – 6.9	VII – IX	8. Damage slight in specially designed structures; considerable damage in ordinary buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. 9. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
7.0 and higher	X – XII	10. Some well-build wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent. 11. Few, if any masonry structures remain standing. Bridges destroyed. Rails bent greatly. 12. Damage total. Lines of sight and level are distorted. Objects thrown into the air.

9.1.3 Ground Motion

Earthquake hazard assessment is also based on expected ground motion. This involves determining the annual probability that certain ground motion accelerations will be exceeded, then summing the annual probabilities over the time period of interest. The most commonly mapped ground motion parameters are the horizontal and vertical peak ground accelerations (PGA) for a given soil or rock type. Instruments called accelerographs record levels of ground motion due to earthquakes at stations throughout a region. These readings are recorded by state and federal agencies that monitor and predict seismic activity.

Maps of PGA values form the basis of seismic zone maps that are included in building codes such as the International Building Code. Building codes that include seismic provisions specify the horizontal force due to lateral acceleration that a building should be able to withstand during an earthquake. PGA values are directly related to these lateral forces that could damage "short period structures" (e.g. single-family dwellings). Longer period response components determine the lateral forces that damage larger structures with longer natural periods (apartment buildings, factories, high-rises, bridges). Table 9-3 lists damage potential by PGA factors compared to the Mercalli scale.

Table 9-3. Mercalli Scale and Peak Ground Acceleration Comparison.

Mercalli Scale	Potential Damage	Estimated PGA
I	None	0.017
II-III	None	0.017
IV	None	0.014-0.039
V	Very Light	0.039-0.092
VI	None to Slight; USGS-Light	0.02-0.05
	Unreinforced Masonry-Stair Step Cracks; Damage to Chimneys; Threshold of Damage	0.04-0.08
		0.06-0.07
		0.06-0.13
		0.092-0.18
VII	Slight-Moderate; USGS-Moderate	0.05-0.10
	Unreinforced Masonry-Significant; Cracking of parapets	0.08-0.16
		0.10-0.15
	Masonry may fail; Threshold of Structural Damage	0.1
		0.18-0.34
VIII	Moderate-Extensive; USGS: Moderate-Heavy	0.10-0.20
	Unreinforced Masonry-Extensive Cracking; fall of parapets and gable ends	0.16-0.32
		0.25-0.30
		0.13-0.25
		0.2
		0.35-0.65
IX	Extensive-Complete; USGS-Heavy	0.20-0.50
	Structural collapse of some un-reinforced masonry buildings; walls out of plane. Damage to seismically designed structures	0.32-0.55
		0.50-0.55
		0.26-0.44
		0.3
		0.65-1.24
X	Complete ground failures; USGS- Very Heavy (X+); Structural collapse of most un-reinforced masonry buildings; notable damage to seismically designed structures; ground failure	0.50-1.00

9.1.4 Effect of Soil Types

The impact of an earthquake on structures and infrastructure is largely a function of ground shaking, distance from the source of the quake, and liquefaction, a secondary effect of an earthquake in which soils lose their shear strength and flow or behave as liquid, thereby damaging structures that derive their support from the soil. Liquefaction generally occurs in soft, unconsolidated sedimentary soils. A program called the National Earthquake Hazard Reduction Program (NEHRP) creates maps based on soil characteristics to help identify locations subject to liquefaction. Table 9-4 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 most commonly affected by ground shaking have NEHRP Soils D, E, and F. In general, these areas are also most susceptible to liquefaction.

Table 9-4. 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)	

9.2 Hazard Profile

Earthquakes can last from a few seconds to over five minutes; they may also occur as a series of tremors over several days. The actual movement of the ground in an earthquake is seldom the direct cause of injury or death. Casualties generally result from falling objects and debris, because the shocks shake, damage or demolish buildings and other structures. Disruption of communications, electrical power supplies and gas, sewer and water lines should be expected. Earthquakes may trigger fires, dam failures, landslides, or releases of hazardous material, compounding their disastrous effects.

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

For the purposes of this plan four earthquake scenarios were analyzed utilizing Hazus. The four scenarios include Cascadia M9.34, Mount St. Helens M7.0, Nisqually M7.2 and the 100-year probabilistic.

9.2.1 Past Events

Lewis County is located in a seismically active region in the Pacific Northwest. The largest historic earthquake in Lewis County was the 1949 earthquake in the Puget Sound. The earthquake had an estimated magnitude of 7.1 and resulted in 8 fatalities.

Table 9-5. lists past seismic events that have either occurred in the planning area or have in some manner impacted the region. The events listed are earthquakes that have reached a magnitude of 3.0 or above.

Table 9-5. Historical Earthquakes Impacting the Planning Area (Over M3).

Date	Location of the Epicenter	Magnitude
September 11, 2020	Centralia, WA	3.1
December 1, 2019	Goat Rocks, WA	3.4
January 3, 2018	Mt. St. Helens	3.8
March 14, 2017	Morton	3.2
December 9, 2016	Mt. St. Helens	3.3
October 28, 2015	Morton	3.3
September 3, 2015	Mt. St. Helens	3.1

Date	Location of the Epicenter	Magnitude
February 18, 2015	Ellensburg, WA	4.3
June 26, 2013	Wenatchee Area, WA	4.3
February 14, 2011	Spirit Lake, WA (Mt. St. Helens)	4.3
November 16, 2010	Mossyrock Area, WA	4.2
January 30, 2009	Seattle-Tacoma Urban Area	4.5
June 20, 2003	Carnation, WA	3.6
May 30, 2003	Port Orchard, WA	3.7
September 21, 2002	Friday Harbor, WA	4.1
June 16, 2002	Kitsap Peninsula, WA	3.7
February 28, 2001	Nisqually, WA	6.8
May 18, 1980	Mount St. Helens, WA	5.0
April 29, 1965	Puget Sound, WA – Fatalities 7	6.5
April 13, 1949	Puget Sound, WA – Fatalities 8	7.1

Source: PNSN, 2022

9.2.2 Location

Earthquakes can occur anywhere, at any time, and without warning. The entire planning area could experience an earthquake at any time. The majority of earthquakes are not associated with known faults; therefore, they are very unpredictable. Past geological studies indicate areas prone to earthquakes may experience long periods of inactivity. Identifying the extent and location of an earthquake is not as simple as it is for other hazards such as flood, landslide, or wildfire. The impact of an earthquake is largely a function of the following components:

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

Mapping shows the impacts of these components assesses the risk of earthquakes within the planning area. While the impacts from each of these components can build upon each other during an earthquake event, the mapping looks at each component individually. This assessment includes shake maps, soil maps, and liquefaction maps.

9.2.3 Frequency

More than 1,000 earthquakes are recorded in the state annually. A dozen or more earthquakes cause shaking and occasional damage. While most of the state's earthquakes occur in Western Washington, Washington State's largest earthquakes occurred east of the Cascade Crest in 1872. Lewis County's location on the western side of Washington increases the probability of frequent earthquakes. According to the Pacific Northwest Seismic Network, there have been more than 100 earthquakes in Lewis County since 1970, ranging from less than 1.0 to 4.5.

9.2.4 Severity

The severity of an earthquake can be expressed in terms of intensity or magnitude. Intensity represents the observed effects of ground shaking on people, buildings, and natural features. The USGS has created ground motion maps based on current information about several fault zones. These maps show the PGA that has a certain probability (2 percent or 10 percent) of being exceeded in a 50-year period. The PGA is measured in numbers of g's (the acceleration associated with gravity). Figure 9-2 shows the PGAs with a 2-percent exceedance chance in 50 years in Washington. Magnitude is related to the amount of seismic energy released at the hypocenter of an earthquake. It is determined by the amplitude of the earthquake waves recorded on instruments. Whereas intensity varies depending on location with respect to the earthquake epicenter, magnitude is represented by a single, instrumentally determined value for each earthquake event.

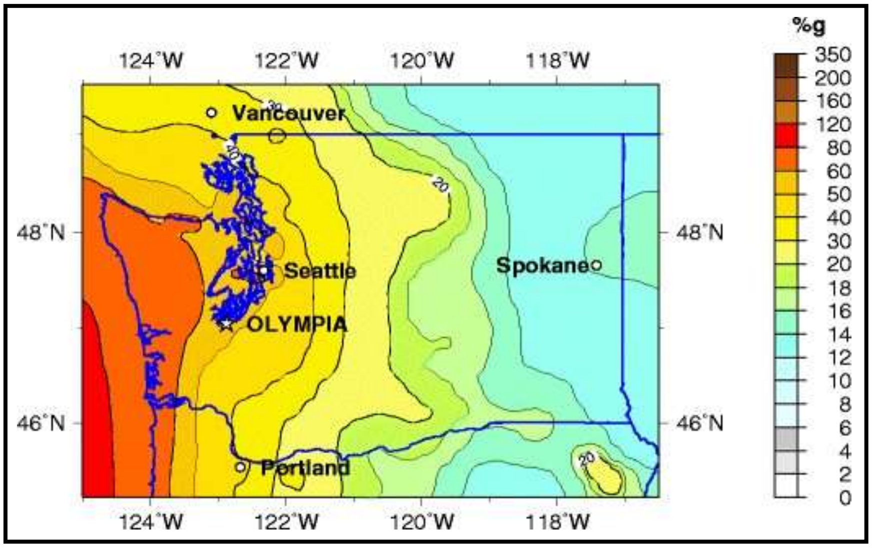


Figure 9-2. PGA with 2-Percent Probability of Exceedance in 50 Years, Northwest Region.

In simplistic terms, the severity of an earthquake event can be measured in the following terms:

- How hard did the ground shake?
- How did the ground move? (Horizontally or vertically)
- How stable was the soil?
- What is the fragility of the built environment in the area of impact?

9.2.5 Warning Time

Currently, no reliable ways exist to predict the day or month that an earthquake will occur at any given location. Research efforts are focused on warning systems that use low energy waves that precede major earthquakes, in an attempt to provide potential warning systems with approximately 40 seconds notice that a major earthquake is about to occur. In 2021, Washington State brought the ShakeAlert Earthquake Early Warning System to the state. The system is operated by the US Geological Survey in cooperation with the Pacific Northwest Seismic Network. The warning time is very short, but it could allow for someone to get under a desk, step away from a hazardous material they are working with, or shut down a computer system. The system also has the potential to automatically close water valves to protect water supplies, lift fire station doors so first responders can get vehicles and equipment out, slow down trains so they don't derail and even warn hospitals to halt surgeries, among many other capabilities. Dozens of pilot projects in Washington are already testing this technology to reduce earthquake damage.

9.3 Probability

9.3.1 Future Events

Examining historical records can help identify seismic activity in specific regions, to increase prediction capabilities of future events. In addition, through utilizes geological studies and fault maps, scientists can create seismic hazard maps, which indicate the probability of different levels of ground shaking over a specified time frame. For example, scientists have determined that the last major Cascadia earthquake happened on January 26, 1700. Based on historical records, scientists predict there is a 37% chance that another similar earthquake will occur within the next 50 years (Oregon.gov, 2023).

9.3.2 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).

In addition, climate change can lead to changes in precipitation patterns, which can in turn affect water levels in lakes, rivers, and aquifers. These changes in water level can potentially trigger earthquakes by altering the stress on fault levels. During drought, the ground may dry out and contract, increasing stress on fault lines. On the contrary, during heavy rainfall, it may increase the weight of the soil and rock on top of fault lines, which can also affect stress (NASA, 2019).

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

9.3.3 Future Trends in Development

As the population in Lewis County continues to grow, the exposure of people, infrastructure, and property to earthquake hazards will increase. Land use in the planning area will be directed by comprehensive plans adopted under Washington's Growth Management Act (GMA) which addresses geological hazard areas as one of the elements within the Critical Areas Ordinance of GMA, and the Washington State Building Council's adoption of the 2021 International Building Codes. 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.

9.4 Vulnerability

9.4.1 People

Lewis County's entire population of 82,036 is potentially vulnerable to direct and indirect impacts from earthquakes. The degree of exposure is dependent on many factors, including the age and construction type of the structures people live in, the soil types their homes are constructed on, their proximity to fault location, etc. Socially vulnerable populations include the very young, the elderly, and those experiencing poverty. These socially vulnerable populations are most susceptible based on many factors, including their physical and financial ability to react or respond during a hazard and the ability to be self-sustaining for prolonged periods of time after an incident because of limited ability to stockpile supplies. Socially vulnerable populations may live in structures that do not conform to seismic building codes; therefore, homes will sustain more damage during an event. Those experiencing homelessness are also especially vulnerable due to their lack of stable shelter and, depending on their location, may be threatened by bridge or other structural collapse.

The National Risk Index identified specific areas near Centralia and Chehalis as very high risk due to higher loss probability and social vulnerability. The areas identified as very high-risk account for 17.2% (14,167) of the County's population. Roughly 74.8% (61,435) of the population reside in areas with a relatively high earthquake risk. Table 9-6 provides a breakdown of the risk factor for earthquake in Lewis County. See section 5.9 for a detailed description of the components of the NRI.

Table 9-6. NRI Scoring for Earthquake in Lewis County

Expected Annual Loss	Social Vulnerability	Community Resilience	Community Risk Factor	Risk Value	Risk Index Score
$1,632,740	Relatively High	Relatively Moderate	1.34	$638,015	93.8

9.4.2 Structures

All structures in the planning area are vulnerable to earthquake impacts to varying degrees. There are estimated to be 36,777 buildings in the planning area, with a total structure and contents value of $21.40 billion.

9.4.3 Critical Facilities and Systems

All critical facilities and systems in Lewis County are vulnerable to the earthquake hazard.

9.4.4 Natural, Historic, Cultural Resources, and Valued Activities

All natural, historic, cultural resources, and valued activities in Lewis County are vulnerable to the earthquake hazard.

9.5 Impacts

Earthquake impact data was generated using a Level 2 Hazus-MH analysis. Once the location and size of a hypothetical earthquake are identified, Hazus-MH estimates the intensity of the ground shaking, the number of buildings damaged, the number of casualties, the damage to transportation systems and utilities, the number of people displaced from their homes, and the estimated cost of repair and clean up. Four event scenarios were modeled:

- Cascadia M9.3
- Nisqually M7.2
- Mt. St. Helens M7.0
- 100-year Probability

9.5.1 People

Whether directly or indirectly impacted, the entire population will have to deal with the consequences of earthquakes to some degree. Business interruption could keep people from working, road closures could isolate populations, and loss of functions of utilities could impact populations that suffered no direct damage from an event itself. Three population groups are particularly vulnerable to earthquake hazards and will be the most impacted:

- **Linguistically Isolated Populations**—Problems arise when there is an urgent need to inform non-English speaking residents of an earthquake event. They are vulnerable because of difficulties in understanding hazard-related information from predominantly English-speaking media and government agencies.
- **Population Below Poverty Level**—These households may lack the financial resources to improve their homes to prevent or mitigate earthquake damage. Poorer residents are also less likely to have insurance to compensate for losses in earthquakes.
- **Population Over 65 Years Old**—This population group is 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.

Impact from household displacement in the planning area was estimated for four scenario events through the Level 2 Hazus-MH analysis. bookmark159 Table 9-7 summarizes the results.

Table 9-7. Estimated Earthquake Impact on Persons and Households.

Scenario	Number of Displaced Households	Number of Persons Requiring Short-Term Shelter
100-Year Earthquake	4	3
Cascadia M9.34	19	74
Mount St. Helens M7.0	1	1
Nisqually M7.2	1	1

9.5.2 Structures

All types of property can be impacted by earthquakes, especially when larger magnitude earthquakes occur like the Cascadia M9.3 scenario. However, certain types of property may be impacted more than others. Older buildings that were constructed before modern building codes were implemented may be especially vulnerable since they were likely not designed to withstand seismic activity. In addition, buildings located along fault lines, on steep slopes, or on unstable soil may also be at greater risk of damage during an earthquake. Table 9-8 and Table 9-9 provide the estimated damage to structures and contents for each of the four earthquake scenarios for the planning area. See Appendix E Table 9-8 and 9-8 for a detailed breakdown of the estimated structure loss potential for the four earthquake scenarios in each jurisdiction.

Table 9-8. Earthquake Structure Loss Potential Cascadia M9.34 and Nisqually M7.2

Estimated Earthquake Loss Value						
	Cascadia M9.3			Nisqually M7.2		
Jurisdiction	Structural	Contents	Total	Structural	Contents	Total
Lewis County	$1,356,156,976	$557,795,765	$1,913,952,741	$417,825,545	$209,281,744	$627,107,288

Table 9-9. Earthquake Structure Loss Potential 100-Year Probabilistic and St. Helens M7.0.

Estimated Earthquake Loss Value						
	100- Year Probabilistic			St. Helens M7.0		
Jurisdiction	Structural	Contents	Total	Structural	Contents	Total
Lewis County	$73,608,895	$44,819,437	$118,428,333	$99,815,910	$55,564,613	$155,380,523

9.5.3 Critical Facilities and Systems

Hazardous materials releases can occur during an earthquake from fixed facilities or transportation-related incidents. Transportation corridors can be disrupted during an earthquake, leading to the release of materials to the surrounding environment. Facilities holding hazardous materials are of particular concern because of possible isolation of neighborhoods surrounding them. During an earthquake, structures storing these materials could rupture and leak into the surrounding area or an adjacent waterway, having a disastrous effect on the environment.

Lewis County could be severely impacted by an earthquake which effects any of its 53 dams currently listed with the Department of Ecology. Power generation could be greatly impacted by an earthquake occurring within the planning area as the potential exists for the collapse of transmission lines, or even a potential breach of the dam itself. This would have far reaching implications and could potentially impact a geographic area much greater than the focus of this plan. This would have disastrous effects on local and regional economies, and could also mean that recovery, repair, and rebuilding time for the planning area would be very lengthy. In addition, large intensity quakes could cause bridge failures, interrupt transportation routes and create accidents on rail systems.

Level of Damage
Hazus-MH classifies the vulnerability of critical facilities

to earthquake damage in five categories: no damage, slight damage, moderate damage, extensive damage, or complete damage. The model was used to assign a vulnerability category to each critical facility in the planning area except hazmat facilities and "other infrastructure" facilities, for which there are no established damage functions. The analysis was performed for Mt. St. Helens M7.0, Nisqually M7.2, Cascadia M9.3, and the 100-year event. Table 9-10 through Table 9-13 summarize critical facilities for each scenario that have a 50% or greater probability of achieving damage level. See Appendix E Table 9-10 and 9-13 for a detailed breakdown of critical facilities impacted by each scenario, including the type of critical facility.

Table 9-10. Critical Facility Impacted by Mt. St. Helens M7.0.

Category	# of Critical Facilities	Number of Building with 50% or Great Probability of Achieving Damage Level				
		No Damage	Slight Damage	Moderate Damage	Extensive Damage	Complete Damage
Total	**908**	**852**	**22**	**20**	**4**	**0**

Table 9-11. Critical Facilities Impacted by Nisqually M7.2.

Category	# of Critical Facilities	Number of Building with 50% or Great Probability of Achieving Damage Level				
		No Damage	Slight Damage	Moderate Damage	Extensive Damage	Complete Damage
Total	**908**	**765**	**112**	**20**	**1**	**0**

Table 9-12. Critical Facilities Impacted by Cascadia M9.3.

Category	# of Critical Facilities	Number of Building with 50% or Great Probability of Achieving Damage Level				
		No Damage	Slight Damage	Moderate Damage	Extensive Damage	Complete Damage
Total	**908**	**409**	**36**	**118**	**305**	**30**

Table 9-13. Critical Facilities Impacted by 100-Year Earthquake.

Category	# of Critical Facilities	Number of Building with 50% or Great Probability of Achieving Damage Level				
		No Damage	Slight Damage	Moderate Damage	Extensive Damage	Complete Damage
Total	**908**	**906**	**2**	**0**	**0**	**0**

9.5.4 Natural, Historic, Cultural Resources, and Valued Activities

Earthquakes can have wide-ranging impacts on natural, historic, and cultural resources. They can trigger landslides, alter water systems, and disrupt ecosystems, affecting natural resources. Historic buildings and landmarks are vulnerable to structural damage or collapse, especially since they were likely built before updated building codes to protect structures from damage. Mitigation efforts including earthquake resistant building designs, disaster preparedness, and conservation and restoration efforts can safeguard these valuable resources.

In addition, there are many indirect effects of earthquakes on the environment including the release of pollutants and hazardous materials from damaged buildings and infrastructure. These pollutants can have significant impact on the environment, as they can contaminate soil and water, affecting the health of plants, animals, and humans.

9.6 Secondary Hazards

Earthquakes cause large and sometimes disastrous landslides and mudslides. River valleys are vulnerable to slope failure, often because of loss of cohesion in clay-rich soils. Soil liquefaction occurs when water-saturated sands, silts or gravelly soils are shaken so violently that the individual grains lose contact with one another and float freely in the water, turning the ground into a pudding-like liquid. Building and road foundations lose load-bearing strength and may sink into what was previously solid ground. Unless properly secured, hazardous materials can be released, causing significant damage to the environment and people. Earthen dams and levees are highly susceptible to seismic events and the impacts of their eventual failures can be considered secondary risks for earthquakes.

9.7 Scenario

An earthquake does not have to occur within Lewis County to have a significant impact on the people, property, and economy of the county.

Any seismic activity of 6.0 or greater on faults within the planning area would have significant impacts throughout the county. Potential warning systems could give approximately 40 seconds notice that a major earthquake is about to occur. This would not provide adequate time for preparation. Earthquakes of this magnitude or higher would lead to massive structural failure of property on NEHRP C, D, E, and F soils. Levees and revetments built on these poor soils would likely fail, representing a loss of critical infrastructure. These events could cause secondary hazards, including landslides and mudslides that would further damage structures. River valley hydraulic-fill sediment areas are also vulnerable to slope failure, often as a result of loss of cohesion in clay-rich soils. Soil liquefaction would occur in water-saturated sands, silts, or gravelly soils.

9.8 Issues

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

- More information is needed on the exposure and performance of soft-story construction within the planning area.
- More than 40 percent of the planning area’s building stock was built prior to 1975, when seismic provisions became uniformly applied through building code applications.
- Critical facility owners should be encouraged to create or enhance Continuity of Operations Plans to use the information on risk and vulnerability contained in this plan.
- Geotechnical standards should be established that consider the probable impacts from earthquakes in the design and construction of new or enhanced facilities.
- There are a large number of dams within the planning area. Dam failure warning and evacuation plans and procedures should be reviewed and updated to reflect the dams’ risk potential associated with earthquake activity in the region.
- Earthquakes could trigger other natural hazard events such as dam failures and landslides, which could severely impact the county.
- A worst-case scenario would be the occurrence of a large seismic event during a flood or high-water event. Dam failures could happen at multiple locations, increasing the impacts of the individual events.

CHAPTER 10. FLOOD

10.1 General Background

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.

Flood – The inundation of normally dry land resulting from the overland flow of water from any source.

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

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

10.1.1 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 one-percent 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 one-percent annual probability of occurrence (the base flood or 100-year flood) is used as the regulatory boundary by many agencies. Also referred to as the special flood hazard area (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.

10.1.2 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.

10.1.3 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 if steps are taken to mitigate the activities' adverse impacts on floodplain functions.

10.1.4 Principal Types of Flooding in Lewis County

Stage flooding is the most common types of flooding that occurs in the Lewis County. Stage flooding occurs during periods of heavy rains, and flooding can last several days after a storm. Flash flooding occurs during the summer with cloudburst-type rainstorms, in the winter with extremely heavy rainfall, or when debris dams the river and suddenly bursts. Since 1880, the Chehalis River Basin within Lewis County has experienced flooding every 4.7 years on average (Lewis County, 2009b).

Stage Flooding

Stage flooding is largely the result of heavy rain events due to atmospheric rivers, and to a lesser degree to rain-on-snow events. Atmospheric rivers funnel large quantities of precipitation in a short time span (WA Ecology, 2017). The magnitude and duration of stage floods can vary significantly depending on the quantity of precipitation, where the precipitation is falling, and duration of storm events (Lewis County, 2008). Stage flooding is prevalent in the flat river valley surrounding Centralia and Chehalis, where water rises and inundates large areas of the cities and county. Areas that regularly become inundated along the mainstem Chehalis River – including backwater flooding on Coffee, China, Salzer, and Dillenbaugh Creeks – typically contain slow-moving water. Inundation by floodwaters disrupts transportation routes such as I-5, the main north south transportation route between Seattle and Portland; forces evacuation of homes and commercial establishments; and can temporarily put sewage treatment plants out of service. A main line of the Burlington Northern Railroad also crosses the floodplain from east to west on the Chehalis River near Chehalis. The tracks are subject to damage at various locations during large floods. The Chehalis-Centralia airport is protected by a dike system, but the dikes were overtopped during the January 1990 and December 2007 flood event, closing the airport (Lewis County, 2008).

Flash Flooding
Flash flooding is flooding characterized by a quick rise and fall of water level from intense rainstorms or debris dams bursting. Flooding during the 2007 flood on the Chehalis River was characterized as flash flooding due to debris that clogged the river, which released as a 4- to 18-foot wall of water that "crashed through the blockages and ripped through the valley floor (Lewis County, 2009b)."

10.2 Hazard Profile

10.2.1 Watersheds

The County includes watersheds associated with four major rivers: the Chehalis River, Cowlitz River, Deschutes River, and Nisqually River. Flooding has been a historic problem in Lewis County. Flooding and drainage problems from heavy storms can happen anywhere in Lewis County, although the major floods are caused by the overflow of the Chehalis, Cowlitz, Tilton, and Newaukum Rivers and Coal, Salzer, and Dillenbaugh Creeks. The Chehalis River valley occupies most of the western parts of the County, and the Cowlitz River valley occupies most of the central and eastern parts. A small portion of the mountainous north central part of the County contains the Nisqually and Deschutes watersheds. The uplands of the eastern County are composed of rugged mountainous and alpine topography, modified by glacial activity, and drained by rivers that flow generally westward. The landscape is characterized by long, steep slopes and relatively straight, parallel drainages.

The Chehalis River begins in southwestern Lewis County at the confluence of the West Fork and East Fork Chehalis River. The Chehalis River flows north and east, collecting a wide array of tributary streams including the Skookumchuck and Newaukum Rivers. Eventually, the Chehalis drains into Grays Harbor which empties into the Pacific Ocean. Historically, the worst flooding has occurred along the Chehalis and its tributaries. In 2009, a stretch of Interstate 5 was shut down due to the roadway being under several feet of water. Again, in 2022 the County faced severe flooding, requiring more than two dozen water rescues (King 5, 2022).

The Nisqually River forms the Pierce-Lewis County line and is approximately 81 miles long, draining into the southern end of the Puget Sound.

The Cowlitz River is a tributary of the Columbia River and is roughly 105 miles long. There are three hydroelectric dams along the river, with several small-scale hydropower and sediment retention structures. The Lewis County PUD funds the Cowlitz Falls Project which is a 70-megawatt hydroelectric dam built in the 1990s. Although there are dams along the river, they are not built to control flooding but do help mitigate high flows. Flooding is generally at its peak from October through April. Luckily, the size of the Cowlitz River causes the water to rise slowly enough to provide early warning to the community.

10.2.2 Past Events

Flooding has been a historic problem in Lewis County, particularly with the Chehalis, Nisqually, and Cowlitz Rivers. Table 10-1 summarizes presidentially declared disasters that have involved flooding. Since 1964, Lewis County has experienced 34 federally declared disasters and many more floods that did not qualify as a presidential disaster declaration. Of these 34 federally declared disasters, 25 were either caused or exacerbated by flooding.

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.

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.

These damage costs are approximate, and of primary and significant structures and businesses. Information about the damages is collected by difference agencies and does not include unreported damages. The information is further confused when initial estimates of damage are refined. This can result in higher or lower value. At best, the primary damage was erosion of public infrastructures (riverbanks, roads, bridges, and revetments). Costs for public damages are based on actual costs or cost estimates reviewed by FEMA. Private costs are based on information provided by victims, Red Cross, and FEMA, and do not include any reduction in property values.

Table 10-1. Presidential Declared Flood Disasters for Lewis County.

Date	Declaration #	Type of Event/River	Estimated Damage ($)
Dec 2021-Jan 2022	DR-4650	Skookumchuck, Chehalis, Newaukum	-
Nov 2021	DR-4635	Newaukum	-
Dec 2020- Jan 2021	DR-4593	Chehalis	-
Jan- Feb 2020	DR-4539	Chehalis	-
Dec 2015	DR-4253	Cowlitz	-
Nov 2015	DR-4249	Cowlitz	-
March 2012	DR-4056	-	-
March 2011	DR-1963	-	-
Dec 2008	DR-1817	Chehalis	-
Dec 2007	DR-1734	Chehalis	166 M
March 1997	DR-1172	Cowlitz	9.4 M
Dec 96-Jan 1997	DR-1159	Chehalis, Cowlitz	3.2 M
Feb 1996	DR-1100	Chehalis, Cowlitz	30.0 M
Nov-Dec 1995	DR-1079	Cowlitz	12.0 M

Dec 1994	DR- 981	Chehalis	40,000
Dec 1990	DR-0883	Nisqually	700,000
Nov 1990	DR-0883	Chehalis	1.0 M
Feb 1990	-	Chehalis	200,000
Jan 1990	DR-0852	Chehalis	1.4 M
Nov 1986	DR-784	Chehalis	3.9 M
Dec 1977	DR-545	Cowlitz	1.3 M
Dec 1975	DR-1079	Cowlitz	50.2 M
Jan 1974	DR-414	-	-
Jan 1972	DR-322	Chehalis	2.0 M
Jan 1971	-	Chehalis	446,570

The scope of the flood damages is related to the magnitude of the flood and location. Low-lying areas, especially river valleys, have flooded regularly for hundreds of years. Final flood damage estimates in Lewis County totaled in the hundreds of millions. FEMA estimated the damages from the 2007 floods to be around $166 million to private and public property (Lewis County Health Department, February 10, 2008; Long Term Recovery Project). The 1996 flood event was also severe. It too affected interstate travel, thus making the associated damage costs (estimated up to $100 million) one of the highest to date. The $30 million estimate given in the Table represents damage costs to public structures incurred within the County.

2007 Chehalis River Flood

The December 2007 Chehalis River Flood is the current flood of record for Lewis County. The flood was equivalent to the 500-yr flood in the upper watershed and a 100-year flood in Chehalis and Centralia area, breaking several records for peak flows. In the upper watershed near the headwaters in the Willapa Hills, stream flow was more than double the previous peak and more than 67 percent greater than the current 100-year flood estimates. The storm caused flooding records to be set at Grand Mound, Porter, Doty, and the South Fork Chehalis gaging stations. (WATERSHED, 2012)

Cause

An atmospheric river brought record rainfall to the Willapa Hills beginning December 1, 2007. Figure 10-1 shows a satellite photo of the storm system. By December 3, 2007, rainfall in the Willapa Hills reached 14-inches of rainfall in 24 hours, setting a record for 24-hour precipitation totals. The stream gage in Doty rose from three-feet to thirty-feet in seventeen hours. At one point, there was about 12-feet of flowing water over Interstate 5.

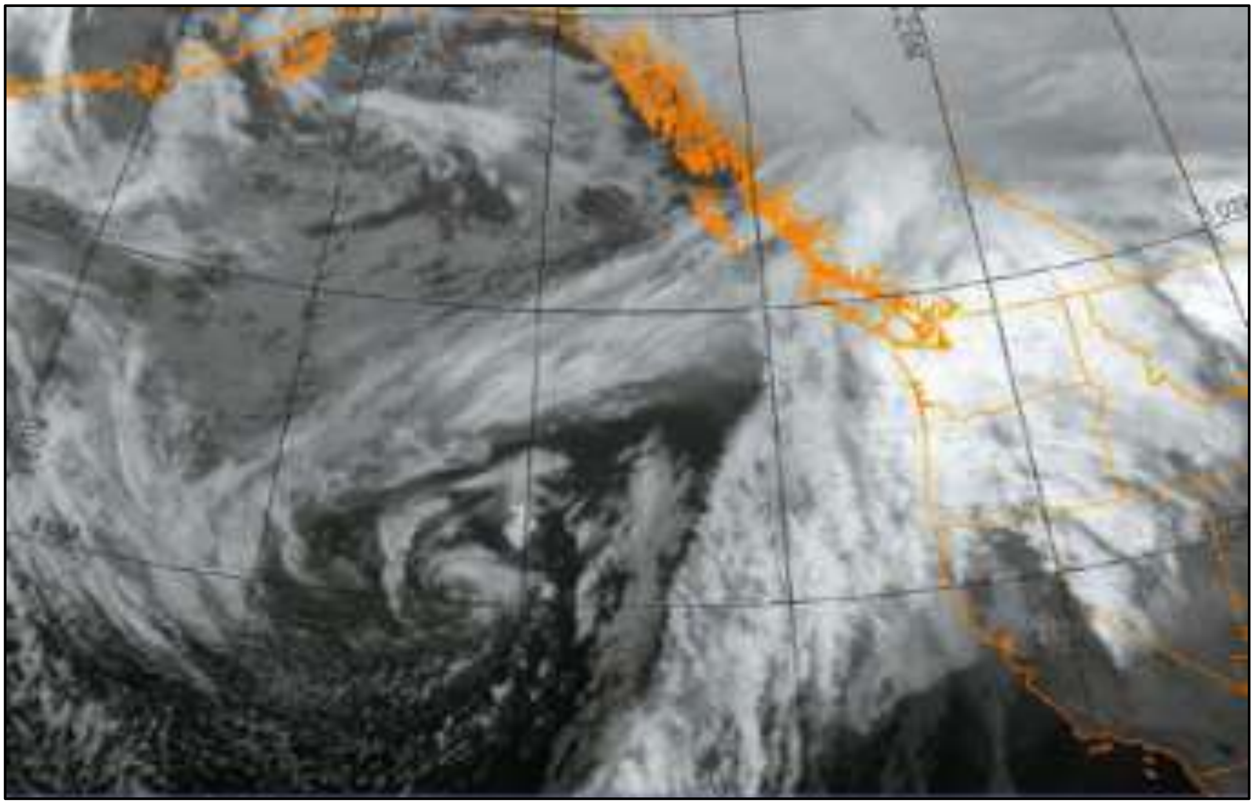


Figure 10-1. Satellite Photo of December 2007 Storm System.

Source: Lewis County, 2009b

Damages

The 2007 storm caused an estimated $166 million in damages in Lewis County alone. The Lewis County 2007 Flood Recovery Strategy released in 2009 (Lewis County, 2009b) summarized the following damage or destruction:

- 1,262 residential structures damaged or destroyed (779 within UGAs)
- 239 commercial/industrial structures damaged or destroyed (178 within UGAs)
- 10 fire district vehicles damaged or destroyed
- Five fire district stations damaged or destroyed
- 10,077 acres of farmland impacted
- 4,776 acres of farmland debris cleanup
- 227,778 linear feet of fence damaged
- 1,886 acres of farmland re-seeded
- 1,836 linear feet of ditch cleaned
- 1,600 commercial livestock disposed (400 cattle)
- 1,655 landslides mapped (actual number estimated to be 30-50 percent greater)
- $1,524,960 of damages to County roads
- $4,479,000 of damages to state highways within Lewis County
- $47,070,000 economic impact from four-day I-5 closure
- 26-day full closure of SR 6, and 47-day partial closure with flaggers

- $1,513,307 of Port of Chehalis rail line and bridge repairs
- $346,164 of damages at Chehalis-Centralia Airport
- 2,552 documented drums and containers recovered
- 793 documented tires recovered
- $14,933,782 allocated to Lewis County from FEMA
- $68,321,072 allocated to Lewis County from FHWA
- $40,338,076 in flood insurance claims
- $23,314,900 in SBA loans approved

The Lewis County December 3, 2007, Chehalis River Flooding Event Description (Lewis County, 2009a) summarized the following:

- $45,000,000 in local business inventory losses, damages, clean-up costs, and lost revenue
- 500 rescues were performed, using 25 boats and 7 helicopters
- The Boistfort water system was out of service for over three months
- 400 school children were reported to be homeless after the flood

Other Historical Flooding Events

The Cowlitz and Nisqually Rivers have dams that were not built to control flooding, but they do provide a level of mitigation to control flows. The Cowlitz River gauge at Castle Rock shows a major flood as occurring in 1959, 1965, 1975, and 1995, or about once every 15 years. At the Randle gauge, upstream of Mayfield Dam major, floods occur about once every 3 or 4 years. The following are notable flooding events in Lewis County (McDonald, 2007):

- December 1887 – The earliest significant flood documented in the Chehalis and Centralia area.
- December 1897 – Floodwaters undermined piers of the bridge crossing the Cowlitz River at Toledo.
- November 1906 – The flood, known as the Schoumacher Flood, may have been devastating and resulted in the loss of life, according to firsthand accounts.
- November 1909 – A rain and windstorm caused damage to roads, railroad tracks, and mills. Floodwater may have been the highest in 25-years. This flooding occurred on the Chehalis River.
- December 1915 – Heavy rains cause worst storm in the city's history, according to long-time residents. Flooding occurred throughout the Chehalis and Cowlitz River basin.
- January 1919 – Newspapers declare flood to be worst in city's history.
- December 1933 – Torrential rainfall designated December 1933 as the wettest month in history and causes flooding that leads to severe damage to transportation infrastructure.
- December 1937 – Rainfall causes the severe flooding, currently designated at the 8th highest flood at the Ground Mound gaging station.
- December 1956 – The Cowlitz River hit its third-highest level of 24.75 feet, forcing several families to evacuate from their homes.
- November 1959 – The Cowlitz River and its tributaries cut off Packwood in East Lewis County. Several bridges were washed out between Randle and Packwood.
- January 1972 – A rainstorm caused an all-time high in Centralia, which currently ranks as the 7th highest flood at the Centralia gage station and the 9th highest flood at the Ground Mound

gaging station. News reports document I-5 flooding, log jams, and debris flows and declared the flood to be the worst in history.

- January 1977 – Extensive flooding occurring on a 37.2-mile reach of the Cowlitz River. The high-water marks were 25 feet above that for medium flow near the downstream end of the reach. The inundation caused damage to residential areas of Packwood and Randle.
- November 1986 – A storm caused the 4th worst flood at the time, flooding the interstate, county roads, and schools. A wood treatment plant in Chehalis flooded, releasing 10,000 gallons of improperly stored pentachlorophenol (PCP), creosote, and other hazardous chemicals into floodwaters that inundated residential neighborhoods. The site became a superfund in 1989 and was delisted in 2020.
- 1990 – Six inches of rain in six days in January led to heavy flooding and all-time highs at the time on the Skookumchuck River and Chehalis River. Additional flooding occurred in February and November.
- February 1996 – Heavy rainfall caused widespread flooding throughout Washington, and at the time a record setting peaks on the Skookumchuck River and Chehalis River. Water levels exceeded the estimated 100-year flood, which led Centralia to begin requiring homes to be elevated one-foot above the 1996 flood levels. The flood currently ranks the second highest flood at the Ground Mound gaging station and remains the highest flood on the Skookumchuck River.
- December 2007 – The current highest flood at the Ground Mound gaging station.
- January 2009 – Heavy rain caused high flows throughout the Chehalis River basin. The flood was the 5th largest flood in 82 years of records at the Grand Mound gaging station, and the 7th largest in 71 years at the Doty gaging station (WATERSHED, 2012).
- December 2015 – Heavy rain caused flooding county-wide. Along the Cowlitz, flood was reported to be the worst since 2006 rescues and road closures due to road damage (The Chronicle, 2015).

10.2.3 Location

Lewis County has significant floodplains county-wide. All areas within the county are at risk of flooding, but higher risk areas are those within 100-year floodplains. The Nisqually and Cowlitz River basins are in rural areas with smaller populations, leading to less extensive damage to life or property. The Chehalis River flows through the western part of Lewis County and runs adjacent to the City of Centralia and Chehalis. The areas that have been historically most impacted by floods are low-lying areas near the rivers, including the Cowlitz, Chehalis, and Newaukum Rivers. The Cities of Centralia and Chehalis have experienced severe flooding in the past.

10.2.4 Frequency

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

The rivers and other perennial streams in Lewis County follow an annual cycle, with peak flow from November to February. There have been few floods in March through October. The National Weather Service (2024) provides historical river flow data at its gages. For the Chehalis River, historical crest data on their website begins in 1971 for the Doty gage and 1950 for the Centralia gage. The Skookumchuck gage data begins in 1950, the Newaukum gage data begins in 1975, and the Cowlitz River gage data begins in 1995.

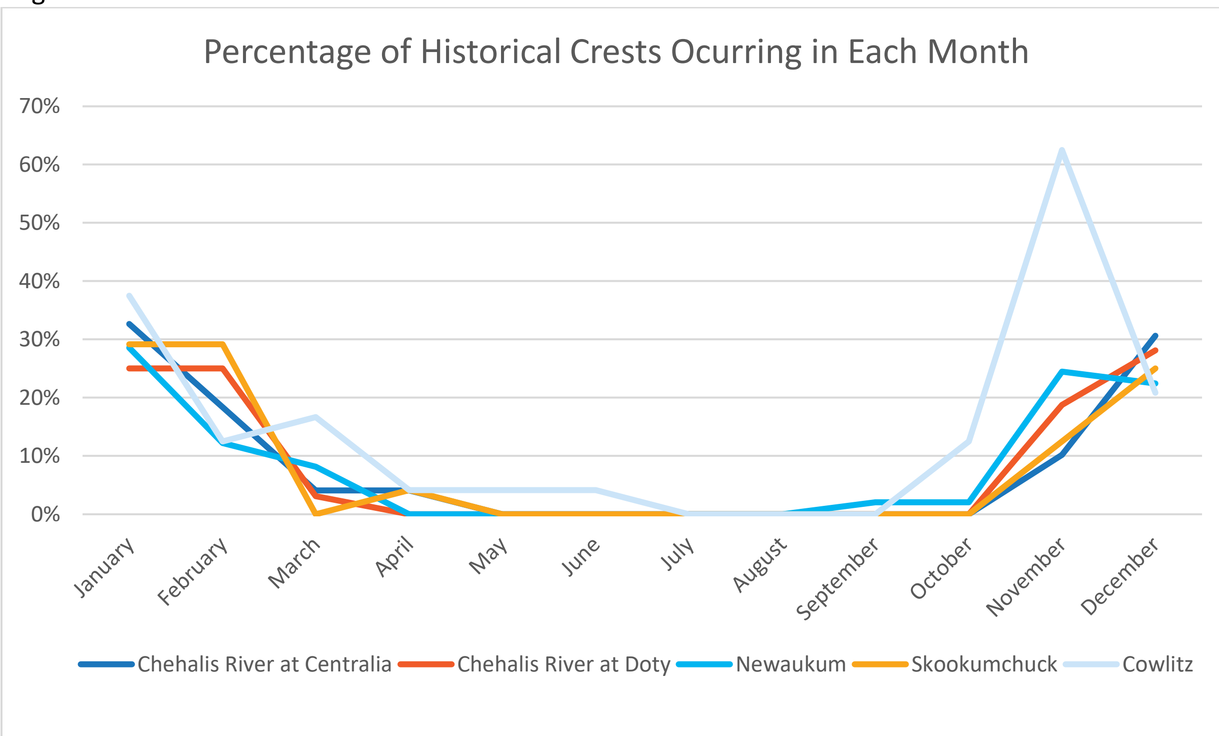


Figure 10-2 shows which months have the most historical crests according to the National Weather Service.

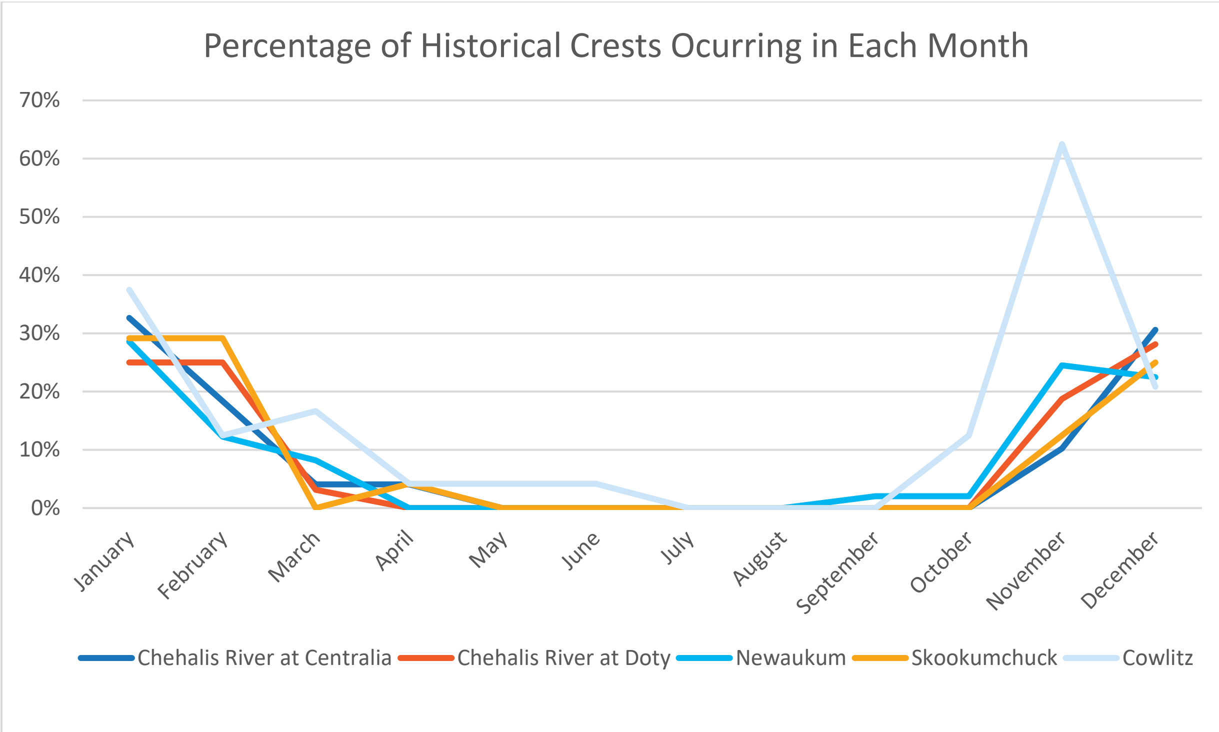


Figure 10-2. Percentage of Historical Crests Occurring in Each Month.
Source: NWS, 2024

Recent history has shown that Lewis County can expect an average of one episode of minor river flooding each winter. On the Chehalis and Cowlitz Rivers, large, damaging floods typically occur every two to five years, and in several years more than one record setting flood has occurred in one flood season. See Figure 10-3.

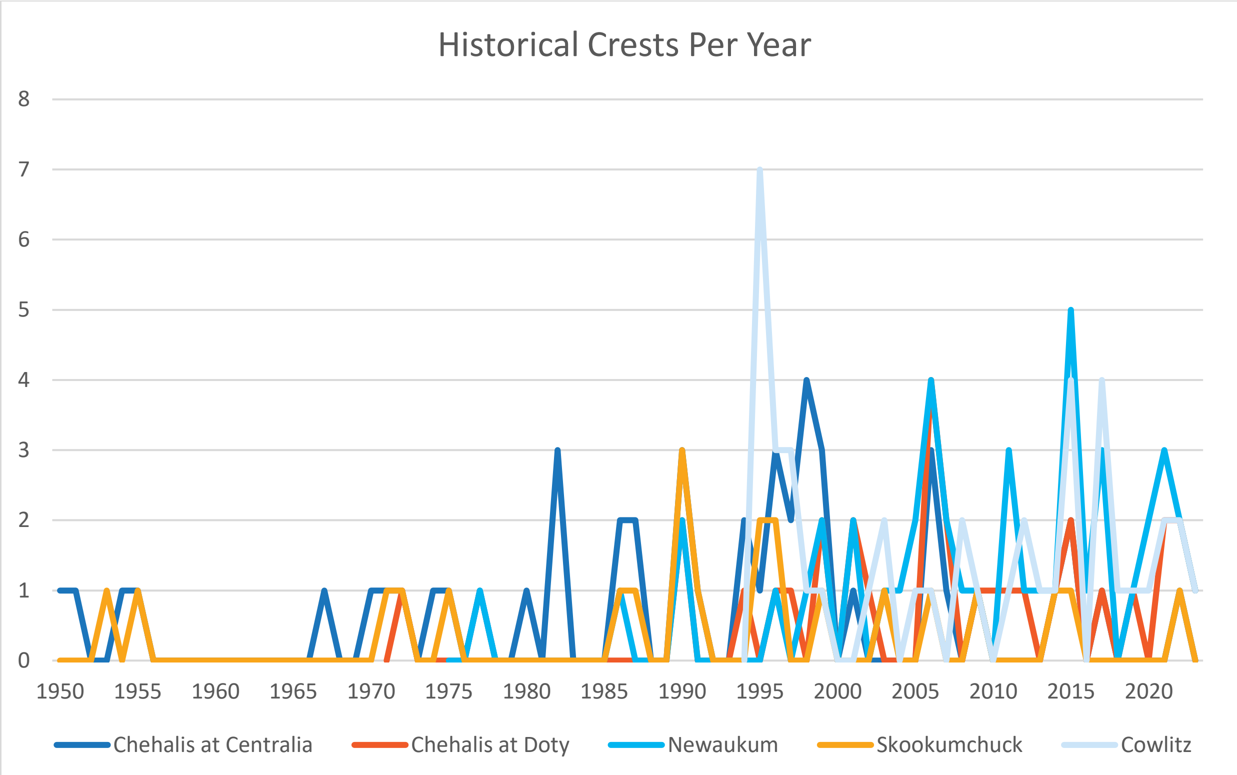


Figure 10-3. Historical Crests Per Year.
Source: NWS, 2024

10.2.5 Severity

The principal factors affecting flood damage are flood depth and velocity. The deeper and faster flood flows become, the more damage they 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.

Flooding in the Chehalis River Basin is increasing in frequency and severity. The largest floods on record have all occurred within the past thirty years. The chances of having the FEMA 100-year flood has increased by 33 percent (Rukelshaus Center, 2014).

The FEMA 100-year flood was defined in September 1979, before the largest and most damaging floods occurred in the basin (FEMA, 2006). FEMA will update the FIRM maps in Lewis County; however, the current 100-year flood on the Chehalis River is based on statistics which do not include the peak floods that occurred in 1996 and 2007, and other floods of record in 1986, 2009, and 2020. FEMA prepared draft updated flood maps in 2010 with a higher discharge than the current maps, but the process stalled.

Flood severity is often evaluated by examining peak discharges. According to the effective FEMA Flood Insurance Study (2006), the discharge at the Grand Mound gaging station used to map the Chehalis River 100-year floodplain in Lewis County is 55,000 cfs and the 500-year flood discharge is 70,000 cfs. The Thurston County 100-year floodplain is based on a discharge of 73,755 at the Grant Mound gaging station. In comparison with more current modeling updates developed for the Chehalis Basin Strategy, the estimated 100-year flood discharge at Grand Mound is 75,000 cfs. The discharge during the current flood of record in 2007 was 79,100 cfs (WA Ecology, 2017). The climate change models estimate an increase from 26 percent to 50 percent (Mauger, 2021 and McNamara, 2020). See Table 10-2 for a comparison of discharge rates at the Grand Mound gaging station. Additional discharge rates for the Chehalis River basin are not provided in this plan as the data is outdated and will change when FEMA updates the county-wide FIRMs.

Table 10-2. Discharge Rates on the Chehalis River at the Grand Mound Gaging Station.

Data Point	Discharge (cubic feet/second)
FEMA 100-Year Flood (effective floodplain)	56,000
FEMA 500-Year Flood	70,000
1996 Flood Actual	74,800
100-Year Modeled Flood	75,000
2007 Flood Actual (Flood of Record)	79,100
Mid-Range Climate Change	102,200
High End Climate Change	128,600
Thurston County FIS 100-year Flood	73,755

Table 10-3 lists peak flows used by FEMA to map the floodplains of the planning area outside of the Chehalis River watershed.

Table 10-3. Summary of Peak Discharges Within Lewis County (FEMA, 2023).

		Peak Discharge (cubic feet/second)			
Source/Location	Drainage Area (Mi²)	10-Year	50-Year	100-Year	500-Year
Tilton River					
At Morton (Downstream of Confluence with Lake Creek)	86	11,100	14,700	17,100	21,000
Downstream Study Limit at River Mile 9.0	138.7	16,100	21,700	24,500	30,650
Cispus River					
Downstream Study Reach (River Mile 12.2	321	15,300	22,000	25,100	32,900
Cowlitz River					
At Packwood	287	27,300	39,800	45,600	60,800
At Toledo (Downstream of Salmon Creek Confluence)	1,542	51,000	63,000	73,600	98,900
Big Creek					
At Confluence with Nisqually River	38.8	5,400	7,300	8,000	10,300
Siler Creek					
At Confluence with Cowlitz River	12.4	930	1,550	1,800	2,500
Surrey Creek					
At Confluence with Cowlitz River	4.4	590	890	1,120	1,460
Silver Creek					
At Confluence with Cowlitz River	51.7	7,100	10,550	12,750	16,300
Hall Creek					
At Confluence with Cowlitz River	12,7	1,660	2,200	2,400	3,000

10.2.6 Warning Time

Chehalis River Flood Warning System

After the 2007 flood and formation of the Chehalis River Basin Flood Authority, regional stakeholders led a process to improve the existing flood warning system that was based primarily on the National Weather Service's (NWS) Advanced Hydrologic Prediction System. The result is a robust, publicly accessible, web-based system that provides several sources of information, including rainfall, stream, wind, temperature, and other weather data. The system lacks an automated warning system. Lewis County Emergency Management monitors the system and sends local alerts using the "Lewis County Alert" system. This system provides emergency warnings and life saving information including evacuation notices.

The current flood warning system website address is https://chehalis.onerain.com/. The site includes several features from more than 250 sensors to help residents be aware of flooding conditions and increase their level preparedness, including the following features:

Inundation Mapping

Figure 10-4 shows the inundation map for the Chehalis River at Centralia for four flood stages: no flooding (blue), minor flooding (orange), moderate flooding (red), and major flooding (purple). The inundation mapping helps residents and emergency services be better prepared by understanding which areas will flood at different river levels. The flood maps can be accessed directly at http://www.chehalisriverflood.org/.

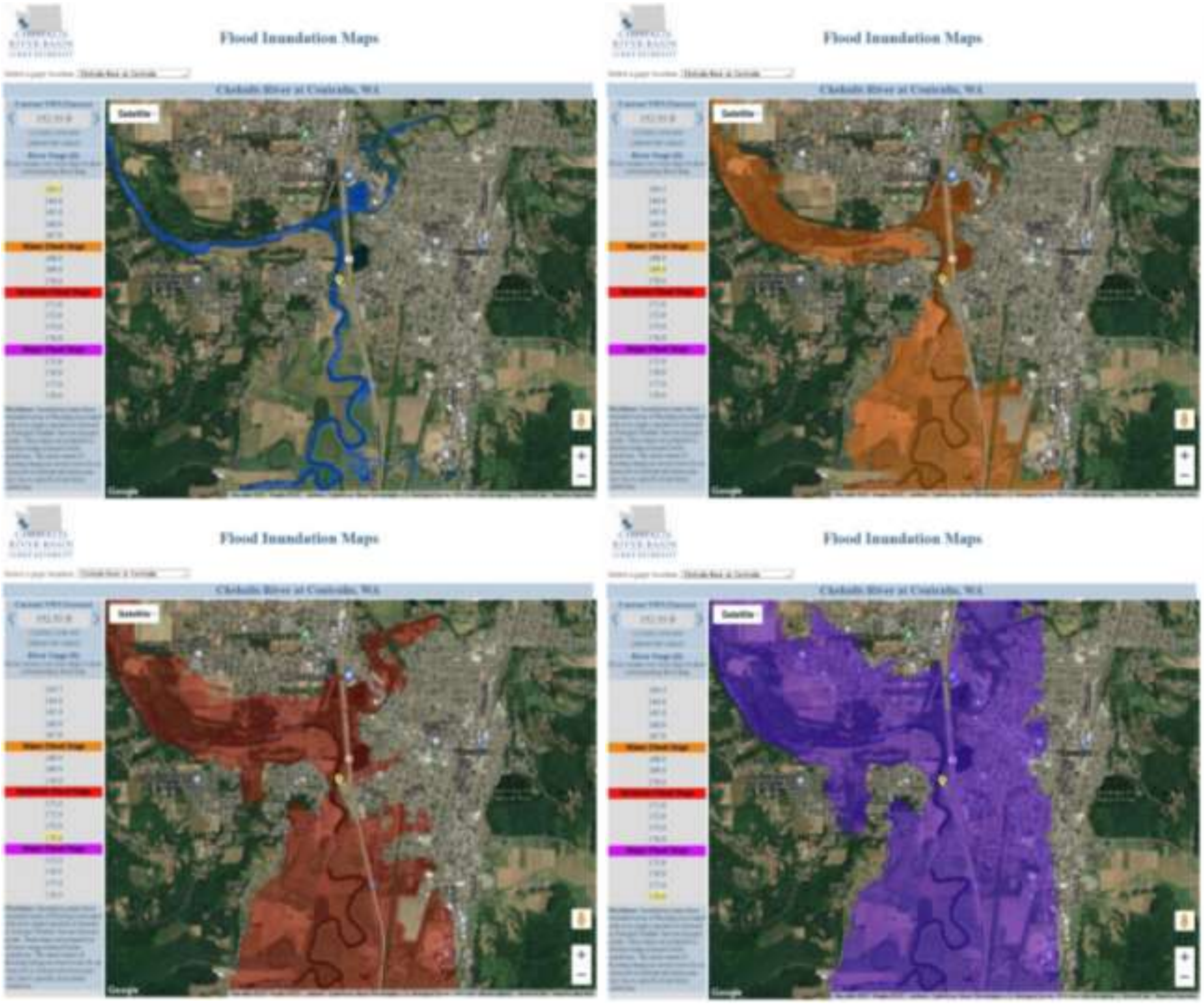


Figure 10-4. Flood inundation mapping.

Stream Alerts

Within Lewis County, there are seven gages providing river and stream status and forecast information with alerts (Gages #1-#7 shown on Figure 10-5). Users can sign up to receive an email alert.

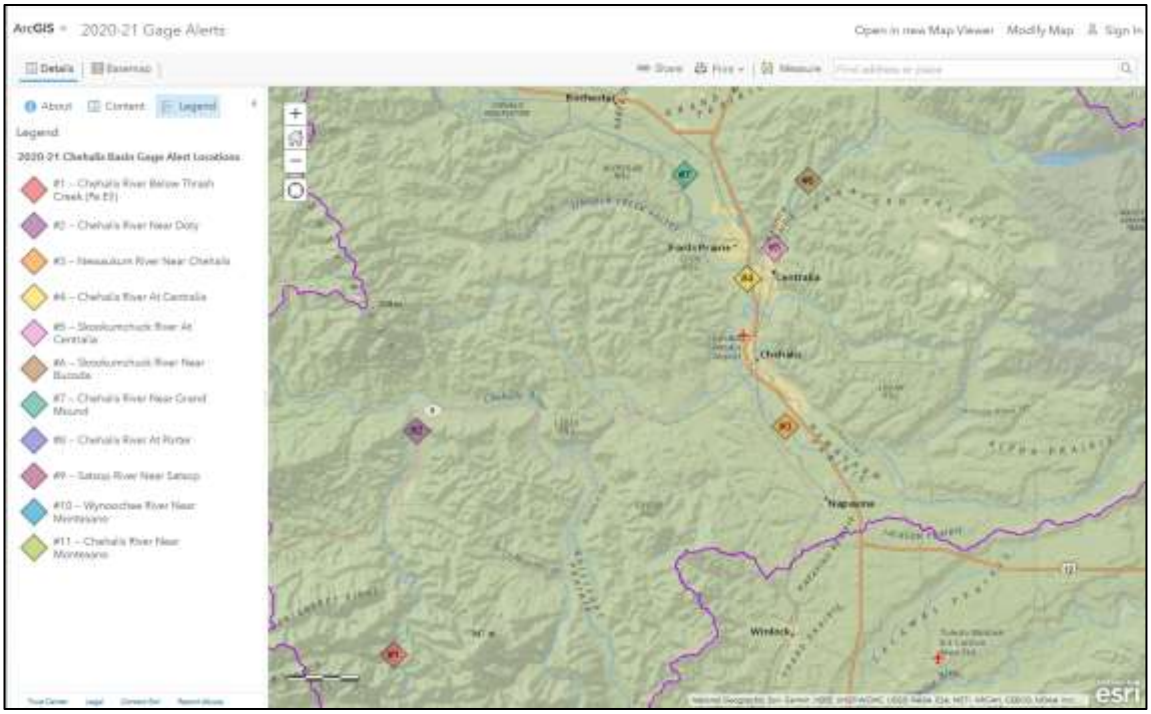


Figure 10-5. Gage alert locations within Lewis County.

Webcams

The flood warning system website provides two webcams for users to visually check river conditions. One of the webcams is in Centralia (Figure 10-6).

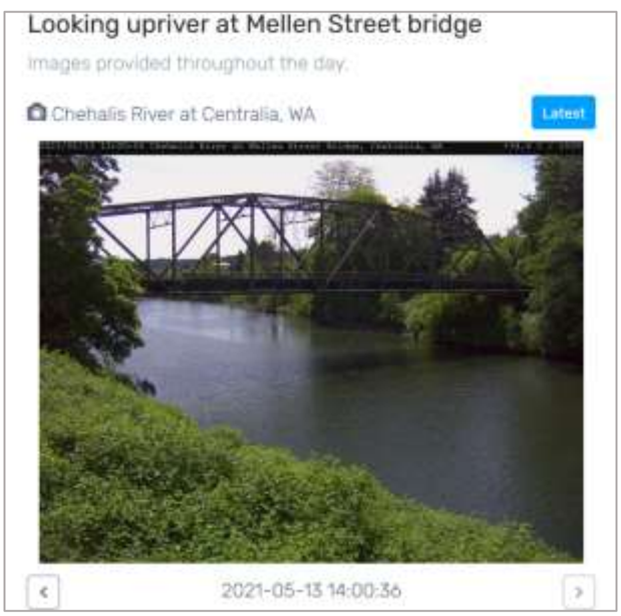


Figure 10-6. Centralia webcam.

10.2.7 Flood Watch and Warning System

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 and weather apps send notification to cell phones. 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 by the National Weather Service on the major rivers within Lewis County are shown in Table 10-4.

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.

Table 10-4. National Weather Service Flood Stages (NWS, 2023).

	Flood Stage in Feet			
Gage Location	Major Flood	Moderate Flood	Flood Stage	Action Stage
Chehalis River near Doty	324.5	323.5	318	315.5
Chehalis River at Centralia	175.5	172	168.5	166
Chehalis River near Grand Mound	144	142.5	141	138.5
Skookumchuck River at Centralia	191	190	189	187
Newaukum River near Chehalis	205.5	204.5	202.5	200.5
Cowlitz River at Packwood	12	11	10.5	8.2
Cowlitz River at Randle	22	20	18	13.2
Cowlitz River below Mayfield Dam	45	35	25	17
Cowlitz River at Castle Rock	57	54	48	46
Nisqually River near National	15	10	8	5.4
Nisqually River at Mckenna	14	13	10	8

10.3 Probability

10.3.1 Future Events

Future flood events will occur. Past flood frequencies indicate that County can expect minor river flooding every year and major river flooding every two-five years. Given the complexity and uncertainty associated with predicting future flood events, collaboration with experts and communities is crucial for informed decision making and effective flood mitigation strategy. Predicting future flood events using FEMA 100-year and 500-year flood maps involves a comprehensive process. Through the collection of historical flood data, analyzing hydrological and meteorological data, and considering climate change predictions, the County can understand and predict future events and risk.

10.3.2 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.

In 2014, the Climate Impact Group at the University of Washington released a report titled Effect of Climate Change on the Hydrology of the Chehalis Basin (Mauger, et. al, 2016). The report supports the ongoing work to reduce the risk and damage from flooding throughout the river basin. The report found that:

- Winter precipitation is projected to increase, while summer precipitation decreases.
- Peak streamflow is projected to increase.
- Annual temperature increases are projected to increase.
- Sea levels are projected to increase by another two feet along the Pacific coastline.

In 2019, the Office of the Chehalis Basin developed a climate change 100-year flood model using information from the University of Washington Climate Impacts Group. The data estimated a 26 percent increase in flood discharge for a late century flood (approximately the year 2080). In 2020, the model was updated using new data from the Climate Impacts Group. This data showed a substantial increase of 40-65 percent in flood discharge, averaging at about 50% basin wide (Mauger, 2021).

Figure 10-7 illustrates the forecast changes in flooding for the mid-range climate change projection. The red areas show the increase in area compared to the updated 100-year floodplain model, which was used to assess risk in this plan. In some areas, the boundaries for the two floodplains are in the same location. In these areas, the floodwaters have reached the extent they can spread and instead of spreading farther the floodwaters get deeper. The high-end projection will cause an even greater area to be subject to flooding and other areas to be much deeper.

Regional projections for water-related impacts are as follows (Mote et al., 2014):

- Snowmelt timing – By 2050, snowmelt is projected to shift three to four weeks earlier than the 20th century average. The amount of snow is critical for water supply and environmental needs, but so is the timing of snowmelt runoff into rivers and streams. Rising snowlines caused by climate change will allow more mountain area to contribute to peak storm runoff. High frequency flood events (e.g. 10 - year floods) in particular will likely increase with a changing climate.
- Stream flow levels – Summer stream flows are expected to be substantially diminished. 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.
- Flood risk – Flood risk is expected to increase most in mixed basin watersheds (those with both rainfall and snowmelt related runoffs) and remain largely unchanged in snow dominated systems.

- Heavy precipitation events – It is unclear if there will be an overall increase in heavy precipitation events, but when averaged over the region models indicate that the number of days with more than one inch of precipitation is likely to increase by approximately 13 percent by mid-century. If such increases do occur, they could impact flooding in both mixed and rain-dominant systems, as well as contribute to localized flooding due to overwhelmed storm water management systems.

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

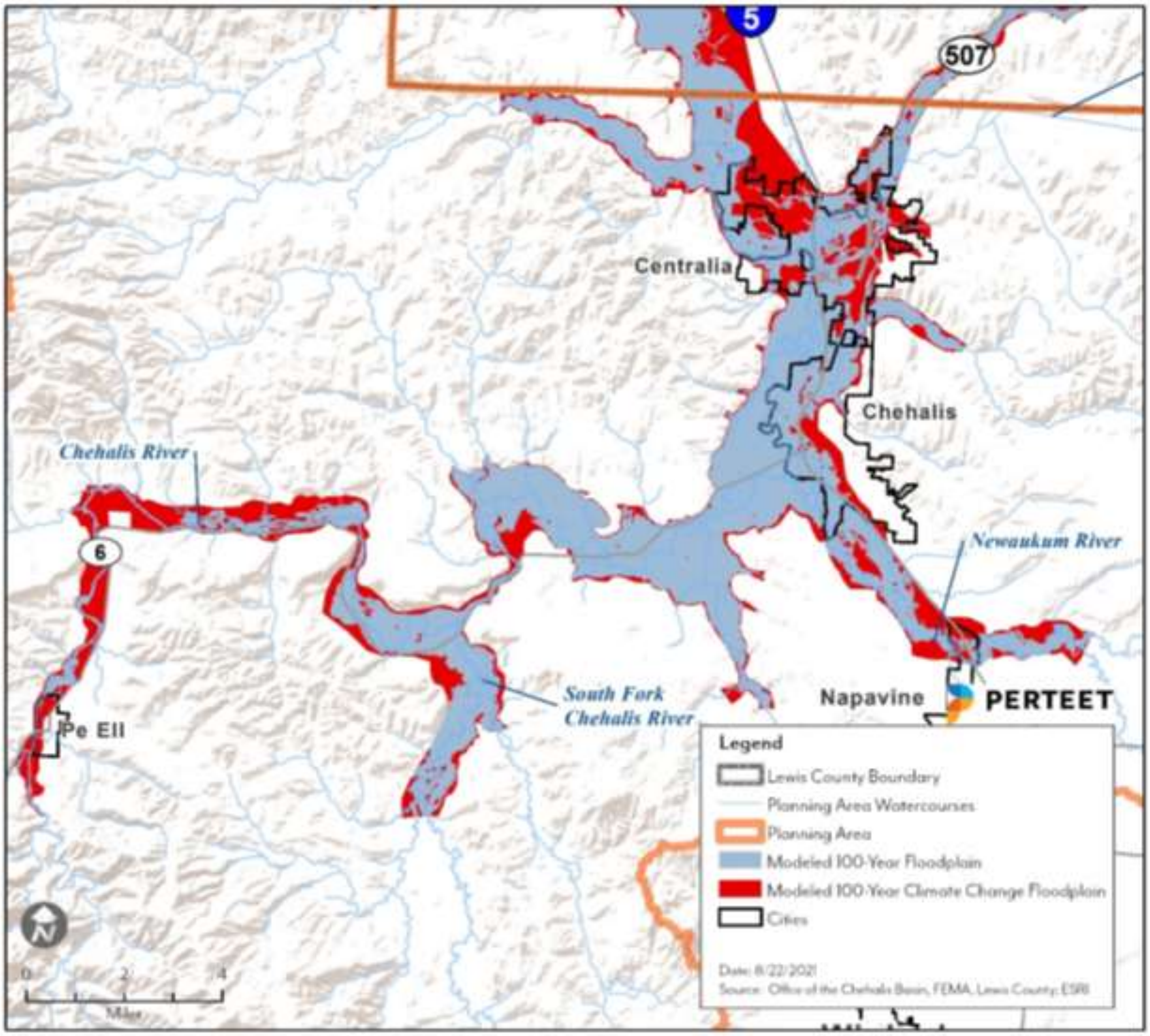


Figure 10-7. Mid-Range Climate Change Projections.

10.3.3 Future Trends in Development

Lewis County is anticipating an additional 10,000 residents by 2040 (OFM, 2017). In 1990, Washington

State adopted the Growth Management Act, which among other things required Lewis County to establish urban growth boundaries, rural areas, and natural resource lands. The County and all of the cities have adopted plans and development regulations that are currently in compliance with the Growth Management Act. 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 Lewis 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 Lewis County. Lewis County's critical areas regulations regulate how development and redevelopment can safely occur on lands that contain critical areas. Additionally, Lewis County and its cities participate in the NFIP and have adopted flood damage prevention ordinances in response to its requirements. Lewis County has committed to maintaining its good standing under the NFIP through actions identified in this plan.

10.4 Vulnerability

Vulnerability is based on the 100-year flood using the best available information, which included:

- Office of the Chehalis Basin (OCB) 100-year flood model for the Chehalis River and tributaries
- Digital FIRMs for the Nisqually River (effective 8-15-2023)
- Draft LOMR for the Cowlitz River near Packwood
- FEMA 100-year data for all other areas

10.4.1 People

Population counts of those living in the 100- year floodplains were generated by analyzing structures in the floodplain. The total planning area population from the 2020 Census 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 vulnerable in each floodplain were estimated as follows:

16.2% of Lewis County is exposed to the 100-year flood, receiving an overall impact rating of medium. Centralia is the municipality with the highest degree of exposure, totaling 42.9% of the population. Table 10-5 summarizes the population exposure to the 100-year flood. See Appendix E Table 10-5 for a detailed breakdown of the estimated population exposure to the 100-year floodplain.

As a result of climate change, the population exposed to flooding in the Chehalis River basin would increase from about 9,000 to 12,500, even without further population growth.

Table 10-5. 100-year Floodplain Population Exposure.

Jurisdiction	Impact	Estimated Population	Population Exposed	% of Population Exposed
Lewis County	**Medium**	**82,036**	**13,264**	**16.2%**

10.4.2 Structures

Structures vulnerable to flooding was based off of the 2022 tax assessor data provided by Lewis County. Based on this data, 19.7% of the total value of property is vulnerable to the 100-year flood county-wide, totaling $4.2 billion dollars. Centralia and Chehalis have the highest degree of property exposure for incorporated municipalities with 40.4% and 30% respectively. Table 10-6 summarizes the structures and contents vulnerable to the 100-year floodplain. See Appendix E Table 10-6 for a detailed breakdown of the structures and contents vulnerable to the 100-year floodplain. Table 10-7 provides the total number of structures and types within the 100-year floodplain. See Appendix E Table 10-7 for a detailed breakdown of the number of structures within the 100-year floodplain.

Table 10-6. Structures and Contents Value in the 100-year Floodplain.

Jurisdiction	Building Exposed	Value of Structure	Value of Contents	Value (Structure and Contents)	% of Total Value Exposed
Lewis County	**5,594**	**$2,307,254,373**	**$1,902,130,905**	**$4,209,385,279**	**19.7%**

Table 10-7. Number of Structures in the Floodplain.

Jurisdiction	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Lewis County	**4,950**	**447**	**79**	**6**	**47**	**30**	**35**	**5,594**

10.4.3 Critical Facilities and Systems

There is a total of 313 critical facilities and infrastructure located within the 100-year floodplain in Lewis County that include communications, energy, health and medical, safety and security, schools, and transportation. There were no identified hazardous material or food, water, and shelter facilities within the 100-year floodplain. Table 10-8 summarizes the critical facilities located within the 100-year floodplain. See Appendix E Table 10-8 for a detailed breakdown of critical facilities located within the 100-year floodplain.

Table 10-8 Critical Facilities Located within 100-year Floodplain.

Jurisdiction	Communications	Energy	Hazardous Material	Health & Medical	Safety & Security	Schools	Transportation	Total
Lewis County	**3**	**13**	**0**	**24**	**28**	**2**	**244**	**313**

Roads

The road system in Lewis County is made up of local public and private roads, interstate, US highways, and state routes. There are over 1,888 miles of public and private roads within the County. The County maintains 1,065 miles of roadways, 196 bridges, and 5,110 culverts. The nine cities (Centralia, Chehalis, Morton, Mossyrock, Napavine, Pe Ell, Toledo, Vader, and Winlock) are responsible for their own roadways within their city limits. Unless there is an agreement between the County and the cities, the County currently maintains the roadways in the unincorporated UGAs.

The Chehalis-Centralia area lies 85 miles midway between the metropolitan areas of Seattle, Washington, and Portland, Oregon. The primary north-south transportation corridor passing through Lewis County and the Cities of Centralia and Chehalis is Interstate 5. Interstate 5 passes through the Chehalis River floodplain and is affected by flooding. The roadway was closed for four days in 1996 and 2007, and two days in 2009, causing millions of dollars of freight delays (WA Ecology, 2020).

US Highway 12 traverses Lewis County from east to west and crosses the Cascade Mountains at White Pass. White Pass is the only major all-season route south of Seattle and north of the Columbia River allowing access to eastern Washington.

Some of these roads are built above the flood level, and others function as levees to prevent flooding. Still, in severe flood events these roads can be blocked or damaged, preventing access to some areas.

Bridges

Flooding events can significantly impact road bridges. These are important because often they provide the only ingress and egress to some neighborhoods. There are 77 bridges located within the 100-year floodplain and 78 located within the 500-year floodplain.

10.4.4 Natural, Historic, Cultural Resources, and Valued Activities

Vulnerable resources are those that are in flood water inundation area. This includes many species of mammals, birds, reptiles, amphibians, and fish that live in Lewis County in ecosystems along streams, wetlands, and floodplains. Many cultural sites are located along river systems.

10.5 Impacts

10.5.1 People

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 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 the US Census Bureau 2015 American Community Survey estimates, there are about 15,000 individuals in Lewis County with some form of disability, representing 19.4 percent of the county population. Approximately 21 percent (17,307 individuals) are 65 years or older (US Census, 2019). Hazus estimated that a 100-year flood could displace up to 5,371 people, with 383 of those people needing short-term shelter.

Table 10-9 summarizes the displaced population and those requiring short-term shelter in the planning area. See Appendix E Table 10-9 for a detailed breakdown of the number of displaced population and those requiring short-term shelter in the event of a 100-year flood.

Table 10-9. Displaced Populations.

Jurisdiction	Displaced Population	People Requiring Short-Term Shelter
Lewis County	**5,371**	**383**

10.5.2 Structures

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

The analysis is summarized in Table 10-10 for the 100-year flood event. It is estimated that there would be up to $252 million of flood loss from a 100-year flood event in the planning area. This represents 19.7 percent of the total exposure to the 100-year flood and 1.2 percent of the total assessed value for the county. See Appendix E Table 10-10 for a detailed breakdown of the estimated flood loss for the 100-year flood event.

Table 10-10. Estimated Flood Loss for the 100-Year Flood Event.

	Estimated Flood Loss			
Jurisdiction	Structure	Contents	Total	% of Total Assessed Value
Lewis County	**$96,461,207**	**$155,817,937**	**$252,279,143**	**1.2%**

10.5.3 Critical Facilities and Systems

Hazus-MH was used to estimate the flood loss potential to critical facilities exposed to the flood risk. Using depth/damage function curves to estimate the percent of damage to the building and contents of critical facilities, Hazus-MH correlates these estimates into an estimate of functional down-time (the estimated time it will take to restore a facility to 100 percent of its functionality). This helps to gauge how long the planning area could have limited usage of facilities deemed critical to flood response and recovery. The Hazus critical facility results for the planning area are summarized in Table 10-11. See Appendix E Table 10-11 for a detailed breakdown of the type of critical facility and flood loss potential.

Table 10-11. Flood Loss Potential to Critical Facilities.

	Number of Facilities Affected	Average % of Total Value Damaged	
		Structure	Content
Total/Average	**130**	**8.63**	**26.12**

It is important to determine who may be at risk if infrastructure is damaged by flooding. Roads or railroads that are blocked or damaged can isolate residents and can prevent access throughout the county, including 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 can fail or be overtopped, inundating the land that they protect. 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.

10.5.4 Natural, Historic, Cultural Resources, and Valued Activities

Flooding is a natural event and floodplains provide natural and beneficial functions. Still, flooding can impact the environment in negative ways, especially when compounded with impacts from human development. Migrating fish can be stranded in puddles after they are washed over 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 Lewis 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 rely 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.
- A great number of birds are associated with riparian areas. They swim, dive, feed along the shoreline, or snatch food from above. Lewis 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.

Another measure of environmental impacts from flooding is the amount of debris that that would be generated by each scenario flood event. Hazus includes a debris estimation component. These estimates can provide local governments information on the potential exposure to debris carried by flood water as well as estimates useful for planning for recovery. The Hazus debris estimates for the 100-year flood event in the planning area are shown in Table 10-12. See Appendix E Table 10-12 for a detailed breakdown of the estimated flood-caused debris.

Table 10-12. Estimated Flood-Caused Debris.

Jurisdiction	Debris to be Removed (tons)
Lewis County	**36,118**

10.6 NFIP and CRS Participation

10.6.1 Insurance Summary

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

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 100-year flood.
- New floodplain development must not aggravate existing flood problems or increase damage to other properties.
- New floodplain development must exercise a reasonable and prudent effort to reduce its adverse impacts on threatened salmon species.

Compliance is monitored by FEMA regional staff and by the Washington State Department of Ecology. Maintaining compliance under the NFIP is an important component of flood risk reduction. All planning partners that participate in the NFIP have identified initiatives to maintain their compliance and good standing.

Table 10-13 lists flood insurance statistics that help identify vulnerability in Lewis County. Eight communities in the planning area, including unincorporated Lewis County participate in the NFIP, with 1,399 flood insurance policies providing $383.080 million in insurance coverage.

According to FEMA statistics, 2,112 flood insurance claims were paid between January 1, 1978, and October 24, 2022, for a total of $80,749,721, an average of $38,233 per claim.

Table 10-13. Flood Insurance Statistics for Lewis County

Jurisdiction	Date of Entry Initial FIRM Effective Date	# of Flood Insurance Policies as of 10/24/2022	Insurance in Force	Total Annual Premium	# of Claims, 11/1978 to 10/4/2022	Value of Claims paid, 11/1988 to 10/24/2022
Centralia	6/1/82	468	$125,591,000	$412,888	753	$26,708,892
Chehalis	5/1/80	178	$58,445,800	$258,088	545	$29,626,478
Morton	12/4/79	0	$0	$0	1	$0
Napavine	7/17/06	2	$850,000	$1,516	0	$0
Pe Ell	3/4/80	4	$1,076,000	$2,821	1	$37,771
Toledo	11/5/80	17	$3,999,500	$19,603	4	$75,538
Vader	9/14/79	1	$250,000	$298	0	$0
Winlock	9/14/79	0	$0	$0	2	$859
Unincorporated	12/15/81	729	$192,867,800	$551,332	806	$24,300,183

Total	**1,399**	**$383,080,100**	**$1,246,546**	**2,112**	**$80,749,721**

10.6.2. Repetitive Loss Summary

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 percent of flood insurance policies in force nationally, yet they account for 40 percent 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 percent 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.

Table 10-14 summarizes Lewis County's repetitively flooded NFIP-insured structures. This table includes the number of structures in each jurisdiction and the type of property for repetitive/severe repetitive loss properties. Table 10-15 summarizes the unmitigated NFIP repetitive loss properties.

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10.7 Secondary Hazards

The most problematic secondary hazard for 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 the floodplain or causing them to fall in.

Erosion is the deterioration and wearing away of riverbanks. Erosion causes issues with infrastructure and private property located along the riverbanks and creates sediment issues downstream. The Chehalis Basin experiences the following types of erosion:

- Channel migration is the lateral movement of a river when it naturally meanders through soft, erodible banks. A study of the Chehalis River between Pe Ell and Chehalis found that between 1945-2013 the channel migrated on average between 0.5 to 20 meters annually.
- Bank erosion often occurs with heavy flows or high velocity, often along the outside of river bends. Bank erosion also occurs after there is a disruption in flow, such as a logjam, that creates a new flow pattern.
- Channel incision is the eroding of the riverbed, lowering the elevation of the river and often disconnecting it from the floodplain (WA Ecology, 2017).

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.

10.8 Scenario

The primary water courses in Lewis County have the potential to flood at irregular intervals, generally in response to a succession of intense winter rainstorms. Storm patterns of warm, moist air usually occur between early October and April. A series of such weather events can cause severe flooding in the planning area. The worst-case scenario is a series of storms that flood numerous drainage basins in a short time. This could overwhelm the response and floodplain management capability within the planning area. Major roads could be blocked, preventing critical access for many residents and critical functions. High in-channel flows could cause water courses to scour, possibly washing out roads and creating more isolation problems. In the case of multi-basin flooding, the County would not be able to make repairs quickly enough to restore critical facilities and infrastructure.

10.9 Issues

The planning team has identified the following flood-related issues relevant to the planning area:

- The extent of the flood-protection currently provided by flood control facilities (dams, dikes, and levees) is not known due to the lack of an established national policy on flood protection standards.
- Older levees are subject to failure or do not meet current building practices for flood protection.
- The risk associated with the flood hazard overlaps the risk associated with other hazards such as earthquake, landslide, and fishing losses. This provides an opportunity to seek mitigation alternatives with multiple objectives that can reduce risk for multiple hazards.
- How will potential climate change impact flood conditions in Lewis County?
- More information is needed on flood risk to support the concept of risk-based analysis of capital projects.
- 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 future mitigation projects.
- Ongoing flood hazard mitigation will require funding from multiple sources.
- There needs to be a coordinated hazard mitigation effort between jurisdictions affected by flood hazards in the county.
- Floodplain residents need to continue to be educated about flood preparedness and the resources available during and after floods.
- The concept of residual risk should be considered in the design of future capital flood control projects and should be communicated with residents living in the floodplain.
- The promotion of flood insurance as a means of protecting private property owners from the economic impacts of frequent flood events should continue.
- Existing floodplain-compatible uses such as agricultural and open space need to be maintained. There is constant pressure to convert these existing uses to more intense uses within the planning area during times of moderate to high growth.
- The economy affects a jurisdiction's ability to manage its floodplains. Budget cuts and personnel

losses can strain resources needed to support floodplain management.

CHAPTER 11. LANDSLIDE

11.1 General Background

A landslide is a mass of rock, earth or debris moving down a slope. Landslides may be minor or very large and can move at slow to very high speeds. They can be initiated by storms, earthquakes, fires, volcanic eruptions, or human modification of the land.

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

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

11.1.1 Landslide Types

The two primary types of landslides are:

Earth flow – This is the dominant form of landslide in the area. Both ancient and active earth flows are common, not only in the high and steep terrain, but also in the low, rolling hills of the Chehalis-Centralia area. Stream erosion along the toes of the flow usually causes reactivation of these landslides. Excavations, such as those for freeway construction, also may reactivate dormant earth flows or start new ones.

Debris flow – These types of landslides are locally a problem in the western Cascades and Olympic mountains; they tend to occur where the rocks are strong and relatively un-weathered. These rocks tend to have steep slopes and smooth surfaces overlain by thin soils. Intense rainstorms, or rain on the wet snow in the mountains trigger these landslides (Source: Washington State Hazard Mitigation Plan, 2013).

11.1.2 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

11.2 Hazard Profile

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

- A slope greater than 33 percent
- A history of landslide activity or movement during the last 10,000 years
- Stream or wave activity, which has caused erosion, undercut a bank or cut into a bank to cause the surrounding land to be unstable
- The presence or potential for snow avalanches
- The presence of an alluvial fan, indicating vulnerability to the flow of debris or sediments
- The presence of impermeable soils, such as silt or clay, which are mixed with granular soils such as sand and gravel.

Flows and slides are commonly categorized by the form of initial ground failure. Figure 11-1 through Figure 11-4 _bookmark203show common types of slides. 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, although they are less common than other types.

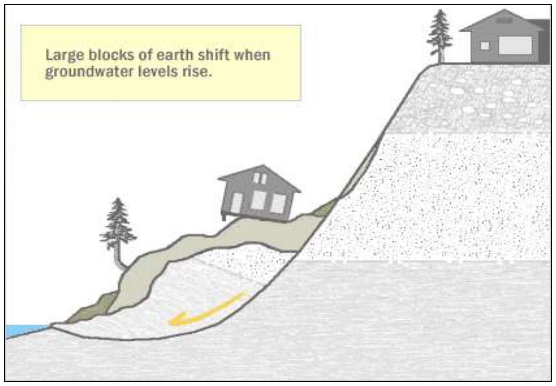

Figure 11-1. Deep Seated Slide.

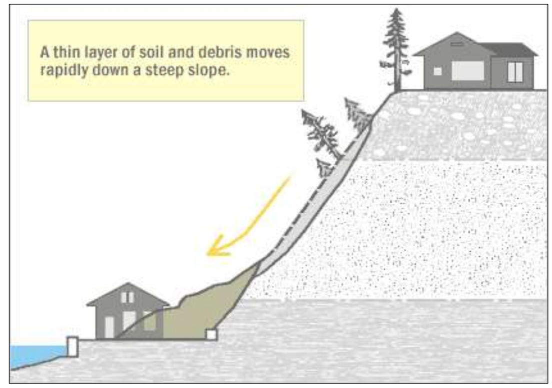

Figure 11-2. Shallow Colluvial Slide.

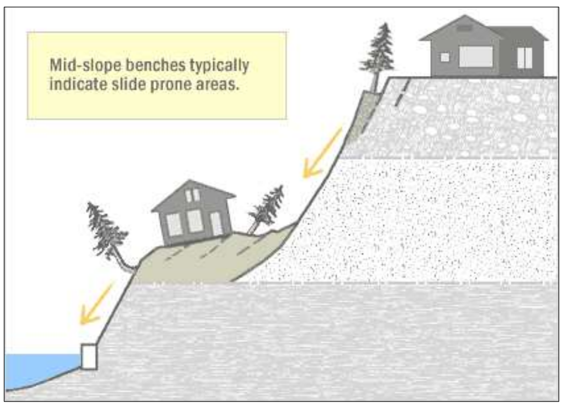

Figure 11-3. Bench Slide.

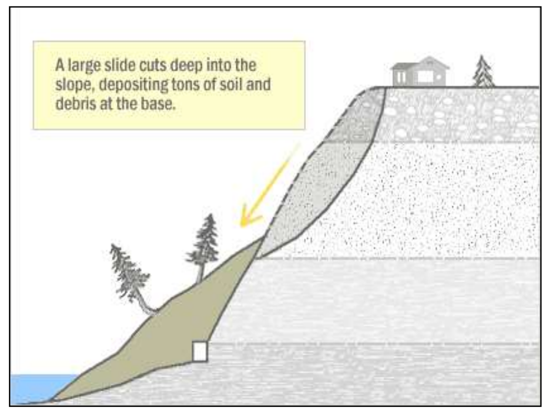

Figure 11-4. Large Slide.

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

11.2.1 Past Events

The majority of landslides that occur within the planning area are the result of flooding and severe storms.

- January 7-8, 2009 storm, over 500 landslides initiated in Lewis County, blocking roads and damaging houses. Rainfall totaled over 10 inches between January 7-8, triggering hundreds of debris flows between Morton and Randle. Near Glenoma, when the debris flows reached the valley, they transformed into hyper-concentrated flows, moving across fields and pirating on Highway 12 and into roads and driveways.
- December 2007 storm just west of Pe Ell, a massive debris avalanches along with numerous smaller landslides blocked State Route 6, from Pe Ell to Raymond, isolating 21 households without electricity and water. In addition, State Route 8, just west between Porter and Malone, and SR 508 near Onalaska were blocked by landslides. In the Chehalis headwaters area, the hardest hit area from the storm, nearly 20 inches of rain was recorded within a 48-

hour period, most of that falling within the first 24 hours. Woody debris and sediment, including material from more than 1,000 landslides in the Chehalis headwaters basin, clogged channels at bridges, creating temporary dams and causing widespread deposition of logs and debris, especially around the Boistfort valley.

- 2007— A landslide in Pe Ell blocked State Route 6 and destroyed a home.
- The winter storms of January 29 through March 11, 1999 – brought snow, heavy rains, high winds, and landslides. Heavy saturated soils and unstable conditions on the hillside above Kresky Avenue (Chehalis) resulted in a large mass land movement. It caused severe damage (over $100,000) to the Elks Lodge. During this same time frame, Pe Ell had a newly installed water line collapse from another mass land movement.
- February 1996 – Lewis County experienced its largest recorded landslide with an estimated 1.5 million cubic yards of debris. The event destroyed a house five miles east of Glenoma. Landslides blocked State Route 504 in two places by landslides in Kid Valley, and a landslide closed State Route 7 near Mineral Lake for two days.
- 1984 – A mudslide shut down the water supply intake to the reservoir of the cities of Centralia and Chehalis. In November 1990 and January 1991, muddy water was observed at the same location.
- November 1994 – After heavy rains, a mass land movement occurred approximately one-half mile west of Randle between Peters and Silverbrook Roads. An entire portion of a hill near State Route 12 rolled down onto the highway. The slide was about 30 feet high and more than 100 feet wide. The clean-up cost an estimated $1.2 million.

11.2.2 Location

In Lewis County there are particular areas that are more vulnerable. Landslides in the planning area generally occur along cuts in a hillside usually along a roads or highway. Land that lies along river bluffs is also susceptible to landslides and could cause damage to, or completely destroy, any structure built on it. For this plan, the areas with highest risk are assumed to be those areas and structures located above, below, or on slopes steeper than 15%.

11.2.3 Frequency

The frequency of landslides can vary greatly depending on factors such as geographic location, climate, topography, and human activities. Lewis County has experienced landslides in the past due to its hilly terrain and wet climate. The Lewis County region is known to experience heavy rainfall making landslides occur more frequently. Rainwater can saturate soil, making it more prone to sliding. In addition, steep slopes are inherently less stable and more susceptible to movement.

11.2.4 Severity

Landslides destroy property and infrastructure and can take the lives of people. They have the potential of destabilizing the foundation of structures, which may result in monetary loss for residents. Slope failures in the United States result in an average of 25 to 50 lives lost per year and an annual cost to society of about $1.5 billion (FEMA, n.d.). Landslides can pose a serious hazard to properties on or below hillsides. They can 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.

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 2 miles upstream and reached approximately 20 feet deep, inundating an additional 6 homes. Total property damage was estimated at $60 million (NOAA 2015). Although north of Lewis County, 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.

11.2.5 Warning Time

Mass movements can occur suddenly or slowly. The velocity of movement may range from a slow creep of inches per year to many feet per second, depending on slope angle, material, and water content. Some methods used to monitor mass movements can provide an idea of the type of movement and the amount of time prior to failure. It is also possible to determine what areas are at risk during general time periods. Assessing the geology, vegetation, and amount of predicted precipitation for an area can help in these predictions. However, there is no practical warning system for individual landslides. The current standard operating procedure is to monitor situations on a case-by-case basis and respond after the event has occurred. Generally accepted warning signs for landslide activity include:

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

11.3 Probability

11.3.1 Future Events

Landslides can occur due to a combination of factors and predicting a future event involves assessing these criteria. Landslides can occur due to factors such as steep slopes, geological and soil characteristics, soil saturation, precipitation patterns, previous landslide history, vegetation cover, and seismic activity. Through continuous weather monitoring, including rainfall intensity and soil moisture, conditions that can trigger landslides can be monitored. In addition, analyzing historical data may reveal patterns and high-risk regions. Through regular monitoring and updates, there is assurance that assessment remains current.

11.3.2 Climate Change Impacts

Climate change may impact storm patterns, increasing the probability of more frequent, intense storms with varying duration. Increase in global temperature could affect the snowpack and its ability to hold and store water. Warming temperatures also could increase the probability of wildfire, reducing the vegetation that helps to support steep slopes. The UW Climate Impact Group Climate Mapping for Resilient Washington predicts that in the next 50 years, the 2-year rain storm intensity will increase on average by 14%, and the average increase in the number of high fire danger days each year is 8. All of these factors would increase the probability for landslide occurrences.

11.3.3 Future Trends in Development

The ever-increasing pressure for development in or near the mountains and narrow valleys brings 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. Higher population density could result in more development in high-risk landslide areas, putting more lives and property at risk. Changes in land use, such as increased development intensity, can alter the natural landscape and lead to increased landslide susceptibility. Development may include the construction of roads, buildings, houses, and infrastructure on steep slopes that can disturb the natural stability of the terrain, which may increase likelihood of landslides.

The County and its planning partners are equipped to handle future growth within landslide hazard areas. All partners have committed to linking their comprehensive plans to this hazard mitigation plan update. This will create an opportunity for wise land use decisions as future growth impacts landslide hazard areas.

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.

11.4 Vulnerability and Impacts

The Hazus results examine the exposure of property and population on slopes 15-35% and slopes greater than 35%.

11.4.1 People

The people vulnerable to landslides are generally those located on, above, or below steeper slopes. This plan evaluated the people living on slopes 15-35% and slopes greater than 35%. The number of people in the planning area, shown in Table 11-1, was estimated based on the number of structures. See Appendix E Table 11-1 for a detailed breakdown of the population in areas most vulnerable to landslides.

While all people located on steeper slopes are considered exposed and potentially vulnerable, socially vulnerable populations include the very young, the elderly, and those experiencing poverty may be more vulnerable based on many factors, including their physical and financial ability to react or respond during a hazard and the ability to be self-sustaining for prolonged periods of time after an incident.

People impacted by landslides may experience death or property damage.

The National Risk Index determined three census tracts in eastern Lewis County to be very high risk for landslide risk, roughly 15.3% of the population reside in these areas. The areas near Centralia and Chehalis and south along Interstate 5 have a relatively high landslide risk, including roughly 35.5% of the County's population. Table 11-2 provides a breakdown of the risk factor for landslide in Lewis County. See section 5.9 for a detailed description of the components of the NRI.

Table 11-1. Population in Areas Most Vulnerable to Landslides.

		Slopes 15-35%		Slopes greater than 35%	
Jurisdiction	Total Population	Population Exposed	% of Population Exposed	Population Exposed	% of Population Exposed
Lewis County	**82,036**	**5,016**	**6.1%**	**327**	**0.4%**

Table 11-2. NRI Scoring for Earthquake in Lewis County

Expected Annual Loss	Social Vulnerability	Community Resilience	Community Risk Factor	Risk Value	Risk Index Score
$632,993	Relatively High	Relatively Moderate	1.34	$633,510	98.1

11.4.2 Structures

Potential losses from a landslide event vary greatly depending on the area affected. A landslide that occurs in an undeveloped rural area may cause no monetary damage at all. In other instances, there may be extensive road damage or destruction of homes or other structures. The number of structures in the planning area are described in Table 11-3 and Table 11-4. See Appendix E Table 11-3 and 11-4 for a detailed breakdown of the structures exposed to the hazard.

All property vulnerable to the landslide hazard can be impacted. Property located in very high landslide susceptibility classes is most vulnerable, especially structures that were built before modern building codes were adopted. Structures impacted by landslides can suffer a range of effects, from being completely destroyed, knocked off their foundation, or minor effects that cause cracks and separation of the walls. Table 11-5 and 11-6 summarize the structure and contents value on slopes 15-35% and greater than 35% in the planning area. See Appendix E Table 11-5 and 11-6 for a detailed breakdown of the structure and contents value exposed in each jurisdiction.

Table 11-3. Structures Exposed to Slope 15-35%.

	Number of Structures in Hazard Area							
Jurisdiction	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Lewis County	2,138	34	1	1	4	2	0	2,180

Table 11-4. Structures Exposed Slope Greater than 35%.

	Number of Structures in Hazard Area							
Jurisdiction	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Lewis County	148	21	0	0	0	0	0	169

Table 11-5. Structure and Contents Value on Slopes 15-35%.

Jurisdiction	Value of Structure Exposed	Value of Content Exposed	Total Value (Structure and Content)	% of Total Value
Lewis County	$603,017,184	$323,979,340	$926,996,524	4.3%

Table 11-6. Structure and Contents Value on Slopes Greater than 35%.

Jurisdiction	Value of Structure Exposed	Value of Content Exposed	Total Value (Structure and Content)	% of Total Value
Lewis County	$39,448,652	$24,927,077	$64,375,729	0.3%

11.4.3 Critical Facilities and Systems

Landslides also damage the land or the hillsides, making roadway conditions unsafe. Depending on the magnitude and severity of a landslide event, losses could reach well into the millions of dollars. Additionally, landslides can cause a disruption of commerce if a road closure results. Table 11-7 and 11-8 summarize the critical facilities exposed to slopes 15-35% and greater than 35% in the planning area. See Appendix E Table 11-7 and 11-8 for a detailed breakdown of critical facilities that are exposed in each jurisdiction.

Table 11-7. Critical Facilities Exposed to Slopes 15-35%.

Jurisdiction	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health and Medical	Safety and Security	Transportation	Total
Lewis County	4	4	0	0	0	1	25	34

Table 11-8. Critical Facilities Exposed to Slopes greater than 35%.

Jurisdiction	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health and Medical	Safety and Security	Transportation	Total
Lewis County	**5**	**13**	**0**	**0**	**1**	**2**	**10**	**31**

All exposed critical facilities and infrastructure are vulnerable to the landslide hazard. Landslides can have a range of impacts on critical facilities and infrastructure:

- **Roads**—Access to major roads after a disaster is crucial to safety and to response operations. Landslides can block roads, isolating neighborhoods and causing problems for public and private transportation. This can result in economic losses for businesses.
- **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, 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.

14.4.4 Natural, Historic, Cultural Resources, and Valued Activities

Landslides pose multifaceted threats to natural, historic, and cultural resources. Some natural resources that may be vulnerable to avalanche include forests, rivers, streams, and wildfire habitats. Cultural resources, such as buildings and infrastructure, archaeological sites, and cultural artifacts may also be vulnerable to landslides.

Environmental problems as a result of mass movements can be numerous. Landslides that fall into streams may significantly impact fish and wildlife habitat due to the sediment that is carried by the landslide. This may contaminate water sources and affect water quality and aquatic life. Landslides have the potential to redirect water flow, which may change drainage patterns and potentially cause flooding downstream. Furthermore, hillsides that provide wildlife habitat can be lost for prolonged periods of time due to landslides.

11.5 Secondary Hazards

Landslides can cause several types of secondary effects, such as blocking access to 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 landslides are power and communication failures. Vegetation or poles on slopes can be knocked over, resulting in possible losses to power and communication lines. Landslides also have the potential of destabilizing the foundation of structures, which may result in monetary loss for residents. They also can damage rivers or streams, potentially harming water quality, fisheries, and spawning habitat.

11.6 Scenario

Landslides in Lewis County occur as a result of soil conditions that have been affected by severe storms, groundwater or human development. The worst-case scenario for landslide hazards in the planning area would generally correspond to a severe storm that had heavy rain and caused flooding. Landslides are most likely during the fall/winter timeframe, when the water tables are higher. After heavy rains from October to April, soils become saturated with water. As water seeps downward through upper soils that may consist of permeable sands and gravels and accumulates on impermeable silt, it will cause weakness and destabilization in the slope. A short intense storm could cause saturated soil to move, resulting in landslides. As rains continue, the groundwater table rises, adding to the weakening of the slope. Gravity, poor drainage, a rising groundwater table and poor soil exacerbate hazardous conditions. This factor is of high concern within the dam areas as well, as Lewis County has 53 dams countywide.

Mass movements are becoming more of a concern as development moves outside of city centers and into areas less developed in terms of infrastructure. Most mass movements would be isolated events affecting specific areas. It is probable that private and public property, including infrastructure, will be affected. Mass movements could affect dams and their supporting structures, and bridges that pass over landslide prone ravines and knock out rail service through the county. Road obstructions caused by mass movements could create isolation problems for some residents and businesses in sparsely developed areas. Property owners exposed to steep slopes may suffer damage to property or structures. Landslides carrying vegetation such as shrubs and trees may cause a break in utility lines, cutting off power and communication access to residents.

Continued heavy rains and flooding will complicate the problem further. As emergency response resources are applied to problems with flooding, it is possible they will be unavailable to assist with landslides occurring all over Lewis County.

11.7 Issues

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

- The impact of slide damages around the dams within Lewis County should be further studied, as the stability of the surrounding land and impacts from potential slides is unknown.
- There are existing homes in landslide risk areas throughout the County. 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.
- Future development could lead to more homes in landslide risk areas.
- Mapping and assessment of landslide hazards are constantly evolving. As new data and science become available, assessments of landslide risk should be reevaluated.
- The impact of climate change on landslides is uncertain. If climate change impacts atmospheric conditions, then exposure to landslide risks is likely to increase.
- Landslides may cause negative environmental consequences, including water quality degradation.
- 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.

CHAPTER 12. SEVERE WEATHER

12.1 General Background

Severe weather refers to any dangerous meteorological phenomena with the potential to cause damage, serious social disruption, or loss of human life. It includes thunderstorms, downbursts, tornadoes, waterspouts, snowstorms, ice storms, and dust storms.

Severe weather can be categorized into two groups: those that form over wide geographic areas are classified as general severe weather and those with a more limited geographic area are classified as localized severe weather. Severe weather, technically, is not the same as extreme weather, which refers to unusual weather events are at the extremes of the historical distribution for a given area. However, as extreme weather events are becoming more common, temperature extremes are included in this chapter.

Lewis County is impacted by several types of severe weather events. This plan evaluates five types of severe weather: thunderstorms, high winds, winter storms, temperature extremes, and heavy rainfall. Flooding issues associated with atmospheric rivers are discussed in Chapter 10.

12.1.1 Thunderstorms

Severe weather in Lewis County generally includes heavy rains, lightning, or hail. A thunderstorm is a rain event that includes thunder and lightning. A thunderstorm is classified as “severe” when it contains one or more of the following: hail with a diameter of three-quarter inch or greater, winds gusting in excess of 50 knots (57.5 mph), or a tornado. Hail occurs when updrafts in thunderstorms carry raindrops upward into extremely cold areas of the atmosphere where they freeze into ice.

NOAA classifies a thunderstorm as a storm with lightning and thunder produced by cumulonimbus clouds, usually producing gusty winds, heavy rains, and sometimes hail. Thunderstorms are usually short in duration (seldom more than 2 hours). Heavy rains associated with thunderstorms can lead to flash flooding during the wet or dry season.

Thunderstorms are reported as light, medium, or heavy according to the following characteristics:

- Nature of lightning and thunder
- Type and intensity of the precipitation, if any
- Speed and gustiness of the wind
- Appearance of the clouds
- Effect on surface temperature (American Meteorological Society)

Lightning 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 reaches temperatures approaching 50,000ºF instantaneously. The rapid heating and cooling of air near the lightning causes thunder. Lightning is a major threat during a thunderstorm. In the United States, between 75 and 100 Americans are killed by lightning each year.

12.1.2 High Winds

The National Weather Service defines high winds as sustained winds of 40 mph or gusts of 58 mph or greater, not caused by thunderstorms, expected to last for an hour or more. Areas most vulnerable to high winds are those affected by a strong pressure difference from deep storms originating over the Pacific Ocean; an outbreak of very cold, Arctic air originating over Canada; or air pressure differences between western and eastern Washington that primarily affect the Columbia River Gorge, Cascade Mountain passes, ridges and east slopes, and portions of the Columbia Basin. There are seven types of damaging winds:

- **Straight-line winds—**Any thunderstorm wind that is not associated with rotation; this term is used mainly to differentiate from tornado winds. Most thunderstorms produce some straight-line winds as a result of outflow generated by the thunderstorm downdraft.
- **Downdrafts—**A small-scale column of air that rapidly sinks toward the ground.
- **Downbursts—**A strong downdraft with horizontal dimensions larger than 2.5 miles resulting in an outward burst or damaging winds on or near the ground. Downburst winds may begin as a microburst and spread out over a wider area, sometimes producing damage similar to a strong tornado. Although usually associated with thunderstorms, downbursts can occur with showers too weak to produce thunder.
- **Microbursts—**A small, concentrated downburst that produces an outward burst of damaging winds at the surface. Microbursts are generally less than 2.5 miles across and short-lived, lasting only 5 to 10 minutes, with maximum wind speeds up to 168 mph. There are two kinds of microbursts: wet and dry. A wet microburst is accompanied by heavy precipitation at the surface. Dry microbursts, common in places like the high plains and the intermountain west, occur with little or no precipitation reaching the ground.
- **Gust front—**A gust front is the leading edge of rain-cooled air that clashes with warmer thunderstorm inflow. Gust fronts are characterized by a wind shift, temperature drop, and gusty winds out ahead of a thunderstorm. Sometimes the winds push up air above them, forming a shelf cloud or detached roll cloud.
- **Derecho—**A derecho is a widespread thunderstorm wind caused when new thunderstorms form along the leading edge of an outflow boundary (the boundary formed by horizontal spreading of thunderstorm cooled air). The word "derecho" is of Spanish origin and means "straight ahead." Thunderstorms feed on the boundary and continue to reproduce. Derechos typically occur in summer when complexes of thunderstorms form over plains, producing heavy rain and severe wind. The damaging winds can last a long time and cover a large area.
- **Bow Echo—**A bow echo is a linear wind front bent outward in a bow shape. Damaging straight-line winds often occur near the center of a bow echo. Bow echoes can be 200 miles long, last for several hours, and produce extensive wind damage at the ground.
- **Tornado—** is a violently rotating column of air extending between, and in contact with, a cloud and the surface of the earth. Tornadoes are often (but not always) visible as a funnel cloud. On a local-scale, tornadoes are the most intense of all atmospheric circulations and wind can reach destructive speeds of more than 300 mph. A tornado's vortex is typically a few hundred meters in diameter, and damage paths can be up to 1 mile wide and 50 miles long. Figure 12-1 demonstrates the occurrence of tornadoes in Washington State. Tornadoes can occur throughout the year at any time of day but are most frequent in the spring during the late afternoon.

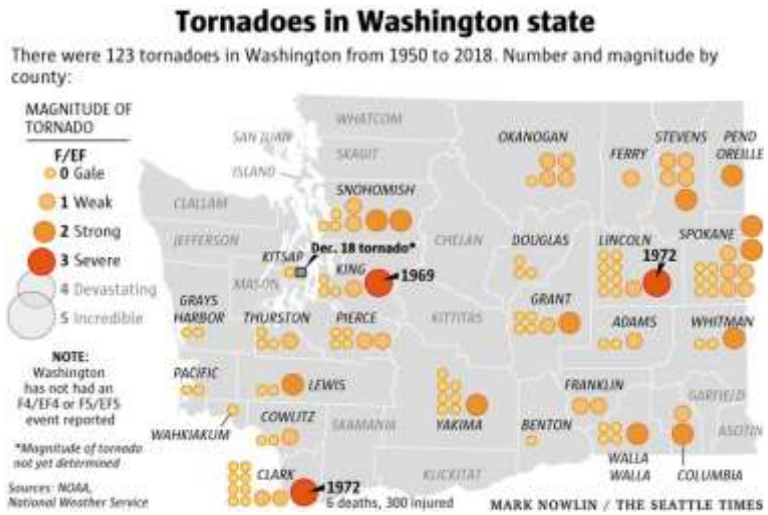

Figure 12-1. Washington State Tornado Occurrences.

Large wind events most often occur in the autumn and winter due a low pressure cyclone system that takes over in the North Pacific Ocean, with air spiraling inward in a counter-clockwise fashion.

West winds generate from the Pacific Ocean and are strong along the coast, but slow down inland due to the obstruction of the mountain ranges. Prevailing winds in Lewis County vary with the seasons. In summer, the most common wind directions are from the west or northwest; in winter, they are from the south and east. Local topography, however, plays a major role in affecting wind direction (Source: Office of the Washington State Climatologist, www.climate.washington.edu).

12.1.3 Severe Winter Storms

The National Weather Service defines a Severe Winter Storm as having significant snowfall, ice, and/or freezing rain; the quantity of precipitation varies by elevation. Heavy snowfall is 4 inches or more in a 12-hour period, or 6 inches or more 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.

Areas most vulnerable to winter storms are those affected by convergence of dry, cold air from the interior of the North American continent, and warm, moist air off the Pacific Ocean. Typically, significant winter storms occur during the transition between cold and warm periods.

There is no area in the planning area that is void from the effects of winter storms. A winter storm can have the capability to affect the entire planning area during and after the event. The entire infrastructure, including critical facilities, is vulnerable and is at risk of being damaged or affected by severe winter storms. Winter storms can cause damage to structures, damage to pipes, downed power lines, loss of electricity, obstruct traffic flow, and significantly damage trees. A loss of electricity in combination with cold weather can pose a significant threat to human life.

The unique characteristics of different jurisdictions allow winter storms to impact them differently. Cities and utility districts are vulnerable in that their power, cable, and telephone lines can accrue ice during a winter storm and break. Heavy snow buildup can cause structural damage to residential, commercial, and public structures as well as critical facilities. Snow and ice can also endanger residents that travel on the roads. Residents in the rural areas of the county can be affected by severe winter storms as snow and ice can greatly hinder travel. Also, power can be cut off to residents in unincorporated areas for days and sometimes weeks.

12.1.4 Extreme Temperatures

In most of the United States, extreme heat is defined as a period (two to three days) of high heat and humidity with temperatures above 90ºF. In extreme heat, evaporation is slowed, and the body must work extra hard to maintain a normal temperature, which can lead to death by overworking the human body. Extreme heat can cause heat exhaustion, in which the body becomes dehydrated, resulting in an imbalance of electrolytes. Without intervention, heat exhaustion can lead to collapse and heatstroke. Heatstroke occurs when perspiration cannot occur, and the body overheats. Without intervention, heatstroke can lead to confusion, coma, and death. Extreme heat often results in the highest number of annual deaths among all weather-related hazards.

Older adults, children, and sick or overweight individuals are at greater risk from extreme heat. It can take several days of oppressive heat for a heat wave to have a significant or quantifiable impact. Heat waves do not strike victims immediately, but their cumulative effects slowly cause harm to vulnerable populations. Excessive heat is the primary weather-related cause of death in the United States, claiming over 100 lives each year. In a 30-year record of weather fatalities across the nation (1990-2019), excessive heat claimed more lives each year than floods, lightning, tornados, and hurricanes (Erdman 2021). Extreme heat events do not typically impact buildings; however, losses may be associated with the urban heat island effect and overheating of heating, ventilation, and air conditioning systems. These extreme heat events can lead to drought, impact water supplies, and lead to an increase in heat-related illnesses and deaths.

12.4.5 Severe Rainfall

In Washington State, severe rainfall not associated with a thunderstorm generally are caused aby an atmospheric river. An atmospheric river is a concentrated moisture corridor in the atmosphere that can become a severe weather hazard when interacting with other weather systems. These moisture-laden corridors can combine with low-pressure systems or fronts, leading to heavy rainfall that can cause flooding, landslides, avalanches, and strong winds. See Figure 12-2 for more information on atmospheric rivers.

The United States Geological Survey says high-intensity atmospheric rivers can be as destructive as hurricanes. Similar to hurricanes, these storms have a rating system — but their ratings incorporate the idea that they can be beneficial, hazardous or both (USGS, 2019).

The ratings range from Category 1 to Category 5, with the higher numbers indicating an escalating level of hazard. USGS explains:

- **Category 1 (weak):** A Category 1 atmospheric river would be a milder and briefer weather event with primarily beneficial effects, like 24 hours of modest rainfall.
- **Category 2 (moderate):** A Category 2 atmospheric river is a moderate storm with mostly beneficial effects, but also somewhat hazardous.
- **Category 3 (strong):** A Category 3 atmospheric river is more powerful and longer lasting, with a balance of beneficial and hazardous impacts. For example, a storm in this category could bring 5-10 inches of rain over 36 hours, enough to help replenish reservoirs but also pushing some rivers close to flood stage.
- **Category 4 (extreme):** A Category 4 atmospheric river is mostly hazardous, though also with some beneficial aspects. A storm of this rating could dump enough heavy rain over several

days to bring many rivers to flood stage.

- **Category 5 (exceptional):** A Category 5 atmospheric river is primarily hazardous.

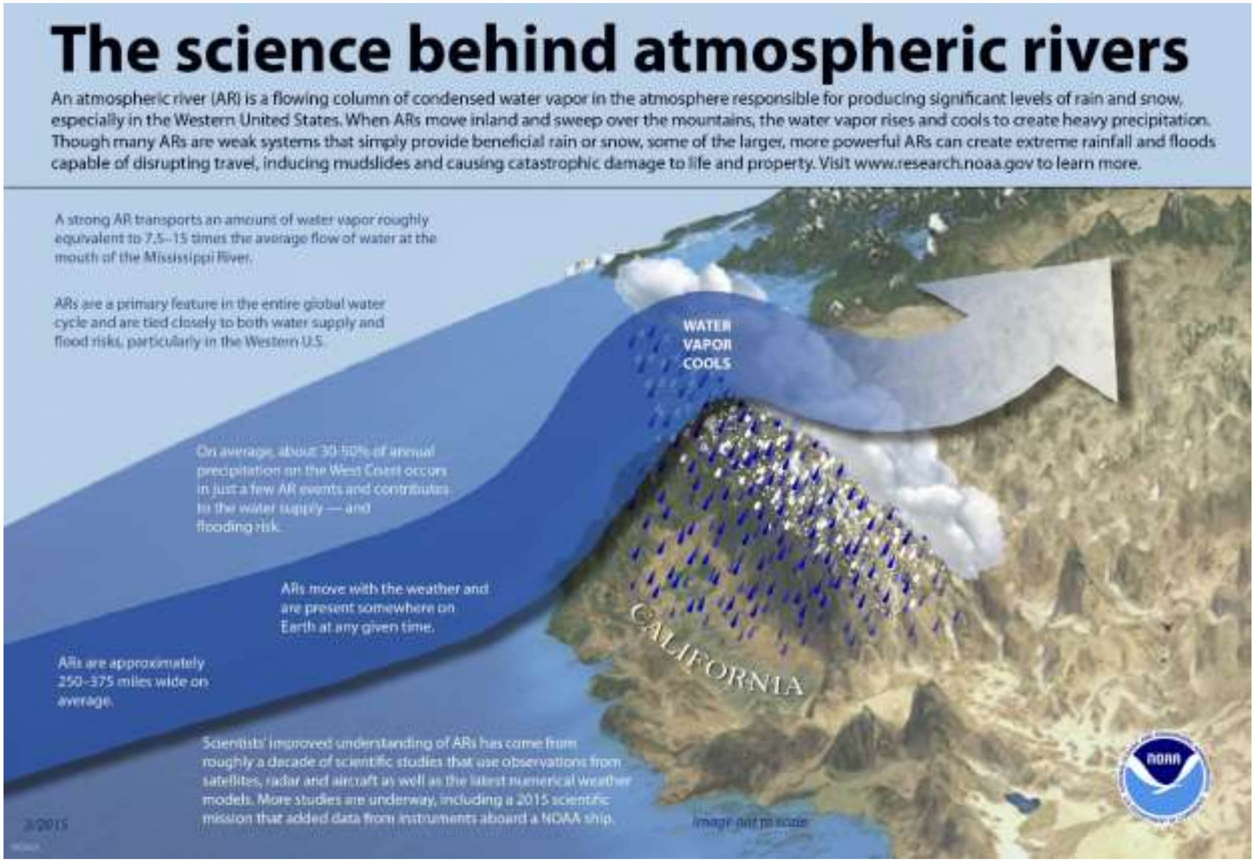

Figure 12-2. The Science Behind Atmospheric Rivers. ***Source: NOAA***

12.2 Hazard Profile

12.2.1 Past Events

Historically, Lewis County has been subject to many storms including severe wind and winter-related storms. These storms have ranged from mild-severe. While not all of these have caused major long-term problems, their disruption into the daily lives of community members has placed a great burden. Table 12-1 describes some of the major past events.

Table 12-1. Past Major Storms in Lewis County.

Date	Type of Event	Comment
November 3-8, 2022	Severe Winter Storm, Straight-line Winds, Flooding, Landslides, and Mudslides- FEMA- DR-4682-WA	
June 2021	Heat Wave	A station at the Mayfield Power Plant recorded a temperature of 118 degrees.

Date	Type of Event	Comment
December 29, 2020 to January 16, 2021	Severe Winter Storm, Straight-line Winds- FEMA-4593-DR-WA	
November 12-21, 2015	Severe Storms, Straight-line Winds- FEMA-4056-DR-WA	
January 14-23, 2012	Severe Winter Storm- FEMA-DR-4056-WA	Pacific Northwest snowstorm was a large extratropical cyclone that brought record snowfall to the Pacific Northwest. Interstate 5 near Centralia, Washington, was closed temporarily due to power lines brought down by snowfall; the standard detour route was also blocked by trees and power lines.
January 11-21, 2011	Severe Winter Storm-FEMA-DR-1963-WA	
January 6-16, 2009	Severe Winter Storm, Landslides, Mudslides, and Flooding: FEMA-1817-DR	
December 12, 2008 to January 5, 2009	Severe Winter Storm and Record and Near Record Snow: FEMA-1825-DR	
December 1-17, 2007	Severe Storms: FEMA-DR-1734-WA	
November 29, 2007	Windstorm: Strong Low Pressure System	The storm was fed by the remnants of Typhoon Mitag and Typhoon Hagibis, formed in the central Pacific Ocean, and was carried via the Pineapple Express to the Pacific Northwest.
October 18, 2007	Windstorm: Gale	This low developed from the remnants of tropical storm Linling. Another cyclone developed right on the heels of this tropically-fed low, cutting off a large supply of cold air that probably would have contributed to a much stronger storm.
December 14-15, 2006	Severe Winter Storm: The Major Windstorm (Hanukkah Eve Windstorm)	
December 14-15, 2006	Severe Winter Storm, Landslides, and Mudslides: FEMA-DR-1671	
January 29-30, 2004	Windstorm: Minor Windstorm	
January 15-16, 2000	Windstorm: The Sou'wester	
January 1997	Severe Winter Storms/Flooding: FEMA-DR- 1159	
January 1997	Severe Ice and Snow Storms: FEMA-DR- 1152	
December 12, 1995	Windstorm: The Major West Coast Windstorm	

Date	Type of Event	Comment
January 20, 1993	Windstorm: The Devastating Inaugural Day Storm	
November 13-15, 1981	Windstorm	Double windstorms in 3 days. Gusts were 60 to 70 mph with Newaukum Hill station reporting 52 mph.
October 12, 1962	Windstorm	Columbus Day Storm was a tropical storm named Freda formed 500 miles (800 km) from Wake Island in the central Pacific Ocean. The system became an extratropical cyclone as it moved into colder waters and interacted with the jet stream. The low moved northeastward, and then hooked straight north as it neared southwest Oregon. The storm then raced nearly northward at an average speed of 40 miles per hour (64 km/h), with the center just 50 miles (80 km) off the Pacific Coast.
November 3, 1958	Windstorm	Wind came out of west with gusts around 60-80 mph.
October 26-27, 1950	Windstorm	The Double Windstorms.
October 21, 1934	WIndstorm	The Major Windstorm. Wind gusts reported around 80-90 mph.

12.2.2 Location

Severe weather events have the potential to happen anywhere in the planning area. Communities in low-lying areas next to streams or lakes are more susceptible to flooding. Wind events are often most damaging to areas that are heavily wooded due to falling trees.

The planning area as a whole may not be affected by a single event. For example, high winds usually occur in one area at a time. This is why the planning area as a whole will experience ‘limited’ extent, while a single community could be entirely affected by a high wind, thus being ‘severe.’

12.2.3 Frequency

Windstorms usually occur each fall and winter season, producing strong winds to 60 mph and causing power outages and property damage. Approximately once every 10 years, storms with winds of 70 mph or more pound the region and cause significant damage. These storms last an average of three to six hours of prolonged winds in one area before the storm moves on. Because a storm with winds in excess of 70 mph can happen often, preparedness and awareness are needed to avoid its disastrous effects.

12.2.4 Severity

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.

12.2.5 Warning Time

Meteorologists can often predict the likelihood of a severe storm. This can give several days of warning time. However, meteorologists cannot predict the exact time of onset or severity of the storm. Some storms may come on more quickly and have only a few hours of warning time.

12.3 Probability

12.3.1 Future Events

Over the past 20 years, there have been several severe weather events with some years having multiple events. It is likely that into the future there will be at least one severe weather event every year or every other year.

12.3.2 Climate Change Impacts

Climate change presents a significant challenge for risk management associated with severe weather. The frequency of severe weather events has increased steadily over the last century. The number of weather-related disasters during the 1990s was four times that of the 1950s, and cost 14 times as much in economic losses. According to the UW Climate Change Mapping for a Resilient Washington, Lewis County has a projected 3.4 degree maximum summer temperature increase in the next 30 years. The changing hydrograph caused by climate change could have a significant impact on the intensity, duration and frequency of storm events. All of these impacts could have significant economic consequences.

Not only can warmer temperatures increase the probability for severe weather events but heat stress can have devastating impacts on crop yields and livestock. Warmer summer temperatures may lead to an increased demand for irrigation water, further depleting water resources. As temperatures continue to warm, extreme precipitation becomes more likely.

12.3.3 Future Trends in Development

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, such as requiring more stringent building standards for areas with a high probability of strong winds or heavy snowfall. 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.

12.4 Vulnerability and Impacts

12.4.1 People

The entire planning area is exposed, to some extent, to severe weather events. Certain areas are more exposed due to geographic location and local weather patterns. 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 due to heavy rainstorms. The National Risk Index results are summarized in Table 12-2. See section 5.9 for a detailed description of the components of the NRI.

Vulnerable populations are the elderly, low income, or linguistically isolated populations, people with life-threatening illnesses, and residents living in areas that are isolated from major roads. Power outages can be life threatening to those dependent on electricity for life support. Isolation of these populations is a significant concern. These populations face isolation and exposure during severe weather events and could suffer more secondary effects of the hazard.

Furthermore, extreme heat and cold temperatures can have significant impacts on populations. Extreme heat events, such as the event in 2021, can lead to heat-related illnesses such as heat stroke. Vulnerable populations such as the elderly and infants are especially susceptible. Extreme cold can cause hypothermia and frostbite. Individuals without adequate shelter or clothing can face severe impacts from extreme cold weather.

Table 12-2. NRI Scoring for Severe Weather in Lewis County

Hazard Type	Expected Annual Loss	Social Vulnerability	Community Resilience	Community Risk Factor	Risk Value	Risk Index Score
Ice Storm	$78,572	Relatively High	Relatively Moderate	1.34	$101,985	58.6
Heat Wave	$63,153	Relatively High	Relatively Moderate	1.34	$79,959	48.7
Lightning	$35,964	Relatively High	Relatively Moderate	1.34	$44,668	23.9
Strong Wind	$29,137	Relatively High	Relatively Moderate	1.34	$37,516	9.2
Winter Weathre	$29,708	Relatively High	Relatively Moderate	1.34	$36,205	37.9
Hail	$3,951	Relatively High	Relatively Moderate	1.34	$4,513	5.6
Cold Wave	$4	Relatively High	Relatively Moderate	1.34	$4	28.7

12.4.2 Structures

According to the Lewis County Assessor, there are 21,841 buildings within the census tracts that define the planning area. All of these buildings are considered to be vulnerable to the severe weather hazard, but structures in poor condition or in particularly vulnerable locations (located on hilltops or exposed open areas) may be the most impacted. All structures and infrastructure vulnerable are at risk of being damaged by high winds or the effects of falling trees. The frequency and degree of damage will depend on specific locations.

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. If extreme cold events accompany a severe winter storm, pipes may freeze, resulting in property damage. In addition, during winter storms, heavy snowfall may accumulate of roofs, adding significant weight to the structure which may strain the roof's load-bearing capacity, potentially leading to roof collapse. Sleet and hail may cause dents, holes, or cracks in roofing materials.
- **Severe Thunderstorms**—Damage from thunderstorms in the planning area is most likely to be related to secondary hazards accompanying the event, such as flooding, landslides, 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, 2018). According to the American Community Survey, there are about 2,000 mobile homes in the planning area. Properties at higher elevations or on ridges may be more prone to wind damage. Falling trees can result in significant damage to structures. A major tornado could cause widespread damage to property in the planning area, but such an event is unlikely.

12.4.3 Critical Facilities and Systems

All systems and critical facilities within the County are vulnerable to severe weather.

Incapacity and loss of roads are the primary transportation failures resulting from severe weather, mostly associated with secondary hazards. Landslides caused by heavy prolonged rains can block roads are. High winds can cause significant damage to trees and power lines, blocking roads with debris, incapacitating transportation, isolating population, and disrupting ingress and egress. Snowstorms in higher elevations can significantly impact the transportation system and the availability of public safety services. Of particular concern are roads providing access to isolated areas and to the elderly.

Prolonged obstruction of major routes due to landslides, snow, debris, or floodwaters can disrupt the shipment of goods and other commerce. Large, prolonged storms can have negative economic impacts for an entire region.

Severe windstorms, downed trees, and ice can create serious impacts on above-ground power and communication lines. Frozen and ice-covered vegetation can fall on power and communication lines and can cause them to break, disrupting electricity and communication. Loss of electricity and phone connection would leave certain populations isolated because residents would be unable to call for assistance.

12.4.4 Natural, Historic, Cultural Resources, and Valued Activities

The environment is highly exposed to severe weather events. Natural habitats such as streams and trees are exposed to the elements during a severe storm and risk major damage and destruction. Prolonged rains can saturate soils and lead to slope failure. Flooding events caused by severe weather or snowmelt can produce river channel migration or damage riparian habitat.

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12.5 Secondary Hazards

The most significant secondary hazards associated with severe local storms are floods, falling and downed trees, landslides, and downed power lines. Rapidly melting snow combined with heavy rain can overwhelm both natural and man-made drainage systems, causing overflow and property destruction. Landslides occur when the soil on slopes becomes oversaturated and fails

12.6 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.

12.7 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.

CHAPTER 13. VOLCANO

13.1 General Background

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

Volcanic hazards can occur with or without an actual eruption. Non-eruptive events, such as the generation of debris flows or lahars, generally have no movement of magma and there may not be any detectable precursors to the event. Hazards associated with an eruption, or magmatic activity, can usually be detected through volcano monitoring and are able to provide warning time. The various types of volcanic hazards are described below.

13.1.1 Non-Magmatic Volcanic Hazards

Debris Flows
Debris flows of glacial ice and rock debris may be set in motion by explosions, earthquakes, and heat-induced melting of ice and snow, or the sudden release of water held within a glacier called a glacial outburst flood. A debris flow is a type of landslide that moves at high speeds.

Lahars
Lahars are volcanic mudflows consisting of dense mixtures of water-saturated debris that move down-valley, looking and behaving much like flowing concrete. They involve much greater quantities of material than do the normal debris flows and can cover many square miles of the valley bottom with mud and other debris many meters deep.

Toxic Gases
Pockets or clouds of toxic gases may develop on or near both active and inactive volcanoes. Their chemical poisons can cause internal and external burns, or asphyxiation through oxygen starvation. Gases that may be present include carbon dioxide, sulfur compounds, carbon monoxide, chlorine, fluorine, boron, ammonia, and various other compounds. Except for inside the summit caves these generally are dissipated rapidly by wind.

Landslide
Landslides from the sides of the volcano may be large or small, but all can have effects on valleys downstream. Depending on the size of the slide and the consistency and temperature of the material, some of them may transform into lahars.

13.1.2 Magmatic Volcanic Hazards

Volcanic Earthquakes
Earthquakes associated with volcanic activity will not directly cause major damage to areas surrounding the volcano, but they will give scientists important information about magma movement beneath the volcano. They could, however, potentially trigger landslides, which might result in debris flows or lahars

that could cause widespread damage to population centers in the valleys surrounding the volcano.

Lava Flows
Lava flows are masses of hot, partially molten to molten rock that flow downslope, generally following valleys. Lava flow from the Cascade volcanoes tend to have high viscosity.

Tephra
Tephra is the general term now used by volcanologists for airborne volcanic ejecta of any size. Table 13-1 identifies tephra types and related sizes.

Table 13-1. Tephra Types and Sizes.

Tephra Types	Sizes
Fine ash	<1/16 mm
Coarse ash	1/16 mm-2 mm
Lapilli	2-64 mm
Block and Bombs	>64 mm

Pyroclastic Flows and Surges
Pyroclastic flows and surges can occur during explosive eruptions. Pyroclastic flows are avalanches of hot ash, rock fragments, and gas that move at high speeds down the sides of a volcano during explosive eruptions or when the edge of a thick, viscous lava flow or dome breaks apart or collapses. Such flows can be as hot as 800 degrees Celsius and are capable of burning and destroying everything in their paths. As pyroclastic flows descend glaciers they are transformed into a lahar.

13.2 Hazard Profile

13.2.1 Past Events

Lewis County is located in an area where volcanic events have occurred in both the ancient and the recent past. Figure 13-1 summarizes past eruptions in the Cascades. Lewis County is located just north of Mt. St. Helens. In the 1980 Mt. St. Helens eruption, 23 square miles of volcanic material buried the North Fork of the Toutle River and there were 57 human fatalities.

The catastrophic eruption on May 18, 1980, was preceded by two months of intense activity that included more than 10,000 earthquakes, hundreds of small phreatic (steam blast) explosions, and the outward growth of the volcano's entire north flank by more than 80 meters. A magnitude 5.1 earthquake struck beneath the volcano at 8:32 a.m. on May 18, setting in motion the devastating eruption.

Within seconds of the earthquake, the volcano's bulging north flank slid away in the largest landslide in recorded history, triggering a destructive, lethal lateral blast of hot gas, steam, and rock debris that swept across the landscape as fast as 1,100 kilometers per hour. The lateral blast, which lasted only the first few minutes of a 9-hour continuous eruption, devastated more than 150 square miles of forest and recreation area, killed countless animals, and left about 60 persons dead or missing.

Temperatures within the blast reached as high as 300 degrees Celsius. Snow and ice on the volcano melted, forming torrents of water and rock debris that swept down river valleys leading from the volcano. Within minutes, a massive plume of ash thrust 15 miles into the sky, where the prevailing wind carried about 490 tons of ash across 57,000 square kilometers of the Western United States.

The 9-hour eruption, the huge debris avalanche that immediately preceded it, and intermittent eruptions during the following 3 days removed about 4 billion cubic yards (0.7 cubic mile) of new magmatic material and of the upper and northern parts of the mountain, including about 170 million cubic yards (0.03 cubic mile) of glacial snow and ice.

The eruption caused pyroclastic flows and mudflows, the largest of which produced deposits so extensive and voluminous that they reached and blocked the shipping channel of the Columbia River about 70 river miles from the volcano. Following the 1980 explosive eruption, more than a dozen extrusions of thick, pasty lava built a mound shaped lava dome in the new crater. The dome is about 1,100 meters in diameter and 250 meters tall.

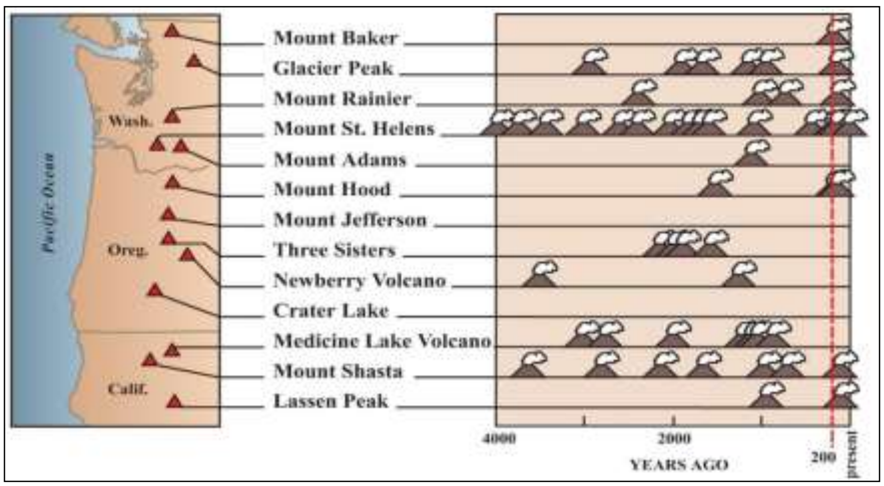

Figure 13-1. Past Eruptions in the Cascade Range.

13.2.2 Location

All of Lewis County is exposed to volcanic hazards associated with the Cascade Range. The Cascade Range extends more than 1,000 miles from southern British Columbia into northern California and includes 13 potentially active volcanic peaks in the US.

Lewis County could be affected by a volcanic eruption from Mt. St. Helens, Mt. Rainier, Mt. Baker, and Mt. Adams and Glacier Peak. Eruptions of Mt. Rainer, Mt. Adams, and Mt. St. Helens could directly affect Lewis County with lahars and lava flows. Lahars originating from Mt. Rainier's southwest area may flow into the Cowlitz River, impacting Packwood and Randle. Lahars originating from Mt. Rainier's southeast area may flow into the Nisqually River. Lahar flows from Mt. Adams will affect the community along the Cispus River. Figure 13-2 and Figure 13-3 show volcano hazard zones for Mt. Rainer and Mt. Adams.

Another major issue following an eruption would be dealing with the large amounts of volcanic ash. Ash can travel long distances before settling and could be from a distant volcano. Volcanic ash is pulverized rock ejected from a volcano. Unlike wood ash, newly ejected volcanic ash is sharp and abrasive. It can damage car finishes and scratch eyes. It can clog machinery, vents, and pipes, and can cause respiratory discomfort. In large enough quantities, its weight can be enough to collapse roofs, especially if it gets wet.

Most volcanoes in the Cascade Range are known to be "active," that is, to have erupted at least once during historical time. Few major Cascade volcanoes are known to have been inactive long enough to be considered "extinct" or incapable of further eruption. Most display some evidence of residual volcanic heat, such as fumaroles, hot springs, or hot ground where snow melt is unusually rapid.

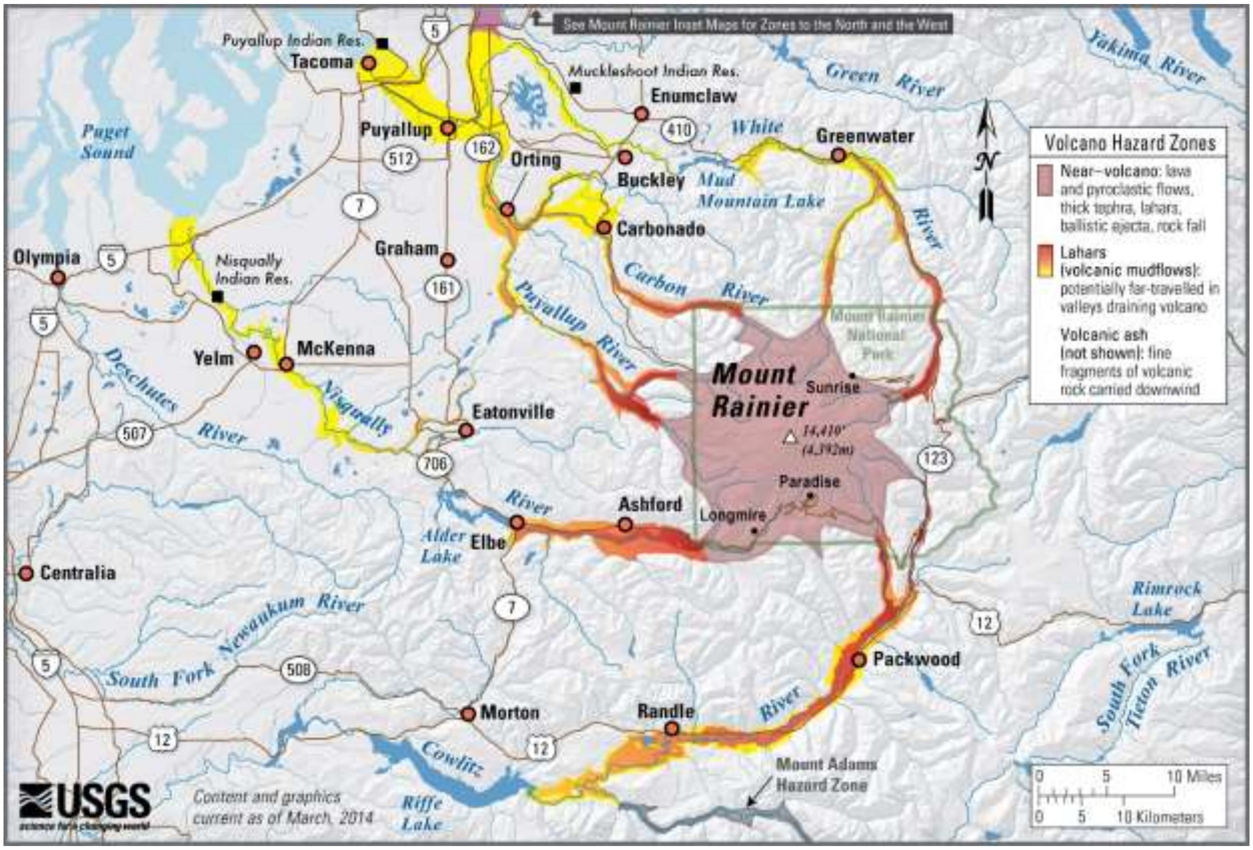

Figure 13-2. Mount Rainier Volcano Hazards.

13.2.3 Frequency

Many Cascade volcanoes have erupted in the recent past and will be active again in the foreseeable future. Given an average rate of one or two eruptions per century during the past 12,000 years, these disasters are not part of our everyday experience; however, in the past hundred years, California's Lassen Peak and Washington's Mt. St. Helens have erupted with terrifying results. The US Geological Survey classifies Glacier Peak, Mt. Adams, Mt. Baker, Mt. Hood, Mt. St. Helens, and Mt. Rainier as potentially active volcanoes in Washington State. Mt. St. Helens is by far the most active volcano in the Cascades, with four major explosive eruptions in the last 515 years. Figure 13-4 shows the annual probability of a tephra, or ash, accumulation of 10 centimeters or more (about 4 inches). Areas in Lewis County have a 1 in 5,000 to 10,000 (.02% to .01%) chance of receiving 10 centimeters of ash fall each year.

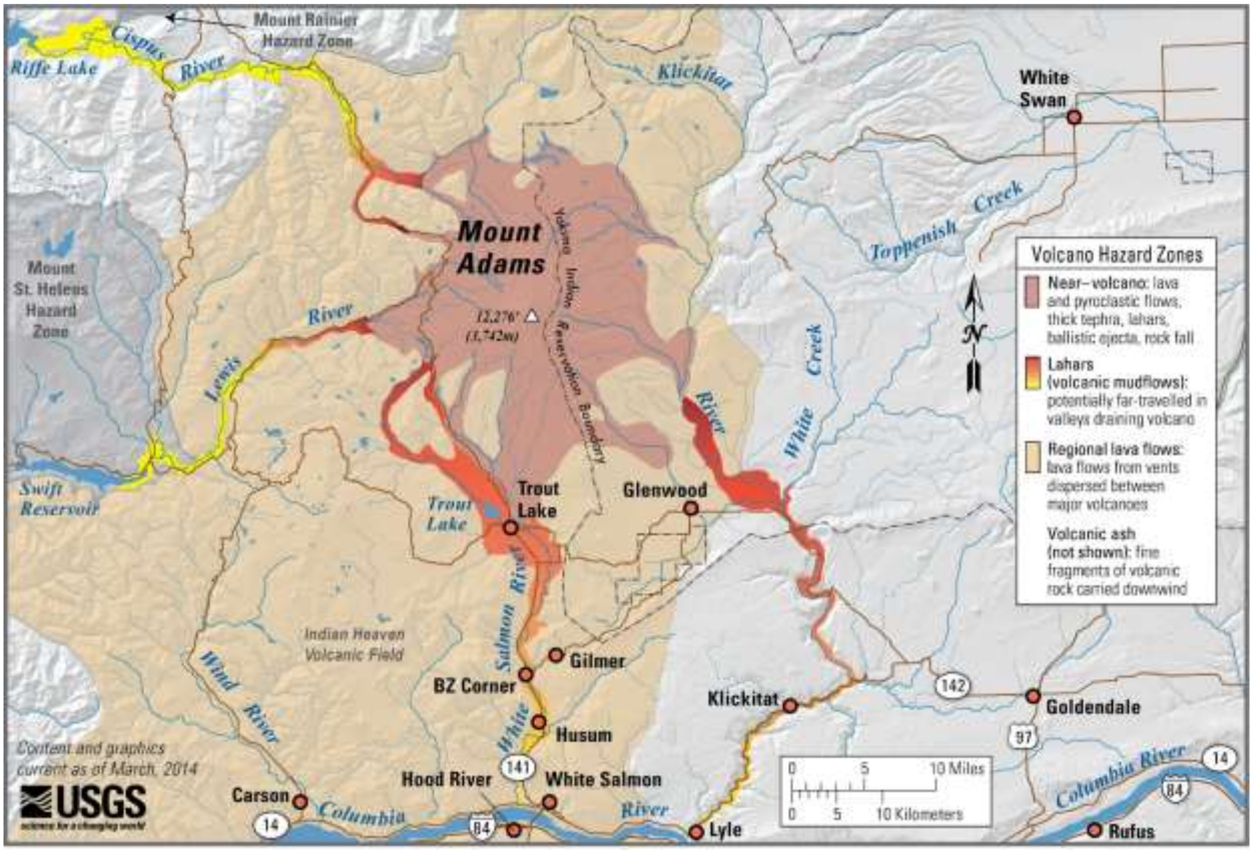

Figure 13-3. Mount Adams Volcano Hazard.

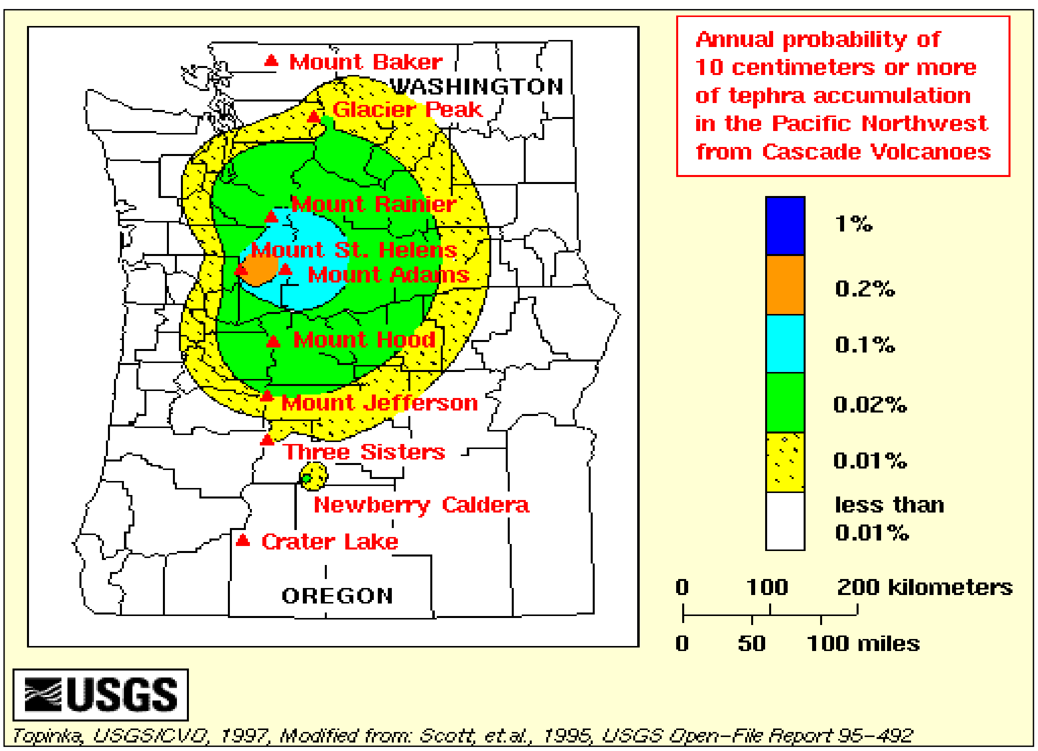

Figure 13-4. Probability of Tephra Accumulation in Pacific Northwest.

13.2.4 Severity

The explosive disintegration of Mt. St. Helens' north flank in 1980 vividly demonstrated the power that Cascade volcanoes can unleash. A one-inch-deep layer of ash weighs an average of 10 pounds per square foot, causing danger of structural collapse. Ash is harsh, acidic, and gritty, and it has a sulfuric odor. Ash may also carry a high static charge for up to two days after being ejected from a volcano. When an ash cloud combines with rain, sulfur dioxide in the cloud combines with the rainwater to form diluted sulfuric acid that may cause minor, but painful burns to the skin, eyes, nose, and throat.

Lahars have the potential to be the major destroyer of economic viability within Lewis County. Any major lahar coming down one of the valleys from Mt. Rainier will destroy the homes, businesses, and much of the infrastructure within whichever valley it descends.

Lahars are categorized by both cohesiveness and size. Case M, I, II, and III lahars are outlined below by their recurrence intervals:

Case M Lahars – The largest lahar to occur in the past 10,000 years is the Osceola Mudflow. It formed about 5,600 years ago when a massive debris avalanche of weak, chemically altered rock transformed into a lahar. Osceola deposits cover an area of about 212 square miles in the Puget Sound lowland, extending at least as far as Kent and to Commencement Bay in Tacoma. This lahar is at least 10 times larger than any other known lahar from Mount Rainier. Geologists believe flows of this magnitude occur far less frequently than once every 1,000 years.

Case I Lahars – Cohesive lahars originate as enormous avalanches of weak, chemically altered rock from the volcano. They can occur with or without eruptive activity. Most Case I flows have reached some part of the Puget Sound lowland. The Electron Mudflow reached the lowland about 600 years ago along the Puyallup River. Average recurrence rate for Case I lahars on Mt. Rainier is about 500 to 1,000 years.

Case II Lahars – Usually relatively large non-cohesive lahars, most commonly are caused by melting of snow and glacier ice by hot rock fragments during eruption, but which can also have a non-eruptive origin. More than a dozen lahars of this type have occurred in the past 6,000 years. A few have reached the Puget Sound lowland, including the National Lahar, which occurred about 2,000 years ago. It inundated the Nisqually River valley to depths of 30 to 120 feet and flowed all the way to Puget Sound. The average time interval between Case II lahars from Mt. Rainier is near the lower end of the 100-to-500-year range.

Case III Lahars – This class of flows includes small debris avalanches as well as debris flows triggered by sudden, unpredictable release of water stored by glaciers. These debris flows are largely restricted to the slopes of the volcano, rarely moving beyond the National Park boundary; since 1926, outburst floods destroyed or damaged bridges, roads, and national park visitor facilities on about 10 occasions. Glacial outburst floods are unrelated to volcanic activity and typically coincide with periods of unusually high temperatures or unusually heavy rain in summer or early autumn. About three dozen such flows occurred during the 20th century. Case III lahars occur at an average time interval at Mt. Rainier of about 1 to 100 years.

Magmatic or Eruption Triggered Lahar
As the developing threat from the volcano is recognized by the scientists and they begin to warn the public there will be some time for some people and business to move some of their belongings, records

and goods to higher ground. However, no matter how much they are able to save this way, the economic recovery will be long and hard. With the destruction of homes and the physical structures of the businesses in the valley, people will have no option except to leave the area and find homes and work elsewhere.

Spontaneous Lahar

With a spontaneous lahar, almost no community in the pathway of the lahar will have the ability to adequately protect its assets. This is the worst-case scenario. There could be a total loss of homes and businesses in the impacted area. With buildings, equipment, records, inventories, and community infrastructure gone, no business in the lahar zone will be able to restart immediately. Even attempting to reestablish their business at a different location, outside the inundation zone, will, in many cases, fall short. With the exodus by many members of the community, numerous businesses will have little incentive to even attempt rebuilding in the valley.

13.2.5 Warning Time

Constant monitoring of all active volcanoes means that there should adequate time for evacuation before an event. Mt. Rainer has a lahar detection and warning system for the Puyallup and Nisqually River systems. The warnings will be publicized on television, radio, NOAA weather radio, social media, and other broadcast platforms (USGS, 2023). Since 1980, Mt. St. Helens has settled into a pattern of intermittent, moderate and generally non-explosive activity, and the severity of tephra, explosions, and lava flows have diminished. All episodes, except for one very small event in 1984, have been successfully predicted several days to three weeks in advance. However, scientists remain uncertain as to whether the volcano’s current cycle of explosivity ended with the 1980 explosion. The possibility of further large-scale events continues for the foreseeable future.

13.3 Probability

13.3.1 Future Events

Future volcanic events will occur; however, without any indications of activity it is difficult to predict when the next major event will happen.

13.3.2 Climate Change Impacts

Climate change is not likely to affect volcanic hazards; however, volcanic hazards can cause changes to the climate. Large-scale volcanic eruptions can reduce the amount of solar radiation reaching the Earth’s surface, lowering temperatures in the lower atmosphere and changing atmospheric circulation patterns. The massive outpouring of gases and ash can influence climate patterns for years. Sulfuric gases convert to sub-micron droplets containing about 75 percent sulfuric acid. These particles can linger three to four years in the stratosphere. Volcanic clouds absorb terrestrial radiation and scatter a significant amount of incoming solar radiation, an effect that can last from two to three years following a volcanic eruption.

13.3.3 Future Trends in Development

As populations in Lewis County continue to grow and urban areas expand, more people, properties, and critical facilities may encroach upon volcanic hazard zones and lahar hazard areas. This can greatly increase the potential for human and economic loss during volcanic eruptions. All future development has the potential of being impacted by ash fall generated from volcanic events. The weight of the ash should be taken into consideration when new construction occurs to ensure reduced impact from damaging events by strengthening the load values of roofs.

13.4 Vulnerability and Impacts

Lewis County could be inflicted with results from a volcanic eruption from Mt. St. Helens, Mt. Hood, Mt. Adams, Mt. Rainier, Mt. Baker, and Glacier Peak. For the purpose of planning, this chapter will analyze the vulnerability and impact of the most likely scenarios of a volcanic event at Mt. Rainier and Mt. Adams that causes a lahar to flow into a river valley into Lewis County.

Ash fallout from the explosive events of volcanos can inflict upon the county as much devastation as a severe winter storm. Transportation, utilities, and communication can be interrupted, and masses of people stranded. The clean-up from ash fall will inflict enormous economic loss. However, due to the unpredictable nature of an ash fall, the damage is difficult to quantify.

Lahars coming down one or more valleys from Mt. Rainier or Mt. Adams have the potential to cause the highest number of fatalities and casualties of any hazard treated in this risk assessment. In Lewis County, the difference in the impact on the population will be highly dependent on whether the lahar was a result of increasing volcanic activity or is due to the spontaneous collapse of a portion of the mountain. Lahars can be devastating in their consequences.

The vulnerability analysis analyzed the estimated exposure of populations and structures for Mt. Rainer lahar flows into the Cowlitz River valley and Nisqually River valley. For Mt. Adams, the Hazus analysis focused on the Cispus River valley.

13.4.1 People

The whole population of Lewis County is vulnerable to the effects of a tephra fall. The populations most vulnerable are the elderly, the very young and those already experiencing ear, nose, and throat problems. Homeless people, who may lack adequate shelter, are also vulnerable to the effects of a tephra fall.

The National Risk Index identified areas as very high risk for volcanic activity in the western portion of the County and areas located along Interstate 5 including Napavine, Chehalis, Centralia, and Fords Prairie. Very high-risk area designations account 63.3% (52,000) of the population.

No people within cities are vulnerable to the direct effects of a lahar flow from Mt. Adams or Mt. Rainer. Within the unincorporated County, there are 279 people vulnerable to a lahar flow from Mt. Adams along the Cispus River valley. There are 6,072 people vulnerable to a lahar flow from Mt. Rainer, in both the Cowlitz River valley and Nisqually River valley. Due to the nature of a lahar flow, the effects on people unable to evacuate may be death or severe injury.

Table 13-2 provides a breakdown of the risk factor for volcano in Lewis County. See section 5.9 for a detailed description of the components of the NRI.

Table 13-2. NRI Scoring for Volcano in Lewis County

Expected Annual Loss	Social Vulnerability	Community Resilience	Community Risk Factor	Risk Value	Risk Index Score
$7,689,816	Relatively High	Relatively Moderate	1.34	$10,045,415	93.3

13.4.2 Structures

All of the property and infrastructure exposed to nature in the County are exposed to the effects of a tephra fall and lahars. Vulnerable property includes equipment and machinery left out in the open, such as combines, whose parts can become clogged by the fine dust. Additionally, roofs may not be built to withstand the weight of ash, especially when mixed with rain or snow, which would increase its weight. This could potentially impact both public and private structures.

No structures within the cities are exposed to Mt. Adams or Mt. Rainier lahar flows. Within the unincorporated County, there are 165 structures exposed to lahar flows from Mt. Adams, including 135 residential, 13 commercial, 1 government, and 16 education structures. The value of those structures and contents is $62,673,373. There are 3,081 structures exposed to Mt. Rainer lahar flows, including 2,939 residential, 96 commercial, 4 industrial, 7 agricultural, 8 religion, 22 government, and 5 education structures. The value of those structures is $1,048,929,083.

13.4.3 Critical Facilities and Systems

All systems in Lewis County can be affected by tephra fall. As demonstrated by the Mt. St. Helens ash fall, systems can experience significant damage or disruption. Vehicle engines can be damaged by the fine ash. Roads are blocked. Stormwater and water systems become clogged.

In the unincorporated County, there are 2 energy, 7 health and medical, 9 safety and security, and 44 transportation systems that may be impacted by lahar flows.

13.4.4 Natural, Historic, Cultural Resources, and Valued Activities

The environment is highly vulnerable to the effects of a volcanic eruption. Even if the related ash fall from a volcanic eruption were to fall elsewhere, it could still be spread throughout the County by the surrounding rivers and streams. A volcanic blast would expose the local environment to many effects such as lower air quality, and many other elements that could harm local vegetation and water quality.

13.5 Secondary Hazards

The secondary hazards associated with volcanic eruptions are customarily mud flows and landslides, as well as traffic disruptions and increased issues with respect to dust storms recirculating the ash.

13.6 Scenario

In the event of a volcanic eruption in Lewis County, while there would probably not be any loss of life due to adequate warnings, the potential does exist due to the relatively large amounts of ash fall which occurred during the eruption of Mt. St Helens. The elderly, the young, and individuals with breathing problems would be at greater risk of impact. There would also be loss of use property and crops due to ash and sulfuric acid developing when the ash mixes with rain or snow. The economic impact from ash fall and the continuing issue of ash becoming airborne as a result of dust storms would continue for years into the future. People and animals without shelter would be affected, as would farm equipment which was left out in the open.

Lahars are the primary force that will damage the infrastructure, property, and facilities. They will flatten buildings, destroy equipment, bury roads, take out power lines and destroy sewer pumping systems. A major lahar coming down any of the river systems from Mount Rainier will damage, destroy or bury all facilities, property and infrastructure that are above ground in the impacted area. Only those areas on the periphery or where the flow weakens, thins out and reduces in speed and volume will have any chance of survival.

Current buried pipes, power lines, etc. should not be damaged directly; although where they rise to the surface, they can be damaged. However, having a sewer line buried under an extra 15 feet of mud in a community that no longer exists is essentially worthless. In areas where the lahar is shallow, many of these underground utilities may be able to be rehabilitated. The extent of damage will be directly correlated with the quantity of debris the volcano coughs up. Smaller lahars will not cover as much territory as the larger lahar would and cause less damage.

CHAPTER 14. WILDFIRE

14.1 General Background

14.1.1 Factors Affecting Wildfire Risk

A wildfire is an uncontrolled fire on undeveloped or developed land that in most cases, but not all, requires fire suppression. Wildfires can be ignited by lightning or by human activity such as smoking, campfires, equipment use, and arson. Wildfires occur when an ignition source in a wooded or grassy area is brought into contact with a combustible material such as vegetation, with an adequate supply of oxygen from the ambient air.

A wildfire front is the portion of a wildfire sustaining continuous flaming combustion, where unburned material meets active flames. As the front approaches, the fire heats both the surrounding air and vegetative material through convection and thermal radiation. First, vegetative material is dried as water in it is vaporized at a temperature of 212ºF. Next, the wood releases flammable gases at 450ºF. Finally, wood can smolder at 720ºF, and ignite at 1,000ºF. Before the flames of a wildfire arrive at a particular location, heat transfer from the wildfire front can warm the air to 1,470ºF, which pre-heats and dries flammable materials, causing them to ignite faster and allowing the fire to spread faster. High temperature and long-duration surface wildfires may encourage flashover or torching: the drying of tree canopies and their subsequent ignition from below.

Large wildfires may affect air currents by the stack effect: air rises as it is heated, so large wildfires create powerful updrafts that draw in new, cooler air from surrounding areas in thermal columns. Great vertical differences in temperature and humidity encourage fire-created clouds, strong winds, and fire whirls with the force of tornadoes at speeds of more than 50 mph. Rapid rates of spread, prolific crown fires, the presence of fire whirls, and strong convection columns signify extreme conditions.

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. Generally speaking, 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. These slopes also tend to be on the windward side of mountains. Thus, these slopes tend to be “available to burn” a greater portion of the year.

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 physical properties of fuels govern how fires burn. Fuel loading, size and shape, moisture

content, and continuity and arrangement all have an effect on 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. This is apparent to anyone who has ever witnessed the speed at which grass fires burn. 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. That is, they release much more energy. 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, which determines how fires will burn.

The study of fire behavior recognizes the dramatic and often-unexpected effect small changes in any single component have on 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. In western Washington, foehn winds, or east wind events as they are called locally, have the potential to cause catastrophic events. A foehn wind blows warm and dry air over a mountain range and down the leeward side. These east winds cause significant drying, warming, and downslope high winds that can cause extreme fire behavior, especially in areas in east County. The homes and communities throughout the county could be impacted by east wind extreme fire behavior, however a significantly higher risk exists in the communities (and intermix homes/properties) around the Morton, Randle, and Packwood area.

14.1.2 Wildfire Types

Fire types can be generally characterized by their fuels as follows:

- **Ground fires** are fed by roots and other buried organic matter. Ground fires typically burn by smoldering and can burn slowly for days to months.
- **Crawling or surface fires** are fueled by low-lying vegetation such as tree litter, grass, and low shrubbery.

- **Ladder fires** consume material between low-level vegetation and tree canopies, such as small trees, downed logs and vines. Invasive plants that scale trees may encourage ladder fires.
- **Crown, canopy or aerial fires** burn suspended material at the canopy level, such as tall trees, vines and mosses. The ignition of a crown fire depends on the density of the suspended material, canopy height, canopy continuity, and the presence of surface and ladder fires to reach the tree crowns.

14.2 Hazard Profile

14.2.1 Wildfire Risk in Western Washington

Traditional risk assessments categorize most areas west of the Cascade Range as low-to-moderate wildfire risk, due to the very low probability of wildfire occurrence. The low probability of fire is based on the fact that an average of less than 4,000 acres have burned annually in western Washington since 1984, when contemporary fire mapping began. There are over 13 million acres of forest in western Washington. However, the number of acres burned is increasing, with 17,630 acres lost per year over the last five years. The Wildfire Hazard Potential uses a similar definition of wildfire hazard that relies on mean estimates of burn probability. Although traditional risk metrics are relatively low, fire risk mitigation and preparedness are still critical in western Washington, as detailed below.

It is important to recognize that risk mitigation is also about the risk tolerance of the community, homeowner, forest manager, legislator, etc. Conditions on the ground are changing with climate change, translating into longer fire seasons, increased fuel aridity, prolonged drought conditions and sprawling wildland-urban interface that support a steady flow of ignitions.

For reference, eastern Washington is about twice as large as western Washington, with only one-fifth of the population. This means a much higher density of structures in many parts of western Washington. The amount and density of housing/structures in western Washington dramatically changes the ‘fuels’ of this region. Since many of these structures are built in areas with one ingress/egress route, evacuation challenges are often much higher. There are more values at risk, ignitions, and drought than there was 200 years ago. The impacts of these fires, should they happen, will be significant and likely to increase over time.

Steps towards fire preparedness should be focused on home hardening as well as evacuation preparedness activities. This can include shaded fuel breaks along primary and secondary ingress and egress routes, developing household and community evacuation plans, and outfitting properties with signage that is visible in smoke-heavy conditions. The uncertainty associated with how much and how fast fire regimes might change in western Washington and the destructive potential of western Washington fires might elicit action for a community, even if the likelihood of fire is low.

2022 was the first year that the area burned on the westside surpassed the area burned on the eastside in Washington, since consistent fire perimeter records were maintained. This serves as another indicator of the need to address fire risk on the westside and what these hazard and risk metrics mean for the socio-ecological landscape. (Reference: WADNR - https://www.dnr.wa.gov/WildfireDefense**)**

14.2.1 Fire History

Lewis County's fire season runs from approximately mid-May through October. Dry periods can extend throughout the season. The possibility of a wildland fire depends on fuel availability, topography, the time of year, weather, and activities such as debris burning, land clearing, camping, and recreation. In Washington, wildland fires start most often in lawns, fields, open areas, transportation areas, and wooded wildland areas. They are usually extinguished with less minor damage but can spread to over 100,000 acres and may require thousands of firefighters several weeks to extinguish. Wildland fire protection can be provided by federal, state, county, city, and private fire protection agencies.

Historically, Lewis County fires have been small and quickly contained. Table 14-1 shows the number of fires and acres burned from 2008-2023. Over the past two years, more acreage has burned than any previous year. In 2022, the Goat Rocks Fire burned 6,196 acres. In 2023, the Cowlitz Complex burned 721 acres. Although smaller in size, the Cowlitz Complex began as 30 individual fires that were started due to a dry lightning storm.

Table 14-1. Fire History.

Jurisdiction	2008[1]	2009	2010	2011	2012	2013	2014-2021	2022	2023[2]
Number of Fires	19	29	11	15	34	25	N/A	N/A	30+
Acres Burned	37	15	7	7	377	302	N/A	6,196[1]	868+

[1] Source: Washington State Enhanced Hazard Mitigation Plan, October 2013
[2] Source: Chronicle Online, 2023; Inciweb, 2023
[2] Source: Inciweb, 2022

14.2.2 Location

A wildfire or major brush fire could occur anywhere within Lewis County. However, due to varying terrain, vegetation, and climate, the eastern portion of the County has the most wildfire fuels and the greatest risk. The large fires that have occurred in the past two years both were located in the east part of the County, which receives far less rainfall than the western part of the County and is more remote and difficult to access. Identifying specific areas most at risk to fire or to determine the course a fire takes requires precise science. It is not the intent of this plan to make those assumptions.

Figure 14-1 shows the Wildfire Risk to Communities' burn probability dataset, and DNR's wildland urban intermix and wildland urban interface dataset. There is a delineation, indicated by the vertical black line, where the risk of wildfire in Lewis County increases from low/medium threat in the western part of Lewis County to high/very high threat in the eastern part of Lewis County. When reviewing the wildfire risks to Lewis County, in particular the eastern side of Lewis County, we took into consideration all the factors below. We also considered the number of structures, including critical infrastructure such as Hwy 12 that have been and will continue to be impacted by wildland fires. The below items are factors that were considered when rating East Lewis County as high/very high:

- Mapping resources provided by DNR and Wilfirerisk.org
- Discussions with local Fire Chiefs and local partners like United States Forest Service and Washington State Department of Natural Resources

- Deployments of Type 1 (Complex) Incident Management Teams within the last two years for, at minimum, 6-week deployments.
- Two level 3 evacuations the past two years due to wildfire structural threats
- Direct impacts to the community and the state due to wildfire threats.
- An increased costs in fire suppression efforts.
- An increase in dry lighting incidents and east wind events, sparking fires in nearby communities.
- Response areas are covered by volunteer fire departments limiting initial fire attack capabilities.
- A lack of community awareness and knowledge of wildfire threats.

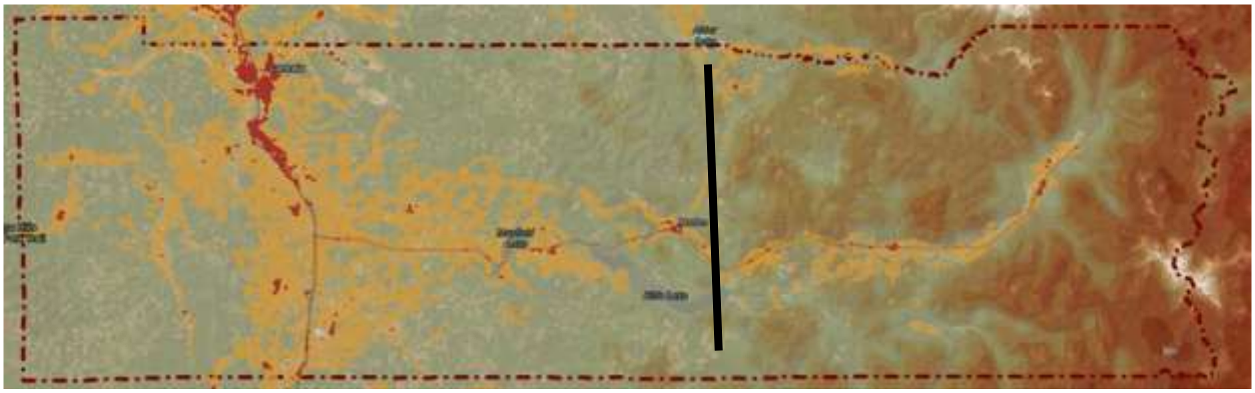

Figure 14-1. High risk area of Lewis County (locally determined).

14.2.3 Frequency

Wildfires occur every year in Lewis County. Until the past two years, large fires have been infrequent. Due to climate change projections and the increase of high fire danger days and increase in the likelihood of fires, large wildfires are anticipated to occur more frequently in Lewis County.

14.2.4 Severity

Risk to communities is generally determined by the number, size, and types of wildfires that have historically affected the area. However, due to the large-scale wildfires that have impacted the region in recent years, the severity of wildfires in Lewis County needs to be based on more than the historical fire regime. Other factors that are utilize to determine the severity include topography; fuel and weather; suppression capability of local and regional resources; where and what types of structures are in the WUI; and what types of pre-fire mitigation activities have been completed.

The historical fire regime of western Washington varied across space, but fire effects and severity were driven primarily by infrequent east wind events. Some areas burned more frequently and less severely, including parts of lowland Puget Sound, Southwest Washington, and the San Juan Islands, tended through Indigenous fire stewardship.

The vast majority of forested acres, however, burned infrequently (every 200-400 years) in very large and severe fires, destroying hundreds of thousands of acres. Western Washington has not had a truly large fire year since the Yacolt Burn in 1902. Thus, large fires are under-represented in the contemporary fire history used to develop burn probability estimates. Because historical fire regimes are

variable, understanding local context is particularly important for western Washington fires, and using local knowledge of fire history and patterns of fire spread and fire weather is recommended.
Most fires result from a “perfect storm” of factors: seasonal drought, high east wind events, and an ignition. Without high winds, suppression and rapid containment is generally possible and thus fire remain small. In 2020, the perfect storm occurred in the Labor Day fires in western Oregon that burned 840 thousand acres, most of which burned at high severity in a 48-hour period. These fires served as a reminder that the western Washington can burn with catastrophic loss.

In 2022, the Bolt Creek (King, Snohomish Counties) and Nakia Creek (Clark County) Fires ignited during strong east wind events and spread rapidly. Fortunately, these east wind events were short lived. If the winds had continued, these fires would have burned through a number of communities in western Washington.

Local analysis of fire risk has determined that large parts of Lewis County have high to very high wildfire risk to the communities within Lewis County. The severe wildfires occurring over the past few years have caused level 3 evacuations and required Type 1 (Complex) Incident Management Team deployment in the County. Fire personnel, including Fire Chiefs, have indicated that the change in hotter dryer summers have caused fires to grow substantially, especially during east wind events. They are concerned that with limited personnel available for initial attack in the county rapid fire growth and extreme fire behavior will overwhelm local resources quickly resulting in the potential for catastrophic loss during these extreme weather events.

Smoke and air pollution from wildfires can be a health hazard, especially for sensitive populations including children, the elderly and those with respiratory and cardiovascular diseases. Wildfire may also threaten the health and safety of those fighting the fires. First responders are exposed to the dangers from the initial incident and after-effects from smoke inhalation and heat stroke. In addition, wildfire can lead to ancillary impacts such as landslides in steep ravine areas and flooding due to the impacts of silt in local watersheds.

Historically, irrigated farmlands, improved fire spotting techniques, better equipment, and trained personnel were major factors in the fairly low severity wildland fires that previously occurred in the county. However, in recent years, it became evident that there is a lack of personnel available for initial attack and there is a need to expand resources.

14.2.5 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.

If a fire does break out and spread rapidly, residents may need to evacuate immediately. A fire’s peak burning period generally is between 1 p.m. and 6 p.m. However, during east wind events fires can grow rapidly and substantially throughout the night. These events create the greatest threat and a significant risk in east Lewis County due to limited initial attack resources, and lack of knowledge and experience from homeowners, with little defensible space for many structures. Once a fire has started, fire alerting is reasonably fast in most cases. The ubiquitous use of cellular technology and two-way radio communications in recent years has further contributed to a significant improvement in warning time.

An issue unique to east Lewis County is the number of summer-time tourists. When those tourists are in the area of a wildfire, they may not receive notices through their cell phone due to limited coverage in the mountainous area. People traveling to east Lewis County may be unaware of wildfires and closures. In addition, the owners of short term rentals in east Lewis County are often not local and may also not be aware of wildfire. This poses a challenge to providing warning to tourists.

The Washington Department of Natural Resources maintains an online Burn Risk Map. Residents can view current information about the wildfire danger in Washington, as well as any information on outdoor burning restrictions. This site provides information on when conditions are right for destructive wildfires (Washington Department of Natural Resources, 2023).

14.3 Probability

14.3.1 Future Events

Wildfires occur every year in Lewis County. 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. 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, snow pack, 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.

Traditional risk assessments categorize most areas west of the Cascade Range as low-to-moderate wildfire risk, due to the very low probability of wildfire occurrence. The low probability of fire is based on the fact that an average of less than 4,000 acres have burned annually in western Washington since 1984, when contemporary fire mapping began. There are over 13 million acres of forest in western Washington. However, the number of acres burned is increasing, with 17,630 acres lost per year over the last five years. The Wildfire Hazard Potential uses a similar definition of wildfire hazard that relies on mean estimates of burn probability. Although traditional risk metrics are relatively low, fire risk mitigation and preparedness are still critical in western Washington.

Late season east wind events are a significant concern for several communities in Lewis County, with an even greater risk in east Lewis County. The last two Type 1 incidents in the last two years have been late season east wind events which extended until season ending rains arrived at the end of October, early November. These late season events are driven by east winds, dry fuels, and limited resources. For the last two years, these late season events have cause level 3 evacuations and Type 1 (Complex) Incident Management Teams (Type 1 IMT's) to come in an manage these incidents.

14.3.2 Climate Change

Fire in western ecosystems is determined by climate variability, local topography, and human intervention. Climate change has the potential to affect multiple elements of the wildfire system: fire behavior, ignitions, fire management, and vegetation fuels. Hot dry spells create the highest fire risk. Increased temperatures may intensify wildfire danger by warming and drying out vegetation. When climate alters fuel loads and fuel moisture, forest susceptibility to wildfires changes. Climate change also may increase winds that spread fires. Faster fires are harder to contain, and thus are more likely to expand into residential neighborhoods.

The UW Climate Mapping for Resilient Washington map indicates that high temperatures in summer are predicted to increase by over 3 degrees F over the next 30 years and some parts of the County are expected to have a decrease in the annual precipitation and the annual snowpack, which may increase the chances of a drought. These climate changes are predicted to cause Lewis County to experience average of 6 additional fire hazard days per year within the next 30 years. Over the next 50 years, the western portion of the County is predicted to experience 11-12 additional high fire danger days each year. The maps also predict that over the next 30 years, the eastern portion of the county will have a 30% chance each year that there will be the climate and fuel conditions conducive to wildfires. Over the next 50 years, it is predicted that a larger area of the east county will have a 30-50% of conducive wildfire conditions each year.

14.3.3 Future Trends in Development

As the County's population grows, there will be more expansion into the wildlands, increasing the number of vulnerable structures and people living in higher risk areas in the County. This will create more opportunities for human caused fires and the demand for firefighting capabilities. The expansion of the wildland urban interface can be managed with strong land use and building codes that require homes to be constructed in a manner which reduces the impacts of wildfires and ensuring fire districts capabilities also grow with the population.

14.4 Vulnerability and Impacts

To determine vulnerability and impacts, the analysis initially used two data sources from WIldfirerisk.org and the Wildland Urban Interface (WUI) Areas data from Washington Department of Natural Resources. The Wildfirerisk.org data included Risk to Homes and Wildfire Likelihood. After reviewing the results of the risk assessment using the Wildfirerisk.org data, the County determined that the risk did not accurately portray actual conditions and conducted a local risk assessment using factors such as topography, fuel and weather, suppression capability oflocal and regional resources, where and what types of structures are in the WUI, and what types of pre-fire mitigation activities have been completed. The local assessment found the eastern half of the county to have a much higher risk compared to the Wildfirerisk.org data, which identified the developed areas as primarily low likelihood (0.01% to 0.1% annual chance) and a moderate risk to homes.

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.

14.4.1 People

Everyone in Lewis County is vulnerable to a wildfire if located near one. However, the Wildfirerisk.org national dataset found that almost the entire population (94.8%) reside in areas with a very low fire likelihood (0% to 0.01% annual chance).

However, local expertise and recent fire activity demonstrate that these numbers may be significantly underscoring the true vulnerability of people to wildfires in Lewis County. In particular, the communities of Morton, Randle and Packwood have been identified by local fire personnel and the Lewis County Emergency Management Department as being vulnerable to wildfires, especially during east wind events. There are thousands of tourists that visit Morton, Randle and Packwood during the summer and are vulnerable to wildfire, perhaps even more vulnerable because they do not have knowledge of the area and communication tools or knowledge of the area to effectively evacuate.

Using the locally determined high risk area, there are approximately 5,300 people who live in areas with a high risk of wildfire. However, the eastern part of the county is a tourist destination, especially during the summers, so the actual population at any one time is likely understated.

All people within the County can be impacted by wildfires. Even if they are not directly impacted, smoke and air pollution from nearby or distant 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 a wildfire if there is not adequate warning time before evacuation is needed.

Though wildfires are not new to the area, the threat from large catastrophic incidents are. While some residents and business owners in Lewis County are aware of the wildfire threat here in the county, many have little knowledge and even less experience with large, fast-moving wildfires. Some of these communities are low income with high vulnerability so there is an ever-increasing need to bolster wildfire prevention and education outreach and community mitigation strategies throughout Lewis County.

14.4.2 Structures

The WUI data identifies developed areas that interface or intermix with the wildlands. Wildlands can be forests, grasslands, or other vegetation that has more than 50% burnable cover. As wildlands are developed, they turn into interface or intermix areas. The WUI map does not define risk. It does not consider climate, vegetation moisture contents, or other factors that better define risk.

During the wildfire incidents over the past two years, the Type 1 (Complex) Incident Management Teams (Teams) have conducted structural protection assessments throughout high/very high-risk areas. During the outreach and data collection for these assessments it was determined that many homes do not meet the protections and defensible space standards for wildfire protection. Unfortunately numerous homes and businesses were indicated as non-defensible – prep and leave, to non-defensible rescue drive-by.

All structures within the County are vulnerable to wildfires and can be impacted. Even areas of the County with the lowest risk are vulnerable because any structure in the path of a wildfire, no matter how severe, can be impacted. However, only a few structures are located in areas with a higher annual burn probability and greater risk to homes. Property owners can take measures to reduce their vulnerability to wildfires, such as removing flammable vegetation growing near the structure and using fireproof roofing and siding. See Table 14-2 for the number of buildings exposed and value of the structures and contents.

Table 14-2. High Wildfire Likelihood and High Risk to Homes (locally determined).

Jurisdiction	Total Buildings Exposed	Residential Buildings	Total Value	Percent of Total Value
Lewis County	**3,993**	**3,857**	**$1,244,977,145**	**6%**

14.4.3 Critical Facilities and Systems

All systems within the County are vulnerable to wildfire and can experience direct or indirect disruptions as a result of a wildfire. Systems that are flammable, such as wooden structures and power poles, can be destroyed during a fire. Roads can be blocked and power outages may occur, which will affect all critical facilities that do not have backup power.

With the increasing wildfire danger, exacerbated by east wind events, and limited resources available for initial attack, critical facilities and systems have a greater threat to ignitability and total loss. Should there be damages to critical facilities and systems, many of which do not have redundancies, there will be disruption to surrounding communities and the County.

14.4.4 Natural, Historic, Cultural Resources, and Valued Activities

All natural resources and habitats within the County are vulnerable to wildfires. 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.

14.6 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.

14.7 Scenario

A major conflagration in Lewis County might begin with a wet spring, adding to fuels already present. 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 from the east. 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 miles by hot, dry winds. The deposition zone for these embers could be in wooded areas or an interface zone. 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.

14.8 Issues

The major issues for wildfire are the following:

- Public education and outreach to people living in or near the fire hazard zones should include information about and assistance with mitigation activities such as defensible space, and advance identification of evacuation routes and safe zones.
- Wildfires could cause landslides as a secondary natural hazard.
- Climate change can lead to higher severity or more frequent wildfires.
- Future growth into interface areas should continue to be managed.
- Area fire districts need to continue to train on wildland-urban interface events.
- Vegetation management activities. This would include enhancement through expansion of the target areas as well as additional resources.
- Regional consistency of higher building code standards such as residential sprinkler requirements and prohibitive combustible roof standards.
- Lack of initial attack resources?
- Expand certifications and qualifications for fire department personnel. Ensure that all firefighters are trained in basic wildfire behavior, basic fire weather, and that all company officers and chief level officers are trained in the wildland command and strike team leader.

14.9 Wildfire Mitigation Actions

Table 14-3. Wildfire Mitigation Actions.

Benefits New or Existing Assets	Objectives Met	Lead Agency	Support Agency	Estimated Cost	Sources of Funding	Timeline[a]
Fuels Reduction						
Action WF-1— Conduct hazard fuel reduction projects on the lands surrounding the developments of: High Valley, Goat Rocks, Timberline, Cispus, Silverbrook, etc, including the Cispus Environmental Learning Center.						
Hazards Mitigated: Wildfire						
New and Existing	1,5	Fire District 10, 14, 18	Lewis County Emergency Management	High	Local Funds, Private Funding, CWDG, HMGP, BRIC	Medium-Term
Action WF-2— Identify strategic locations for fuel breaks and firebreaks to impede the progress of wildfires. Find funding and implement.						
Hazards Mitigated: Wildfire						
New and Existing	1,6	Fire District 10, 14, 18	DNR, US Forest Service	High	Local Funds, CWDG, HMGP, BRIC	Medium-Term

Benefits New or Existing Assets	Objectives Met	Lead Agency	Support Agency	Estimated Cost	Sources of Funding	Timeline[a]
Action WF-3— Conduct community chipping projects to assist with structural protection enhancements. Provide additional support for the vulnerable populations who may be unable to perform the work around their residences, such as elderly or those with disabilities.						
Hazards Mitigated: Wildfire						
Existing	1	Fire District 10, 14, 18 Timberline, Goat Rocks, High Valley, Cispus, Silverbrook	Lewis County Emergency Management	High	Local Funds, Private Funding, HMGP, BRIC, DNR, CWDG	Medium-Term
Action WF-4— Establish and maintain defensible spaces around homes and critical infrastructure.						
Hazards Mitigated: Wildfire						
Existing	1,5,6	Fire District 10, 14, 18 Timberline, Goat Rocks, High Valley, Cispus, Silverbook	Lewis County Emergency Management, DNR	High	CWDG, HMGP,BRIC, DNR	Long-Term
Structural Ignitability						
Action WF-5— Upgrade or install fire-resistant roofing, siding, and windows in vulnerable structures including residential structures and critical facilities.						
Hazards Mitigated: Wildfire						
Existing	1,5,6	Timberline, Goat Rocks, High Valley, Cispus, Silverbrook	Lewis County Emergency Management	High	CWDG, HMGP,BRIC	Medium-Term
Action WF-6— Secure funding to support homeowners to make fire-resistant home upgrades, especially for those homeowners that are low-income.						
Hazards Mitigated: Wildfire						
Existing	1,5,6	Fire District 10, 14, 18	Lewis County Emergency Management	High	HMGP,BRIC, DNR, CWDG	Medium-Term
Education and Outreach						
Action WF-7— Develop and implement a comprehensive wildfire education program for residents (i.e. Firewise USA, Wildfire Ready Neighbors, Ready, Set, Go!).						
Hazards Mitigated: Wildfire						
New and Existing	3,4	Fire District 10, 14, 18	Lewis County Emergency Management	Medium	Local funds, HMGP, BRIC, DNR	Medium-Term
Action WF-8— Conduct workshops, seminars, and training sessions on wildfire preparedness and evacuation plans.						
Hazards Mitigated: Wildfire						
New and Existing	3,4	Fire District 10,14,18	Lewis County Emergency Management	Low	Local funds	Medium-Term

Benefits New or Existing Assets	Objectives Met	Lead Agency	Support Agency	Estimated Cost	Sources of Funding	Timeline[a]
Action WF-9— Develop and distribute emergency preparedness kits for residents.						
Hazards Mitigated: Wildfire						
New and Existing	3	Fire District 10,14,18	Lewis County Emergency Management	Medium	Local funds	Medium-Term
Action WF-10— Organize community events to foster a sense of responsibility and solidarity in wildfire prevention.						
Hazards Mitigated: Wildfire						
New and Existing	3	Fire District 10, 14, 18 Timberline, Goat Rocks, High Valley, Cispus, Silverbrook	Lewis County Emergency Management	Low	Local funds	Medium-Term
Action WF-11— Develop and distribute educational materials for short term rental owners and operators to provide to renters that provide information on hazards within the area, how to find information, and other helpful information.						
Hazards Mitigated: Wildfire						
New and Existing	3	Fire District 10, 14, 18	Lewis County Emergency Management	Low	Local funds	Medium-Term
Action WF-12— Encourage community members to participate actively in wildfire prevention efforts around their homes and in their neighborhoods.						
Hazards Mitigated: Wildfire						
New and Existing	3	Fire District 10, 14, 18 Timberline, Goat Rocks, High Valley, Cispus, Silverbrook	Lewis County Emergency Management	Low	Local funds	Medium-Term
Capacity Building						
Action WF-13— Establish community emergency response teams and training programs.						
Hazards Mitigated: Wildfire						
New and Existing	3,4,6	Fire District 10,14,18	Lewis County Emergency Management	High	SAFER, Local funds, HMGP, BRIC	Medium-Term
Action WF-14— Implement water source improvements for firefighting efforts.						
Hazards Mitigated: Wildfire						
New and Existing	6	Fire District 10, 14, 18	Lewis County Emergency Management	High	Local funds, HMGP,BRIC	Medium-Term
Action WF-15— Support the acquisition of necessary firefighting equipment and resources.						
Hazards Mitigated: Wildfire						
New and Existing	6	Fire District 10, 14, 18	Lewis County Emergency Management	High	AFG, HMGP, BRIC	Medium-Term

Benefits New or Existing Assets	Objectives Met	Lead Agency	Support Agency	Estimated Cost	Sources of Funding	Timeline[a]
Action WF-16— Collaborate with fire departments and personnel to enhance wildland fire training exercises.						
Hazards Mitigated: Wildfire						
New and Existing	3	Fire District 10, 14, 18	Lewis County Emergency Management	Low	SAFER	Medium-Term
Action WF-17— Implement the IWUI code and hire staff to support.						
Hazards Mitigated: Wildfire						
New and Existing	2	Lewis County Community Development	Lewis County Emergency Management	Low	Local funds, SAFER, CWDG	Short-term
Action WF-18— Develop a level of service standard, or other form of measurement, to ensure new development is mitigating their impacts to fire service providers.						
Hazards Mitigated: Wildfire						
New and Existing	2	Lewis County Community Development	Lewis County Emergency Management, Fire Districts	Medium	Local funds, planning grants	Short-term
Action WF-19— Secure financial assistance to support community-wide projects that enhance wildfire resilience.						
Hazards Mitigated: Wildfire						
New and Existing	1,3,4,5,6	Fire District 10, 14, 18	Lewis County Emergency Management	Medium	HMGP,BRIC, DNR, CWDG	Short-term
Action WF-20— Install and maintain surveillance cameras in high-risk areas for early fire detection.						
Hazards Mitigated: Wildfire						
New and Existing	4	Fire District 10, 14, 18 Timberline, Goat Rocks, High Valley, Cispus, Silverbrook	Lewis County Emergency Management, USFS, DNR	Medium	HMGP,BRIC, DNR, USFS, CWDG, AFG	Medium-Term

14.10 Wildfire Mitigation Prioritization

Table 14-4 lists the priority of each area-wide wildfire action. A qualitative benefit-cost review was performed for each of these actions. The priorities are defined as follows:

Implementation Priority

- **High Priority**—An action that meets multiple objectives, has benefits that exceed costs, and has a secured source of funding. Action can be completed in the short term (1 to 5 years).
- **Medium Priority**—An action that meets multiple objectives, has benefits that exceed costs, and is eligible for funding though no funding has yet been secured for it. Action can be completed in the short term (1 to 5 years), once funding is secured. Medium-priority actions become high-priority actions once funding is secured.
- **Low Priority**—An action that will mitigate the risk of a hazard, has benefits that do not exceed the costs or are difficult to quantify, has no secured source of funding, and is not eligible for

any known grant funding. Action can be completed in the long term (1 to 10 years). Low-priority actions are generally "wish-list" actions. They may be eligible for grant funding from programs that have not yet been identified.

Grant Pursuit Priority

- **High Priority**—An action that meets identified grant eligibility requirements, has high benefits, and is listed as high or medium implementation priority; local funding options are unavailable or available local funds could be used instead for actions that are not eligible for grant funding.
- **Medium Priority**—An action that meets identified grant eligibility requirements, has medium or low benefits, and is listed as medium or low implementation priority; local funding options are unavailable.
- **Low Priority**—An action that has not been identified as meeting any grant eligibility requirements.

Table 14-4. Analysis of Mitigation Actions.

Action #	# of Objectives Met	Benefits	Costs	Do Benefits Equal or Exceed Costs?	Is Action Grant Eligible?	Can Action be Funded under Existing Programs/ Budgets?	Implement-ation Priority	Grant Pursuit Priority
WF-1	2	High	High	Yes	Yes	No	High	High
WF-2	2	High	High	Yes	Yes	No	Medium	High
WF-3	1	High	High	Yes	Yes	No	Medium	Medium
WF-4	3	High	High	Yes	Yes	No	High	High
WF-5	3	High	High	Yes	Yes	No	High	High
WF-6	3	High	High	Yes	Yes	No	High	High
WF-7	2	High	Medium	Yes	Yes	Yes	High	Medium
WF-8	2	High	Low	Yes	No	Yes	High	Low
WF-9	1	High	Medium	Yes	No	Yes	Medium	Low
WF-10	1	Medium	Low	Yes	No	Yes	Medium	Low
WF-11	1	High	Low	Yes	No	Yes	Medium	Low
WF-12	1	High	Low	Yes	No	Yes	Medium	Low
WF-13	3	High	High	Yes	Yes	No	High	High
WF-14	1	High	High	Yes	Yes	No	Medium	High
WF-15	1	High	High	Yes	Yes	No	Medium	High
WF-16	1	High	Low	Yes	Yes	Yes	Medium	Medium
WF-17	1	Medium	Low	Yes	Yes	No	Medium	Medium
WF-18	1	High	Medium	Yes	Yes	Yes	Medium	Medium
WF-19	5	High	Medium	Yes	Yes	No	Medium	High
WF-20	1	High	Medium	Yes	Yes	No	Medium	High

14.11 Classification of Wildfire Mitigation Actions

Each recommended action was classified based on the hazard it addresses and the type of mitigation it involves. Table 14-5 shows these classifications.

Table 14-5. Analysis of Mitigation Actions.

	Actions That Address the Hazard, by Mitigation Type							
Hazard	Prevention	Property Protection	Public Education and Awareness	Natural Resource Protection	Emergency Services	Structural Projects	Climate Resiliency	Community Capacity Building
Wildfire	1,2,3,4	1,3,4	7,8,9,10,11, 12		13,14,	5,6		13,14,15,16 ,17,18,19,2 0

14.12 Summary

Utilizing the different data sets as described earlier in this section, along with professional local expertise, the planning team identified areas of high to very high risk in the the county and many communities and homes that are vulnerable to wildfire threats and impacts. To reduce structural ignitability in Lewis County, the planning team is utilizing the different programs adopted in WA State to (i.e. Firewise, Wildfire Ready Neighbors, Ready, Set, Go!, WUI Code) target communities in high/very high risk wildfire areas. The outcome for this plan is to create ignition-resistant communities throughout Lewis County.

CHAPTER 15. PLANNING AREA RISK RANKING

A risk ranking was performed for the hazards of concern described in this plan. This risk ranking assesses the probability of each hazard's occurrence as well as its likely impact on the people, property, and economy of the planning area. The risk ranking was conducted via facilitated brainstorming sessions and in consideration of data generated by Hazus using methodologies promoted by FEMA. The results are used in establishing mitigation priorities.

15.1 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 exposure—There is no probability of occurrence (Probability Factor = 0)

The assessment of hazard frequency is generally based on past hazard events in the area. Table 18-1 summarizes the probability assessment for each hazard of concern for this plan.

15.2 Impact

Hazard impacts were assessed in three categories: impacts on people, impacts on property and impacts on the local economy. Numerical impact factors were assigned as follows:

- **People**—Values were assigned based on the percentage of the total ***population vulnerable*** 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 are vulnerable 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:
    - High—50 percent or more of the population is vulnerable to a hazard (Impact Factor = 3)
    - Medium—25 percent to 49 percent of the population is vulnerable to a hazard (Impact Factor = 2)
    - Low—25 percent or less of the population is vulnerable to the hazard (Impact Factor = 1)
    - No impact—None of the population is vulnerable to a hazard (Impact Factor = 0)
- **Property**—Values were assigned based on the percentage of the total ***property value vulnerable*** to the hazard event:
    - High—30 percent or more of the total assessed property value is vulnerable to a hazard (Impact Factor = 3)
    - Medium—15 percent to 29 percent of the total assessed property value is vulnerable to a hazard (Impact Factor = 2)
    - Low—14 percent or less of the total assessed property value is vulnerable to the hazard (Impact Factor = 1)
    - No impact—None of the total assessed property value is vulnerable 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 assessed value of the property vulnerable to the hazard. For some hazards, such as wildfire, landslide and severe weather, vulnerability was considered to be the same as exposure due to the lack of loss estimation tools specific to those hazards. Loss estimates separate from the exposure estimates were generated for the earthquake and flood hazards using Hazus-MH.
  - High—Estimated loss from the hazard is 20 percent or more of the total assessed property value (Impact Factor = 3)
  - Medium—Estimated loss from the hazard is 10 percent to 19 percent of the total assessed property value (Impact Factor = 2)
  - Low—Estimated loss from the hazard is 9 percent or less of the total assessed property value (Impact Factor = 1)
  - No impact—No loss is estimated from the hazard (Impact Factor = 0)

The impacts of each hazard category were assigned a weighting factor to reflect the significance of the impact. 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 operations was given a weighting factor of 1.

15.3 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 for people, property and operations, as summarized in Table 15-1 and Table 15-2.

The hazards ranked as being of highest concern are earthquake and flood. Hazards ranked as being of medium concern are severe weather and dam failure. The hazards ranked as being of lowest concern are avalanche, volcano, wildfire, and landslide. Table 15-2 shows the hazard risk ranking.

Table 15-1. Lewis County Risk Ranking

Natural Hazard Event	Probability Factor	Impact: People (weight x3)	Impact: Property (weight x2)	Impact: Economy (weight x1)	Risk Rating (max score = 54)
Earthquake	2	High	High	Medium	**34**
Flood	3	High	Medium	Low	**33**
Severe Weather	2	Medium	Low	Low	**18**
Wildfire	2	Medium	Low	Low	**18**
Dam/Levee Failure	1	High	High	Medium	**17**
Volcano	2	Low	Low	Low	**12**
Avalanche	2	Low	Low	Low	**12**
Landslide	2	Low	Low	Low	**12**

Table 15-2. Hazard Risk Ranking

Rank	Hazard Type	Risk Rating Score (Probability x Impact)
1	Earthquake	**34**
2	Flood	**33**
3	Severe Weather	**18**
6	Wildfire	**18**
4	Dam/Levee Failure	**17**
5	Volcano	**12**
7	Avalanche	**12**
8	Landslide	**12**

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PART 3 – THE MITIGATION STRATEGY

CHAPTER 16. GUIDING PRINCIPLE, GOALS, AND OBJECTIVES

Hazard mitigation plans must identify goals for reducing long-term vulnerabilities to identified hazards (44CFR Section 201.6.c(3i)). The Steering Committee established a guiding principle, a set of goals and measurable objectives for this plan, based on data from the preliminary risk assessment and the results of the public involvement strategy. The guiding principle, 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 were prioritized based on the action meeting multiple objectives.

16.1 Guiding Principle

A guiding principle focuses on 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 guiding principle for the Lewis County Hazard Mitigation Plan Update is as follows:

Empower communities to reduce risk associated with natural and manmade hazards to sustain life, health, safety, welfare, and economy of Lewis County.

16.2 Goals

The mitigation goals for this plan are to:

- Increase public awareness of natural hazards and enhance education, outreach, and partnership efforts.
- Minimize injuries and loss of life, property damage, infrastructure, environmental impact, and economic loss caused by natural disasters.
- Support local capacity building that enables the whole community to mitigate against, prepare for, respond to, and recover from disasters.

The effectiveness of a mitigation strategy is assessed by determining how well these goals are achieved.

16.3 Objectives

Each selected 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. The objectives are as follows:

1. Encourage the incorporation of mitigation measures into repairs, major alterations, new development, and redevelopment practices, especially in areas subject to substantial hazard risk.
2. Integrate hazard mitigation policies into comprehensive plans within the planning area.
3. Promote and enhance outreach and education efforts by state, regional and local agencies with hazard mitigation plans and programs to actively encourage engagement of stakeholder groups such as homeowners, private sector businesses, and nonprofit community organizations.
4. Improve and expand systems that provide warning and emergency communications.

5. Retrofit, purchase, or relocate structures in high hazard areas and those that experience repetitive losses.
6. Support the protection of vital records, and strengthening or replacement of buildings, infrastructure, and lifelines to minimize post-disaster disruption and facilitate short-term and long-term recovery.

CHAPTER 17. MITIGATION ALTERNATIVES

Catalogs of hazard mitigation alternatives were developed that present a broad range of alternatives to be considered for use in the planning area, in compliance with 44CFR (Section 201.6.c.3.ii). One catalog was developed for each hazard of concern evaluated in this plan. The catalogs for each hazard are listed in through

The catalogs present alternatives that are categorized in two ways:

- By what the alternative would do:
  - Manipulate a hazard
  - Reduce exposure to a hazard
  - Reduce vulnerability to a hazard
  - Increase the ability to respond to or be prepared for a hazard
- By who would have responsibility for implementation:
  - Community
  - Organizational
  - Government

Hazard mitigation initiatives recommended in this plan were selected from among 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 planning partners' goals and objectives, and are within the capabilities of the partners to implement. However, not all the alternatives meet all the planning partners' selection criteria.

Table 17-1. Catalog of Mitigation Alternatives – Dam/Levee Failure.

Community Scale	Organizational Scale	Government Scale
• **Reduce the probability of hazard events:** ○ None • **Limit risk to new development/ redevelopment:** ○ Relocate out of dam failure inundation areas. • **Reduce risk to existing structures:** ○ Elevate home to appropriate levels. • **Increase the ability to respond to or be prepared for the hazard:** ○ 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.	• **Reduce the probability of hazard events:** ○ Remove dams. ○ Harden dams. • **Limit risk to new development/ redevelopment:** ○ None • **Reduce risk to existing structures:** ○ Flood-proof facilities within dam failure inundation areas. • **Increase the ability to respond to or be prepared for the hazard:** ○ Educate employees on the probable impacts of a dam failure. ○ Develop a continuity of operations plan.	• **Reduce the probability of hazard events:** ○ Remove dams. ○ Harden dams. • **Limit risk to new development/redevelopment:** ○ Consider open space land use in designated dam failure inundation areas. ○ Adopt higher regulatory floodplain standards in mapped dam failure inundation areas. ○ Adopt real-estate disclosure requirements for the re-sale of property located within dam failure inundation areas. • **Reduce risk to existing structures:** ○ Relocate critical facilities out of dam failure inundation areas. ○ Retrofit critical facilities within dam failure inundation areas. • **Increase the ability to respond to or be prepared for the hazard:** ○ Map dam failure inundation areas. ○ Enhance emergency operations plan to include a dam failure component. ○ Institute monthly communications checks with dam operators. ○ Inform the public on risk reduction techniques. ○ Consider the probable impacts of climate change in assessing the risk associated with the dam failure hazard. ○ Establish early warning capability downstream of listed high hazard dams. ○ Consider the residual risk associated with protection provided by dams in future land use decisions.

Table 17-2. Catalog of Mitigation Alternatives – Earthquake.

Community Scale	Organizational Scale	Government Scale
• **Reduce the probability of hazard events:** o None • **Limit risk to new development/redevelopment:** o Locate outside of hazard area (off soft soils). o Build to higher design. • **Reduce risk to existing structures:** o Retrofit structure (anchor house structure to foundation). o Secure household items that can cause injury or damage (such as water heaters, bookcases, and other appliances). • **Increase the ability to respond to or be prepared for the hazard:** o Practice "drop, cover, and hold." o Develop household mitigation plan, such as creating a retrofit savings account, communication capability with outside, 72-hour self-sufficiency during an event. o Keep cash reserves for reconstruction. o Become informed on the hazard and risk reduction alternatives available. o Develop a post-disaster action plan for your household.	• **Reduce the probability of hazard events:** o None • **Limit risk to new development/ redevelopment:** o Locate or relocate mission-critical functions outside hazard area where possible. o Adopt higher standard for new construction; consider "performance-based design" when building new structures. • **Reduce risk to existing structures:** o Build redundancy for critical functions and facilities. o Retrofit critical buildings and areas housing mission-critical functions. • **Increase the ability to respond to or be prepared for the hazard:** o Keep cash reserves for reconstruction. o Inform your employees on the possible impacts of earthquake and how to deal with them at your work facility. o Develop a continuity of operations plan.	• **Reduce the probability of hazard events:** o None • **Limit risk to new development/redevelopment:** o Locate critical facilities or functions outside hazard area where possible. o Adopt higher regulatory standards. • **Reduce risk to existing structures:** o Harden infrastructure. o Provide redundancy for critical functions. • **Increase the ability to respond to or be prepared for the hazard:** o Provide better hazard maps. o Provide technical information and guidance. o Enact tools to help manage development in hazard areas (e.g., tax incentives, information). o Include retrofitting and replacement of critical system elements in capital improvement plan. o Develop strategy to take advantage of post-disaster opportunities. o Warehouse critical infrastructure components such as pipe, power line, and road repair materials. o Develop and adopt a continuity of operations plan. o Initiate triggers guiding improvements (such as <50% substantial damage or improvements). o Further enhance seismic risk assessment to target high hazard buildings for mitigation opportunities. o Develop a post-disaster action plan that includes grant funding and debris removal components.

Table 17-3. Catalog of Mitigation Alternatives – Flood.

Community Scale	Organizational Scale	Government Scale
• **Reduce the probability of hazard events:** ○ Clear storm drains and culverts. ○ Use low-impact development techniques. • **Limit risk to new development/ redevelopment:** ○ Locate outside of hazard area. ○ Use low-impact development techniques. ○ Build new homes above base flood elevation. • **Reduce risk to existing structures:** ○ Elevate utilities above base flood elevation. ○ Raise structures above base flood elevation. ○ Elevate items within house above base flood elevation. ○ Flood-proof structures. • **Increase the ability to respond to or be prepared for the hazard:** ○ Buy flood insurance. ○ Develop household plan, such as retrofit savings, communication with outside, 72- hour self- sufficiency during and after an event.	• **Reduce the probability of hazard events:** ○ Clear storm drains and culverts. ○ Use low-impact development techniques. • **Limit risk to new development/ redevelopment:** ○ Locate critical facilities or functions outside hazard area. ○ Use low-impact development techniques. ○ Provide flood-proofing when new critical infrastructure must be located in floodplains. • **Reduce risk to existing structures:** ○ Build redundancy for critical functions or retrofit critical buildings. • **Increase the ability to respond to or be prepared for the hazard:** ○ Keep cash reserves for reconstruction. ○ Support and implement hazard disclosure for sale of property in risk zones. ○ Solicit cost-sharing through partnerships with others on	• **Reduce the probability of hazard events:** ○ Maintain drainage system. ○ Institute low-impact development techniques on property. ○ Dredging, levee construction, and providing regional retention areas. ○ 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. ○ Adopt "no-adverse impact" floodplain management policies that strive to not increase the flood risk on downstream communities. • **Limit risk to new development/redevelopment:** ○ 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. ○ 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. • **Reduce risk to existing structures:** ○ Harden infrastructure, bridge replacement program. ○ Provide redundancy for critical functions and infrastructure. • **Increase the ability to respond to or be prepared for the hazard:** ○ 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 the probable impacts of climate change on the risk

	projects with multiple benefits.	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.

Table 17-4. Catalog of Mitigation Alternatives – Landslide.

Community Scale	Organizational Scale	Government Scale
• **Reduce the probability of hazard events:** ○ Minimize vegetation removal and the addition of impervious surfaces on steep slopes. ○ Reduce weight on top of slope. ○ Stabilize slope (dewater, armor toe). • **Limit risk to new development/ redevelopment:** ○ Locate structures outside of hazard area (off unstable land and away from slide-run out area). • **Reduce risk to existing structures:** ○ Insulate house. ○ Provide redundant heat and power. ○ Insulate structure. ○ Plant appropriate trees near home and power lines ("Right tree, right place" National Arbor Day Foundation Program). • **Increase the ability to respond to or be prepared for the hazard:** ○ Institute warning system and develop evacuation plan. ○ Keep cash reserves for reconstruction. ○ Educate yourself on risk reduction techniques for landslide hazards. ○ Promote 72-hour self-sufficiency. ○ Obtain a NOAA weather radio. ○ Obtain an emergency generator.	• **Reduce the probability of hazard events:** ○ Minimize vegetation removal and the addition of impervious surfaces on steep slopes. ○ Stabilize slope (dewater, armor toe) ○ Reduce weight on top of slope • **Limit risk to new development/ redevelopment:** ○ Relocate critical infrastructure such as power lines to meet performance expectations. • **Reduce risk to existing structures:** ○ Retrofit at-risk facilities. • **Increase the ability to respond to or be prepared for the hazard:** ○ 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.	• **Reduce the probability of hazard events:** ○ Minimize vegetation removal and the addition of impervious surfaces on steep slopes. ○ Stabilize slope (dewater, armor toe) ○ Reduce weight on top of slope • **Limit risk to new development/redevelopment:** ○ Enact tools to help manage development in hazard areas: better land controls, tax incentives, information. ○ 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 • **Reduce risk to existing structures:** ○ Acquire properties in high-risk landslide areas. ○ Armor/retrofit critical infrastructure against the impact of landslides. • **Increase the ability to respond to or be prepared for the hazard:** ○ Produce better hazard maps. ○ Provide technical information and guidance. ○ Develop strategy to take advantage of post-disaster opportunities. ○ Develop and adopt a Continuity of Operations Plan. ○ Educate the public on the landslide hazard and appropriate risk reduction alternatives.

Table 17-5. Catalog of Mitigation Alternatives – Severe Weather.

Community Scale	Organizational Scale	Government Scale

• **Reduce the probability of hazard events:**
  ○ None
• **Limit risk to new development/ redevelopment:**
  ○ Use construction techniques for high wind and snow loads on new construction.
  ○ Remove snow from roofs.
• **Reduce risk to existing structures:**
  ○ Insulate house.
  ○ Provide redundant heat and power.
  ○ Insulate structure.
  ○ Plant appropriate trees near home and power lines ("Right tree, right place" National Arbor Day Foundation Program).
• **Increase the ability to respond to or be prepared for the hazard:**
  ○ Trim or remove trees that could affect power lines.
  ○ Promote 72-hour self-sufficiency.
  ○ Obtain a NOAA weather radio.
  ○ Obtain an emergency generator.
	• **Reduce the probability of hazard events:**
	  ○ None
	• **Limit risk to new development/ redevelopment:**
	  ○ Relocate critical infrastructure such as power lines to meet performance expectations.
	• **Reduce risk to existing structures:**
	  ○ Relocate critical infrastructure (such as power lines) underground.
	  ○ Reinforce critical infrastructure such as power lines to meet performance expectations.
	  ○ Install tree wire.
	• **Increase the ability to respond to or be prepared for the hazard:**
	  ○ Trim or remove trees that could affect power lines.
	  ○ Create redundancy.
	  ○ Equip facilities with a NOAA weather radio.
	  ○ Equip vital facilities with emergency power sources.
		• **Reduce the probability of hazard events:**
		  ○ None
		• **Limit risk to new development/redevelopment:**
		  ○ None
		• **Reduce risk to existing structures:**
		  ○ Harden infrastructure such as locating utilities underground.
		  ○ Trim trees back from power lines.
		• **Increase the ability to respond to or be prepared for the hazard:**
		  ○ Designate snow routes and strengthen critical road sections and bridges.
		  ○ Support programs such as "Tree Watch" that proactively manage problem areas through use of selective removal of hazardous trees, tree replacement, etc.
		  ○ Establish and enforce building codes that require all roofs to withstand wind and snow loads.
		  ○ 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.
		  ○ Provide NOAA weather radios to the public.

Table 17-6. Catalog of Risk Reduction Measures – Volcano.

Community Scale	Organizational Scale	Government Scale
• **Reduce the probability of hazard events:** ○ None • **Limit risk to new development/ redevelopment:** ○ Locate outside of hazard area. • **Reduce risk to existing structures:** ○ Insu • **Increase the ability to respond to or be prepared for the hazard:** ○ Learn the evacuation routes for a lahar event. ○ Educate yourself on early warning systems and the dissemination of warnings. ○ Promote 72-hour self-sufficiency. ○ Obtain a NOAA weather radio. ○ Obtain an emergency generator.	• **Reduce the probability of hazard events:** ○ None • **Limit risk to new development/ redevelopment:** ○ Relocate critical infrastructure outside of lahar zones. • **Reduce risk to existing structures:** ○ Relocate critical infrastructure outside of lahar zones. ○ Reinforce critical infrastructure such as power lines to meet performance expectations. • **Increase the ability to respond to or be prepared for the hazard:** ○ Trim or remove trees that could affect power lines. ○ Create redundancy. ○ Equip facilities with a NOAA weather radio. ○ Equip vital facilities with emergency power sources.	• **Reduce the probability of hazard events:** ○ None • **Limit risk to new development/redevelopment:** ○ None • **Reduce risk to existing structures:** ○ Harden or relocate critical infrastructure . • **Increase the ability to respond to or be prepared for the hazard:** ○ Locate critical facilities and functions outside of hazard area, such as lahar zones, whenever possible. ○ Establish early warning capability in lahar hazard areas. ○ Enhance emergency operations plan to include a lahar component. ○ Develop an evacuation plan. ○ Increase communication alternatives. ○ Provide NOAA weather radios to the public.

Table 17-7. Catalog of Mitigation Alternatives – Wildfire.

Community Scale	Organizational Scale	Government Scale
• **Reduce the probability of hazard events:** ○ Clear potential fuels on property such as dry overgrown underbrush and diseased trees. • **Limit risk to new development/ redevelopment:** ○ Locate outside of hazard area. ○ Create and maintain defensible space around structures. ○ Use fire-retardant building materials. • **Reduce risk to existing structures:** ○ Mow regularly. ○ Create and maintain defensible space around homes and provide water on site. ○ Install/replace roofing material with non-combustible roofing materials. • **Increase the ability to respond to or be prepared for the hazard:** ○ Employ techniques from the National Fire Protection Association's Firewise Communities program to safeguard home. ○ Identify alternative water supplies for firefighting.	• **Reduce the probability of hazard events:** ○ Clear potential fuels on property such as dry underbrush and diseased trees. • **Limit risk to new development/ redevelopment:** ○ Locate outside of hazard area. ○ Use fire-retardant building materials. ○ Use fire-resistant plantings in buffer areas of high wildfire threat. • **Reduce risk to existing structures:** ○ Create and maintain defensible space around structures and infrastructure and provide water on site. ○ Use fire-resistant plantings in buffer areas of high wildfire threat. • **Increase the ability to respond to or be prepared for the hazard:** ○ Support Firewise community initiatives. ○ Create/establish stored water supplies to be used for firefighting.	• **Reduce the probability of hazard events:** ○ Clear potential fuels on property such as dry underbrush and diseased trees. ○ Implement best management practices on public lands. • **Limit risk to new development/ redevelopment:** ○ Create and maintain defensible space around structures and infrastructure. ○ Locate outside of hazard area. ○ Enhance building code to include use of fire-resistant materials in high hazard area. ○ Use fire-retardant building materials. ○ Use fire-resistant plantings in buffer areas of high wildfire threat. ○ Consider higher regulatory standards (such as Class A roofing). ○ Establish biomass reclamation initiatives. • **Reduce risk to existing structures:** ○ Create and maintain defensible space around structures and infrastructure. ○ Use fire-retardant building materials. ○ Use fire-resistant plantings in buffer areas of high wildfire threat. • **Increase the ability to respond to or be prepared for the hazard:** ○ 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. ○ Create/implement fire plans. ○ Consider the probable impacts of climate change on the risk associated with the wildfire hazard in future land use decisions.

CHAPTER 18. AREA-WIDE MITIGATION INITIATIVES

18.1 Selected County-Wide Mitigation Initiatives

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 18-1 lists the recommended hazard mitigation actions that make up the action plan. The timeframe indicated in the table is defined as follows:

- Short Term = Existing program that will continue or new program that will start within one year
- Medium Term = Completion within 5 years
- Long Term = Completion within 10 years
- Ongoing = Phased project that will have an extended timeframe

18.2 Benefit/Cost Review

44 CFR requires the prioritization of the action plan according to a benefit/cost analysis of the proposed projects and their associated costs (Section 201.6.c.3iii). The benefits of proposed projects were weighed against estimated costs as part of the project prioritization process. The benefit/cost analysis was not of the detailed variety required by FEMA for project grant eligibility under the Hazard Mitigation Grant Program (HMGP) and Pre-Disaster Mitigation (PDM) grant program. A less formal approach was used because some projects may not be implemented for up to 10 years, and associated costs and benefits could change dramatically in that time.

Therefore, a review of the apparent benefits versus the apparent cost of each project was performed. Parameters were established for assigning subjective ratings (high, medium, and low) to the costs and benefits of these projects.

Cost ratings were defined as follows:

- **High**—Existing funding will not cover the cost of the project; implementation would require new revenue through an alternative source (for example, bonds, grants, and fee increases).
- **Medium**—The project could be implemented with existing funding but would require a re-apportionment of the budget or a budget amendment, or the cost of the project would have to be spread over multiple years.
- **Low**—The project could be funded under the existing budget. The project is part of or can be part of an ongoing existing program.

Benefit ratings were defined as follows:

- **High—**Project will provide an immediate reduction of risk exposure for life and property.
- **Medium—**Project will have a long-term impact on the reduction of risk exposure for life and property, or project will provide an immediate reduction in the risk exposure for property.
- **Low—**Long-term benefits of the project are difficult to quantify in the short term.

Using this approach, projects with positive benefit versus cost ratios (such as high over high, high over medium, medium over low, etc.) are considered cost-beneficial and are prioritized accordingly.

Table 18-1. County-Wide Action Plan.

<table>
<tr><th>Hazards Addressed</th><th>Funding Options</th><th>Timeframe</th><th>Objectives Met</th></tr>
<tr><td colspan="4">CW-1—To the extent possible based on available resources, provide coordination and technical assistance in the application for mitigation grant funding that includes assistance in cost vs. benefit analysis for grant eligible projects.
Responsible Agency: Lewis County Emergency Management</td></tr>
<tr><td>All</td><td>Existing County programs; FMA grant funding</td><td>Short-term</td><td>1, 2, 4, 5, 6</td></tr>
<tr><td colspan="4">CW-2—Encourage the development and implementation of a county-wide hazard mitigation public-information strategy that meets the needs of all planning partners and reaches the whole community. 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.
Responsible Agency: Lewis County Emergency Management with participation of all planning partners</td></tr>
<tr><td>All</td><td>Cost sharing from the Partnership, General Fund Allocations, Grant Funding including HMGP, BRIC, FMA</td><td>Short-term</td><td>3</td></tr>
<tr><td colspan="4">CW-3—Coordinate updates to land use and building regulations that reduce the impacts of natural hazards and 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>Medium-term</td><td>1, 2</td></tr>
<tr><td colspan="4">CW-4—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: Lewis County Emergency Management with participation of all planning partners</td></tr>
<tr><td>All</td><td>County general fund through existing programs, grant funding including HMGP, BRIC, FMA</td><td>Short-term</td><td>3</td></tr>
<tr><td colspan="4">CW-5—The Steering Committee will remain as a functioning body over time to monitor progress of the plan, provide technical assistance to planning partners and oversee the update of the plan according to schedule. This body will continue to operate under the ground rules established at its inception. Steering Committee members will designate a replacement member when necessary.
Responsible Agency: Lewis County Emergency Management</td></tr>
<tr><td>All</td><td>Funding through existing, ongoing programs</td><td>Short-term</td><td>1, 2, 3, 6</td></tr>
<tr><td colspan="4">CW-6—Amend or enhance this hazard mitigation plan as needed to comply with state or federal mandates as compliance guidelines become available.
Responsible Agency: Lewis County Emergency Management with participation of all planning partners</td></tr>
<tr><td>All</td><td>Ongoing programs, grant funding (HMGP, BRIC, FMA) depending on the mandate</td><td>Medium-term</td><td>1, 2, 6</td></tr>
<tr><td colspan="4">CW-7—Support the collection of improved data (hydrologic, geologic, topographic, historical, etc.) to better assess risks and vulnerabilities.
Responsible Agency: All planning partners</td></tr>
</table>

Hazards Addressed	Funding Options	Timeframe	Objectives Met
All	Ongoing programs, grant funding including HMGP, BRIC, FMA	Short-term, ongoing	1, 2, 6
CW-8—All planning partners that fully participated in this planning effort will formally adopt this plan once pre-adoption approval has been granted by Washington State Emergency Management Division and FEMA and will adhere to the plan maintenance protocol identified in this plan. **Responsible Agency:** All planning partners			
All	Ongoing programs, grant funding including HMGP, BRIC, FMA	Short-term, Ongoing	1, 2, 3, 6
CW-9—Utilize information within this plan to support updates to emergency management plans, comprehensive plans, capital improvement plans, in effect within the planning area. **Responsible Agency:** All planning partners			
All	Ongoing programs, grant funding including HMGP, BRIC, FMA	Short-term, Ongoing	1, 2
CW-10—Identify, assess, and mitigate vulnerable critical facilities as needed. **Responsible Agency:** All planning partners			
All	Ongoing programs, grant funding including HMGP, BRIC, FMA	Short-term Ongoing	1, 5, 6

For many of the strategies identified in this action plan, the partners may seek financial assistance under the HMGP or PDM programs, both of which require detailed benefit/cost analyses. These analyses will be performed on projects at the time of application using the FEMA benefit-cost model. For projects not seeking financial assistance from grant programs that require detailed analysis, the partners reserve the right to define “benefits” according to parameters that meet the goals and objectives of this plan.

18.3 Action Plan Prioritization

Table 18-2 lists the priority of each area-wide action. A qualitative benefit-cost review was performed for each of these actions. The priorities are defined as follows:

Implementation Priority

- **High Priority**—An action that meets multiple objectives, has benefits that exceed costs, and has a secured source of funding. Action can be completed in the short term (1 to 5 years).
- **Medium Priority**—An action that meets multiple objectives, has benefits that exceed costs, and is eligible for funding though no funding has yet been secured for it. Action can be completed in the short term (1 to 5 years), once funding is secured. Medium-priority actions become high-priority actions once funding is secured.
- **Low Priority**—An action that will mitigate the risk of a hazard, has benefits that do not exceed the costs or are difficult to quantify, has no secured source of funding, and is not eligible for any known grant funding. Action can be completed in the long term (1 to 10 years). Low-priority actions are generally “wish-list” actions. They may be eligible for grant funding from programs that have not yet been identified.

Grant Pursuit Priority

- **High Priority**—An action that meets identified grant eligibility requirements, has high benefits, and is listed as high or medium implementation priority; local funding options are unavailable or available local funds could be used instead for actions that are not eligible for grant funding.
- **Medium Priority**—An action that meets identified grant eligibility requirements, has medium or low benefits, and is listed as medium or low implementation priority; local funding options are unavailable.
- **Low Priority**—An action that has not been identified as meeting any grant eligibility requirements.

Table 18-2. Prioritization of Area-Wide Mitigation Actions.

Action #	# of Objectives Met	Benefits	Costs	Do Benefits Equal or Exceed Costs?	Is Action Grant Eligible?	Can Action be Funded under Existing Programs/ Budgets?	Implementation Priority	Grant Pursuit Priority
CW-1	5	High	Low	Yes	Yes	Yes	Medium	Medium
CW-2	1	High	Medium	Yes	Yes	No	Medium	Medium
CW-3	2	Medium	Low	Yes	No	Yes	Medium	Low
CW-4	1	Medium	Low	Yes	Yes	Yes	Medium	Medium
CW-5	4	High	Low	Yes	No	Yes	High	Low
CW-6	3	High	Medium	Yes	Yes	Yes	Medium	Medium
CW-7	3	High	Medium	Yes	Yes	No	High	High
CW-8	4	High	Low	Yes	Yes	Yes	Medium	Medium
CW-9	2	Medium	Low	Yes	Yes	Yes	Medium	Medium
CW-10	3	High	High	Yes	Yes	No	High	High

18.4 Classification of Mitigation Actions

Each recommended action was classified based on the hazard it addresses and the type of mitigation it involves. Table 18-3 shows these classifications.

Table 18-3. Analysis of Mitigation Actions

	Actions That Address the Hazard, by Mitigation Type							
Hazard	Prevention	Property Protection	Public Education and Awareness	Natural Resource Protection	Emergency Services	Structural Projects	Climate Resiliency	Community Capacity Building
Avalanche	CW-3, 7	CW-10	CW-2		CW-4	CW-10	CW-10	CW-1, 5, 6, 8, 9
Dam/Levee Failure	CW-3, 7	CW-10	CW-2		CW-4	CW-10	CW-10	CW-1, 5, 6, 8, 9
Earthquake	CW-3, 7	CW-10	CW-2		CW-4	CW-10	CW-10	CW-1, 5, 6, 8, 9
Flood	CW-3, 7	CW-10	CW-2		CW-4	CW-10	CW-10	CW-1, 5, 6, 8, 9
Landslide	CW-3, 7	CW-10	CW-2		CW-4	CW-10	CW-10	CW-1, 5, 6, 8, 9
Severe Weather	CW-3, 7	CW-10	CW-2		CW-4	CW-10	CW-10	CW-1, 5, 6, 8, 9
Volcano	CW-3, 7	CW-10	CW-2		CW-4	CW-10	CW-10	CW-1, 5, 6, 8, 9
Wildfire	CW-3, 7	CW-10	CW-2		CW-4	CW-10	CW-10	CW-1, 5, 6, 8, 9

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.

18.5 Action Plan and 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 Lewis County Emergency Management 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.

18.6 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.

CHAPTER 19. PLAN ADOPTION, IMPLEMENTATION, AND MAINTENANCE

19.1 Plan Adoption

Section 201.6.c.5 of 44CFR requires documentation that a hazard mitigation plan has been formally adopted by the governing body of the jurisdiction requesting federal approval of the plan. For multi-jurisdictional plans, each jurisdiction requesting approval must document that it has been formally adopted. This plan will be submitted for a pre-adoption review to Washington Military Department, State Emergency Management Division and the State forwards the plan to the Federal Emergency Management Agency. Once pre-adoption approval has been provided, 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 E of this volume.

19.2 Plan Maintenance

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.

A hazard mitigation plan must present a plan maintenance process that includes the following (44CFR Section 201.6.c.4):

- A section describing the method and schedule of monitoring, evaluating, and updating the mitigation plan over a five-year cycle.
- A process by which local governments incorporate the requirements of the mitigation plan into other planning mechanisms, such as comprehensive or capital improvement plans, when appropriate.
- A discussion on how the community will continue public participation in the plan maintenance process.

This chapter details the formal process that will ensure that the Lewis County Hazard Mitigation Plan remains an active and relevant document and that the planning partners maintain their eligibility for applicable funding sources. The plan maintenance process includes a schedule for monitoring and evaluating the plan annually and producing an updated plan every five years.

This chapter also describes how public participation will be integrated throughout the plan maintenance and implementation process. It also explains how the mitigation strategies outlined in this plan will be incorporated into existing planning mechanisms and programs, such as comprehensive land-use planning processes, capital improvement planning, and building code enforcement and implementation. The plan’s format allows sections to be reviewed and updated when new data becomes available, resulting in a plan that will remain current and relevant.

19.3 Plan Monitoring and Implementation

The effectiveness of the hazard mitigation plan depends on monitoring, implementation, and incorporation of its action items into partner jurisdictions' existing plans, policies, and programs. Together, the action items in the Plan provide a framework for activities that the partnership can implement over the next five years. The planning team and the steering committee have established goals and objectives and have prioritized mitigation actions that will be implemented through existing plans, policies, and programs.

The Lewis County Emergency Management will have lead responsibility for overseeing the plan maintenance strategy. Plan implementation and maintenance will be a shared responsibility among all planning partnership members and agencies. At a minimum, the planning partners will track and report the status of the jurisdiction-specific mitigation actions for inclusion into the annual progress report, described in Section 7.3.

19.4 Steering Committee

The steering committee that oversaw the development of the plan and made recommendations on key elements of the plan, including the maintenance strategy. The steering committee will remain a viable body involved in key elements of the plan maintenance strategy. The steering committee will include representation from each planning partner jurisdiction, as well as other stakeholders in the planning area.

Agencies such as private sector, non-profit organizations, and agencies that support underserved and socially vulnerable populations will be invited to participate as a steering committee meeting to foster partnerships and collaboration in the plan maintenance process. These essential agencies will be invited into the plan maintenance process through outreach such as emails, official letters, or phone calls. The importance of their involvement in the hazard mitigation plan maintenance process will be clearly communicated and their expertise can greatly contribute to improved safety and resilience within Lewis County.

The principal role of the steering committee in this plan maintenance strategy will be to annually review the plan, the annual progress reports and provide input to Lewis County Emergency Management on possible enhancements. Future plan updates will be overseen by the steering committee. Completion of the individual progress reports is the responsibility of each planning partner. The steering committee will review the progress reports in an effort to identify issues needing to be addressed by future plan updates.

19.5 Annual Progress Report

The minimum task of each planning partner will be the evaluation of the progress of its individual mitigation initiatives during a 12-month period. This review will include the following:

- Summary of any hazard events that occurred during the performance period and the impact these events had on the planning area.

- Review of mitigation success stories.
- Review of continuing public involvement.
- Brief discussion about why targeted strategies were not completed.
- Re-evaluation of the action plan to determine if the timeline for identified projects needs to be amended (such as changing a long-term project to a short-term one because of new funding).
- Recommendations for new projects.
- Changes in or potential for new funding options such as grant opportunities.
- Impact of any other planning programs or initiatives that involve hazard mitigation.

The Steering Committee has created a template to guide the planning partners in preparing a progress report (see Appendix C). The Steering Committee will report on the progress of the plan. This report should be used as follows:

- Posted on the Lewis County Department of Emergency Management webpage.
- Presented to planning partner governing bodies to inform them of progress.
- For those planning partners that participate in the Community Rating System, the report can be provided as part of the CRS annual recertification package. The CRS requires an annual recertification to be submitted by October 15 of every calendar year for which the community has not received a formal audit.

Uses of the progress report will be at the discretion of each planning partner. Annual progress reporting is not a requirement specified under 44CFR. However, it may enhance the planning partnership's opportunities for funding. While failure to implement this component of the plan maintenance strategy will not jeopardize a planning partner's compliance under the Disaster Mitigation Act, it may jeopardize its opportunity to partner and leverage funding opportunities with the other partners. Each planning partner was informed of these protocols at the beginning of this planning process (in the "Planning Partner Expectations" package provided at the start of the process), and each partner acknowledged these expectations when with submittal of a letter of intent to participate in this process.

19.6 Plan Update

44CFR requires that local hazard mitigation plans be reviewed, revised if appropriate, and resubmitted for approval in order to remain eligible for benefits under the Disaster Mitigation Act (Section 201.6.d.3). The Lewis County Planning Partnership intends to update the hazard mitigation plan on a five-year cycle from the date of initial plan adoption. This cycle may be accelerated to less than five years based on the following triggers:

- A Presidential Disaster Declaration that impacts the planning area.
- A hazard event that causes loss of life.
- A comprehensive update of the County or participating city's comprehensive plan.

It will not be the intent of future updates to develop a complete new hazard mitigation plan for the planning area. The update will, at a minimum, include the following elements:

- The update process will be convened through a steering committee.
- The hazard risk assessment will be reviewed and if necessary, updated using best available information and technologies.
- The mitigation initiatives will be reviewed and revised to account for actions completed,

removed, replaced, or updated and to account for changes in the risk assessment or new partnership policies identified under other planning mechanisms (such as the comprehensive plan).

- The draft update will be sent to planning partners and organizations for comment.
- The public will be given an opportunity to comment on the update prior to adoption.
- The partnership governing bodies will adopt the updated plan.

Because plan updates can require a year or more to complete, Lewis County Emergency Management will initiate efforts to update the plan before it expires. The County 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.

19.7 Continuing Public Involvement

The public will continue to be apprised of the plan's progress through the Lewis County Emergency Management webpage and press releases. 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 will be distributed to public libraries in Lewis County. Upon initiation of future update processes, a new public involvement strategy will be initiated based on guidance from a new steering committee. This strategy will be based on the needs and capabilities of the planning partnership at the time of the update.

19.8 Incorporation into Other Planning Mechanisms

The information on hazard, risk, vulnerability, and mitigation contained in this plan is based on the best science and technology available at the time this plan was prepared. The Lewis County Comprehensive Plan and the comprehensive plans of the partner cities are considered to be integral parts of this plan. The County and partner cities, through adoption of comprehensive plans and zoning ordinances, have planned for the impact of natural hazards. The plan development process provided the County and the cities with the opportunity to review and expand on policies contained within these planning mechanisms. The planning partners used their comprehensive plans and the hazard mitigation plan as complementary documents that work together to achieve the goal of reducing risk exposure to the citizens of Lewis County. An update to a comprehensive plan may trigger an update to the hazard mitigation plan.

All municipal planning partners are committed to coordinate their own individual comprehensive plans with the hazard mitigation plan. Other planning processes and programs to be coordinated with the recommendations of the hazard mitigation plan include the following:

- Partners' emergency response plans.
- Capital improvement programs.
- Municipal codes.
- Community design guidelines.
- Water-efficient landscape design guidelines.
- Stormwater management programs.
- Water system vulnerability assessments.
- Comprehensive plans.

- Community wildfire protection plans.

Some action items do not need to be implemented through regulation. Instead, these items can be implemented through the creation of new educational programs, continued interagency coordination, or improved public participation. As information becomes available from other planning mechanisms that can enhance this plan, that information will be incorporated via the update process.

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APPENDIX A. ACRONYMS AND DEFINITIONS

ACRONYMS

CFR—Code of Federal Regulations

CFS—Cubic Feet Per Second

CIP—Capital Improvement Plan

CRS—Community Rating System

DFIRM—Digital Flood Insurance Rate Maps

DHS—Department of Homeland Security

DMA—Disaster Mitigation Act

EAP—Emergency Action Plan

EPA—US Environmental Protection Agency

ESA—Endangered Species Act

FEMA—Federal Emergency Management Agency

FERC—Federal Energy Regulatory Commission

FIRM—Flood Insurance Rate Map

FIS—Flood Insurance Study

GIS—Geographic Information System

Hazus-MH—Hazards, United States Multi-Hazard

HMGP—Hazard Mitigation Grant Program

IBC—International Building Code

IRC—International Residential Code

MM—Modified Mercalli Scale

NEHRP—National Earthquake Hazards Reduction Program

NFIP—National Flood Insurance Program

NOAA—National Oceanic and Atmospheric Administration

NWS—National Weather Service

PDM—Pre-Disaster Mitigation Grant Program

PDI—Palmer Drought Index

PGA—Peak Ground Acceleration

PHDI—Palmer Hydrological Drought Index

SFHA—Special Flood Hazard Area

SHELDUS—Spatial Hazard Events and Losses Database for the US

SPI—Standardized Precipitation Index

USGS – US Geological Survey

DEFINITIONS

100-Year Flood: The term "100-year flood" can be misleading. The 100-year flood does not necessarily occur once every 100 years. Rather, it is the flood that has a 1 percent chance of being equaled or exceeded in any given year. Thus, the 100-year flood could occur more than once in a relatively short period of time. The Federal Emergency Management Agency (FEMA) defines it as the 1 percent annual chance flood, which is now the standard definition used by most federal and state agencies and by the National Flood Insurance Program (NFIP).

Acre-Foot: An acre-foot is the amount of water it takes to cover 1 acre to a depth of 1 foot. This measure is used to describe the quantity of storage in a water reservoir. An acre-foot is a unit of volume. One acre foot equals 7,758 barrels; 325,829 gallons; or 43,560 cubic feet. An average household of four will use approximately 1 acre-foot of water per year.

Asset: An asset is any man-made or natural feature that has value, including, but not limited to, people; buildings; infrastructure, such as bridges, roads, sewers, and water systems; lifelines, such as electricity and communication resources; and environmental, cultural, or recreational features such as parks, wetlands, and landmarks.

Base Flood: The flood having a 1% chance of being equaled or exceeded in any given year, also known as the "100-year" or "1% chance" flood. The base flood is a statistical concept used to ensure that all properties subject to the National Flood Insurance Program (NFIP) are protected to the same degree against flooding.

Basin: A basin is the area within which all surface water—whether from rainfall, snowmelt, springs, or other sources—flows to a single water body or watercourse. The boundary of a river basin is defined by natural topography, such as hills, mountains, and ridges. Basins are also referred to as "watersheds" and "drainage basins."

Benefit: A benefit is a net project outcome and is usually defined in monetary terms. Benefits may include direct and indirect effects. For the purposes of benefit-cost analysis of proposed mitigation measures, benefits are limited to specific, measurable, risk reduction factors, including reduction in expected property losses (buildings, contents, and functions) and protection of human life.

Benefit/Cost Analysis: A benefit/cost analysis is a systematic, quantitative method of comparing projected benefits to projected costs of a project or policy. It is used as a measure of cost effectiveness.

Building: A building is defined as a structure that is walled and roofed, principally aboveground, and permanently fixed to a site. The term includes manufactured homes on permanent foundations on which the wheels and axles carry no weight.

Capability Assessment: A capability assessment provides a description and analysis of a community's current capacity to address threats associated with hazards. The assessment includes two components: an inventory of an agency's mission, programs, and policies, and an analysis of its capacity to carry them out. A capability assessment is an integral part of the planning process in which a community's actions to reduce losses are identified, reviewed, and analyzed, and the framework for implementation is identified. The following capabilities were reviewed under this assessment:

1. Legal and regulatory capability
2. Administrative and technical capability
3. Fiscal capability

Community Rating System (CRS): The CRS is a voluntary program under the NFIP that rewards participating communities (provides incentives) for exceeding the minimum requirements of the NFIP and completing activities that reduce flood hazard risk by providing flood insurance premium discounts.

Critical Area: An area defined by state or local regulations as deserving special protection because of unique natural features or its value as habitat for a wide range of species of flora and fauna. A sensitive/critical area is usually subject to more restrictive development regulations.

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

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

Cubic Feet per Second (cfs): Discharge or river flow is commonly measured in cfs. One cubic foot is about 7.5 gallons of liquid.

Dam: Any artificial barrier or controlling mechanism that can or does impound 10 acre-feet or more of water.

Dam Failure: Dam failure refers to a partial or complete breach in a dam (or levee) that impacts its integrity. Dam failures occur for a number of reasons, such as flash flooding, inadequate spillway size, mechanical failure of valves or other equipment, freezing and thawing cycles, earthquakes, and intentional destruction.

Debris Avalanche: Volcanoes are prone to debris and mountain rock avalanches that can approach speeds of 100 mph.

Debris Flow: Dense mixtures of water-saturated debris that move down-valley; looking and behaving much like flowing concrete. They form when loose masses of unconsolidated material are saturated, become unstable, and move down slope. The source of water varies but includes rainfall, melting snow or ice, and glacial outburst floods.

Debris Slide: Debris slides consist of unconsolidated rock or soil that has moved rapidly down slope. They occur on slopes greater than 65 percent.

Disaster Mitigation Act of 2000 (DMA); The DMA is Public Law 106-390 and is the latest federal legislation enacted to encourage and promote proactive, pre-disaster planning as a condition of receiving financial assistance under the Robert T. Stafford Act. The DMA emphasizes planning for disasters before they occur. Under the DMA, a pre-disaster hazard mitigation program and new requirements for the national post-disaster hazard mitigation program (HMGP) were established.

Drainage Basin: A basin is the area within which all surface water- whether from rainfall, snowmelt, springs or other sources- flows to a single water body or watercourse. The boundary of a river basin is defined by natural topography, such as hills, mountains and ridges. Drainage basins are also referred to as **watersheds** or **basins**.

Earthquake: An earthquake is defined as a sudden slip on a fault, volcanic or magmatic activity, and sudden stress changes in the earth that result in ground shaking and radiated seismic energy. Earthquakes can last from a few seconds to over 5 minutes, and have been known to occur as a series of tremors over a period of several days. The actual movement of the ground in an earthquake is seldom the direct cause of injury or death. Casualties may result from falling objects and debris as shocks shake, damage, or demolish buildings and other structures.

Exposure: Exposure is defined as the number and dollar value of assets considered to be at risk during the occurrence of a specific hazard.

Extent: The extent is the size of an area affected by a hazard.

Fire Behavior: Fire behavior refers to the physical characteristics of a fire and is a function of the interaction between the fuel characteristics (such as type of vegetation and structures that could burn), topography, and weather. Variables that affect fire behavior include the rate of spread, intensity, fuel consumption, and fire type (such as underbrush versus crown fire).

Fire Frequency: Fire frequency is the broad measure of the rate of fire occurrence in a particular area. An estimate of the areas most likely to burn is based on past fire history or fire rotation in the area, fuel conditions, weather, ignition sources (such as human or lightning), fire suppression response, and other factors.

Flash Flood: A flash flood occurs with little or no warning when water levels rise at an extremely fast rate

Flood Insurance Rate Map (FIRM): FIRMs are the official maps on which the Federal Emergency Management Agency (FEMA) has delineated the Special Flood Hazard Area (SFHA).

Flood Insurance Study: A report published by the Federal Insurance and Mitigation Administration for a community in conjunction with the community's Flood Insurance rate Map. The study contains such background data as the base flood discharges and water surface elevations that were used to prepare the FIRM. In most cases, a community FIRM with detailed mapping will have a corresponding flood insurance study.

Floodplain: Any land area susceptible to being inundated by flood waters from any source. A flood insurance rate map identifies most, but not necessarily all, of a community's floodplain as the Special Flood Hazard Area (SFHA).

Floodway: Floodways are areas within a floodplain that are reserved for the purpose of conveying flood discharge without increasing the base flood elevation more than 1 foot. Generally speaking, no development is allowed in floodways, as any structures located there would block the flow of floodwaters.

Floodway Fringe: Floodway fringe areas are located in the floodplain but outside of the floodway. Some development is generally allowed in these areas, with a variety of restrictions. On maps that have identified and delineated a floodway, this would be the area beyond the floodway boundary that can be subject to different regulations.

Freeboard: Freeboard is the margin of safety added to the base flood elevation.

Frequency: For the purposes of this plan, frequency refers to how often a hazard of specific magnitude, duration, and/or extent is expected to occur on average. Statistically, a hazard with a 100-year frequency is expected to occur about once every 100 years on average and has a 1 percent chance of occurring any given year. Frequency reliability varies depending on the type of hazard considered.

Goal: A goal is a general guideline that explains what is to be achieved. Goals are usually broad-based, long-term, policy-type statements and represent global visions. Goals help define the benefits that a plan is trying to achieve. The success of a hazard mitigation plan is measured by the degree to which its goals have been met (that is, by the actual benefits in terms of actual hazard mitigation).

Geographic Information System (GIS): GIS is a computer software application that relates data regarding physical and other features on the earth to a database for mapping and analysis.

Hazard: A hazard is a source of potential danger or adverse condition that could harm people and/or cause property damage.

Hazard Mitigation Grant Program (HMGP): Authorized under Section 202 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, the HMGP is administered by FEMA and provides grants to states, tribes, and local governments to implement hazard mitigation actions after a major disaster declaration. The purpose of the program is to reduce the loss of life and property due to disasters and to enable mitigation activities to be implemented as a community recovers from a disaster

Hazus Loss Estimation Program: Hazus is a GIS-based program used to support the development of risk assessments as required under the DMA. The Hazu software program assesses risk in a quantitative manner to estimate damages and losses associated with natural hazards. Hazus is FEMA's nationally applicable, standardized methodology and software program and contains modules for estimating potential losses from earthquakes, floods, and wind hazards. Hazus has also been used to assess vulnerability (exposure) for other hazards.

Hydraulics: Hydraulics is the branch of science or engineering that addresses fluids (especially water) in motion in rivers or canals, works and machinery for conducting or raising water, the use of water as a prime mover, and other fluid-related areas.

Hydrology: Hydrology is the analysis of waters of the earth. For example, a flood discharge estimate is developed by conducting a hydrologic study.

Impact: Impacts are the consequences or effects of each hazard on the participant's assets identified in the vulnerability assessment.

Intensity: For the purposes of this plan, intensity refers to the measure of the effects of a hazard.

Inventory: The assets identified in a study region comprise an inventory. Inventories include assets that could be lost when a disaster occurs and community resources are at risk. Assets include people, buildings, transportation, and other valued community resources.

Landslide: Landslides can be described as the sliding movement of masses of loosened rock and soil down a hillside or slope. Fundamentally, slope failures occur when the strength of the soils forming the slope exceeds the pressure, such as weight or saturation, acting upon them.

Lightning: Lightning is an electrical discharge resulting from the buildup of positive and negative charges within a thunderstorm. When the buildup becomes strong enough, lightning appears as a "bolt," usually within or between clouds and the ground. A bolt of lightning instantaneously reaches temperatures approaching 50,000ºF. The rapid heating and cooling of air near lightning causes thunder. Lightning is a major threat during thunderstorms. In the United States, 75 to 100 Americans are struck and killed by lightning each year (see http://www.fema.gov/hazard/thunderstorms/thunder.shtm).

Liquefaction: Liquefaction is the complete failure of soils, occurring when soils lose shear strength and flow horizontally. It is most likely to occur in fine grain sands and silts, which behave like viscous fluids when liquefaction occurs. This situation is extremely hazardous to development on the soils that liquefy, and generally results in extreme property damage and threats to life and safety.

Local Government: Any county, municipality, city, town, township, public authority, school district, special district, intrastate district, council of governments (regardless of whether the council of governments is incorporated as a nonprofit corporation under State law), regional or interstate government entity, or agency or instrumentality of a local government; any Indian tribe or authorized tribal organization, or Alaska Native village or organization; and any rural community, unincorporated town or village, or other public entity.

Magnitude: Magnitude is the measure of the strength of an earthquake, and is typically measured by the Richter scale. As an estimate of energy, each whole number step in the magnitude scale corresponds to the release of about 31 times more energy than the amount associated with the preceding whole number value.

Mass Movement: A collective term for landslides, mudflows, debris flows, sinkholes and lahars.

Mitigation: A preventive action that can be taken in advance of an event that will reduce or eliminate the risk to life or property.

Mitigation Actions: Mitigation actions are specific actions to achieve goals and objectives that minimize the effects from a disaster and reduce the loss of life and property.

Objective: For the purposes of this plan, an objective is defined as a short-term aim that, when combined with other objectives, forms a strategy or course of action to meet a goal. Unlike goals, objectives are specific and measurable.

Peak Ground Acceleration: Peak Ground Acceleration (PGA) is a measure of the highest amplitude of ground shaking that accompanies an earthquake, based on a percentage of the force of gravity.

Preparedness: Preparedness refers to actions that strengthen the capability of government, citizens, and communities to respond to disasters.

Presidential Disaster Declaration: These declarations are typically made for events that cause more damage than state and local governments and resources can handle without federal government assistance. Generally, no specific dollar loss threshold has been established for such declarations. A Presidential Disaster Declaration puts into motion long-term federal recovery programs, some of which are matched by state programs, designed to help disaster victims, businesses, and public entities.

Probability of Occurrence: The probability of occurrence is a statistical measure or estimate of the likelihood that a hazard will occur. This probability is generally based on past hazard events in the area and a forecast of events that could occur in the future. A probability factor based on yearly values of occurrence is used to estimate probability of occurrence.

Repetitive Loss Property: Any NFIP-insured property that, since 1978 and regardless of any changes of ownership during that period, has experienced:

1. Four or more paid flood losses in excess of $1000.00; or
2. Two paid flood losses in excess of $1000.00 within any 10-year period since 1978 or
3. Three or more paid losses that equal or exceed the current value of the insured property.

Return Period (or Mean Return Period): This term refers to the average period of time in years between occurrences of a particular hazard (equal to the inverse of the annual frequency of occurrence).

Riverine: Of or produced by a river. Riverine floodplains have readily identifiable channels. Floodway maps can only be prepared for riverine floodplains.

Risk: Risk is the estimated impact that a hazard would have on people, services, facilities, and structures in a community. Risk measures the likelihood of a hazard occurring and resulting in an adverse condition that causes injury or damage. Risk is often expressed in relative terms such as a high, moderate, or low likelihood of sustaining damage above a particular threshold due to occurrence of a specific type of hazard. Risk also can be expressed in terms of potential monetary losses associated with the intensity of the hazard.

Risk Assessment: Risk assessment is the process of measuring potential loss of life, personal injury, economic injury, and property damage resulting from hazards. This process assesses the vulnerability of people, buildings, and infrastructure to hazards and focuses on (1) hazard identification; (2) impacts of hazards on physical, social, and economic assets; (3) vulnerability identification; and (4) estimates of the cost of damage or costs that could be avoided through mitigation.

Risk Ranking: This ranking serves two purposes, first to describe the probability that a hazard will occur, and second to describe the impact a hazard will have on people, property, and the economy. Risk estimates for the City are based on the methodology that the City used to prepare the risk assessment for this plan. The following equation shows the risk ranking calculation:

Risk Ranking = Probability + Impact (people + property + economy).

Robert T. Stafford Act: The Robert T. Stafford Disaster Relief and Emergency Assistance Act, Public Law 100-107, was signed into law on November 23, 1988. This law amended the Disaster Relief Act of 1974, Public Law 93-288. The Stafford Act is the statutory authority for most federal disaster response activities, especially as they pertain to FEMA and its programs.

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

Social vulnerability is understood as the potential for loss within an individual or social group, recognizing that some characteristics influence an individual's or group's ability to prepare, respond, cope or recover from an event. These characteristics can overlap within populations to create heightened vulnerability, which may be compounded by infrastructure deficiencies within communities and historic or existing discriminatory government policies.

Special Flood Hazard Area: The base floodplain delineated on a Flood Insurance Rate Map. The SFHA is mapped as a Zone A in riverine situations and Zone V in coastal situations. The SFHA may or may not encompass all of a community's flood problems.

Stakeholder: Business leaders, civic groups, academia, non-profit organizations, major employers, managers of critical facilities, farmers, developers, special purpose districts, and others whose actions could impact hazard mitigation.

Stream Bank Erosion: Stream bank erosion is common along rivers, streams and drains where banks have been eroded, sloughed or undercut. However, it is important to remember that a stream is a dynamic and constantly changing system. It is natural for a stream to want to meander, so not all eroding banks are "bad" and in need of repair. Generally, stream bank erosion becomes a problem where development has limited the meandering nature of streams, where streams have been channelized, or where stream bank structures (like bridges, culverts, etc.) are located in places where they can actually cause damage to downstream areas.

Stabilizing these areas can help protect watercourses from continued sedimentation, damage to adjacent land uses, control unwanted meander, and improvement of habitat for fish and wildlife.

Steep Slope: Different communities and agencies define it differently, depending on what it is being applied to, but generally a steep slope is a slope in which the percent slope equals or exceeds 25%. For this study, steep slope is defined as slopes greater than 33%.

Sustainable Hazard Mitigation: This concept includes the sound management of natural resources, local economic and social resiliency, and the recognition that hazards and mitigation must be understood in the largest possible social and economic context.

Thunderstorm: A thunderstorm is a storm with lightning and thunder produced by cumulonimbus clouds. Thunderstorms usually produce gusty winds, heavy rains, and sometimes hail. Thunderstorms are usually short in duration (seldom more than 2 hours). Heavy rains associated with thunderstorms can lead to flash flooding during the wet or dry seasons.

Tornado: A tornado is a violently rotating column of air extending between and in contact with a cloud and the surface of the earth. Tornadoes are often (but not always) visible as funnel clouds. On a local scale, tornadoes are the most intense of all atmospheric circulations, and winds can reach destructive speeds of more than 300 mph. A tornado's vortex is typically a few hundred meters in diameter, and damage paths can be up to 1 mile wide and 50 miles long.

Watershed: A watershed is an area that drains downgradient from areas of higher land to areas of lower land to the lowest point, a common drainage basin.

Wildfire: These terms refer to any uncontrolled fire occurring on undeveloped land that requires fire suppression. The potential for wildfire is influenced by three factors: the presence of fuel, topography, and air mass. Fuel can include living and dead vegetation on the ground, along the surface as brush and small trees, and in the air such as tree canopies. Topography includes both slope and elevation. Air mass includes temperature, relative humidity, wind speed and direction, cloud cover, precipitation amount, duration, and the stability of the atmosphere at the time of the fire. Wildfires can be ignited by lightning and, most frequently, by human activity including smoking, campfires, equipment use, and arson.

Vulnerability is a description of which assets, including structures, systems, populations and other assets as defined by the community, within locations identified to be hazard-prone, are at risk from the effects of the identified hazard(s).

Windstorm: Windstorms are generally short-duration events involving straight-line winds or gusts exceeding 50 mph. These gusts can produce winds of sufficient strength to cause property damage. Windstorms are especially dangerous in areas with significant tree stands, exposed property, poorly constructed buildings, mobile homes (manufactured housing units), major infrastructure, and aboveground utility lines. A windstorm can topple trees and power lines; cause damage to residential, commercial, critical facilities; and leave tons of debris in its wake.

Zoning Ordinance: The zoning ordinance designates allowable land use and intensities for a local jurisdiction. Zoning ordinances consist of two components: a zoning text and a zoning map.

APPENDIX B. PUBLIC INVOLVEMENT MATERIALS

APPENDIX C. 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 US 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 US 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 national 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 US 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 US 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. 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 percent. For example, a Class 1 community would receive a 45 percent premium discount, and a Class 9 community would receive a 5 percent discount. (Class 10 communities are those that do not participate in the CRS; they receive no discount.) The discount partially depends on location of the property. Properties outside the special flood hazard area receive smaller discounts: a 10-percent discount if the community is at Class 1 to 6 and a 5-percent discount if the community is at Class 7 to 9. The 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 percent 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 US 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 Forest 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-percent-annual-chance flood and the 0.2-percent-annual-chance flood. Base flood elevations and the boundaries of the flood hazard areas are shown on Flood Insurance Rate Maps, which are the principal 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:

1. New buildings and those undergoing substantial improvements must, at a minimum, be elevated to protect against damage by the 1-percent-annual-chance flood.
2. New floodplain development must not aggravate existing flood problems or increase damage to other properties.
3. 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. Lewis 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, Protective 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.

US 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 (US Army Corps of Engineers, 2017).

US Army Corps of Engineers Flood Hazard Management

The US 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-percent 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 percent of the cost.
- The Corps of Engineers has several cost-shared programs (typically 65 percent federal and 35 percent 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 percent federal and 35 percent non-federal.
  - Watershed management planning studies can be specifically authorized and are cost-shared at 50 percent federal and 50 percent 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-percent 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.

US Fire Administration

There are federal agencies that provide technical support to fire agencies/organizations. For example, the US Fire Administration, which is a part of FEMA, provides leadership, advocacy, coordination, and support for fire agencies and organizations.

US Fish and Wildlife Service

The US 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.

US Forest Service Six Rivers National Forest

The US 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 2015 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 2015 International Building Code went into effect as the Washington model code on July 1, 2016.

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 percent of federal disaster expenditures vs. 15 percent with a standard plan).

The *Lewis County Multi-Jurisdictional Natural Hazard Mitigation Plan* must be consistent with the Washington State Plan. One major example of this is that the Lewis County plan must, at a minimum, address those hazards identified in the state plan as impacting Lewis 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 US 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.

APPENDIX D. EXAMPLE PROGRESS REPORT

Lewis County Hazard Mitigation Plan Update Annual Progress Report

Reporting Period: *(Insert reporting period)*

Summary Overview of the Plan's Progress: The performance period for the Hazard Mitigation Plan became effective on____________________with the final approval of the plan by FEMA. The initial performance period for this plan will be 5 years, with an anticipated update to the plan to occur before____________. As of the reporting period, the following overall progress can be reported:

- __out of___initiatives (%) reported ongoing action toward completion.
- __out of___initiatives (%) were reported as being complete.
- __out of___initiatives (_____________%) reported no action taken.

Purpose: The purpose of this report is to provide an annual update on the implementation of the action plan identified in the Lewis County Hazard Mitigation Plan Update. The objective is to ensure that there is a continuing and responsive planning process that will keep the Hazard Mitigation Plan dynamic and responsive to the needs and capabilities of the partner jurisdictions. This report discusses the following:

- Natural hazard events that have occurred within the last year
- Changes in risk exposure within the planning area (all of Lewis County)
- Mitigation success stories
- Review of the action plan
- Changes in capabilities that could impact plan implementation
- Recommendations for changes/enhancement.

The Hazard Mitigation Plan Steering Committee: The Hazard Mitigation Plan Steering Committee, made up of planning partners and stakeholders reviewed and approved this progress report at its annual meeting held on_________________. It was determined through the plan's development process that a Steering Committee would remain in service to oversee maintenance of the plan. At a minimum, the Steering Committee will provide technical review and oversight on the development of the annual progress report. It is anticipated that there will be turnover in the membership annually, which will be documented in the progress reports. For this reporting period, the Steering Committee membership is as indicated in Table 1.

TABLE 1.
STEERING COMMITTEE MEMBERS

Name	Title	Jurisdiction/Agency

Natural Hazard Events within the Planning Area: During the reporting period, there were _________natural hazard events in the planning area that had a measurable impact on people or property. A summary of these events is as follows:

- __
- __

Changes in Risk Exposure in the Planning Area: *(Insert brief overview of any natural hazard event in the planning area that changed the probability of occurrence or ranking of risk for the hazards addressed in the hazard mitigation plan)*

Mitigation Success Stories: *(Insert brief overview of mitigation accomplishments during the reporting period)*

Review of the Action Plan: Table 2 reviews the action plan, reporting the status of each initiative. Reviewers of this report should refer to the Hazard Mitigation Plan for more detailed descriptions of each initiative and the prioritization process.
Address the following in the "status" column of the following table:

- *Was any element of the initiative carried out during the reporting period?*
- *If no action was completed, why?*
- *Is the timeline for implementation for the initiative still appropriate?*
- *If the initiative was completed, does it need to be changed or removed from the action plan?*

TABLE 2.
ACTION PLAN MATRIX

Action Taken? (Yes or No)	Time Line	Priority	Status	Status (X, O,)
Initiative #__—____________________________[description]				
Initiative #__—____________________________[description]				
Initiative #__—____________________________[description]				
Initiative #__—____________________________[description]				
Initiative #__—____________________________[description]				
Initiative #__—____________________________[description]				
Initiative #__—____________________________[description]				
Initiative #__—____________________________[description]				
Initiative #__—____________________________[description]				
Initiative #__—____________________________[description]				
Initiative #__—____________________________[description]				
Initiative #__—____________________________[description]				
Initiative #__—____________________________[description]				
Initiative #__—____________________________[description]				

Completion status legend:

= Project Completed

O = Action ongoing toward completion X =

No progress at this time

Changes That May Impact Implementation of the Plan: *(Insert brief overview of any significant changes in the planning area that would have a profound impact on the implementation of the plan. Specify any changes in technical, regulatory, and financial capabilities identified during the plan's development)*

Recommendations for Changes or Enhancements: Based on the review of this report by the Hazard Mitigation Plan Steering Committee, the following recommendations will be noted for future updates or revisions to the plan:

- __
- __
- __
- __
- __
- __

Public review notice: *The contents of this report are considered to be public knowledge and have been prepared for total public disclosure. Any questions or comments regarding the contents of this report should be directed to:*

Lewis County Department of Emergency
Insert Address

APPENDIX E. RISK ASSESSMENT TABLES

Table 8-4. Population Vulnerable to Dam Failure.

Jurisdiction[1]	Estimated Population	Population Exposed	% of Population Exposed
Centralia	18,193	13,383	73.6%
Centralia UGA	4,020	2,003	49.8%
Chehalis	7,440	180	2.4%
Chehalis UGA	2,598	0	0%
Morton	1,036	0	0%
Morton UGA	233	0	0%
Mossyrock	768	766	99.7%
Mossyrock UGA	79	79	100%
Napavine	1,888	0	0%
Napavine UGA	17	0	0%
Pe Ell	642	0	0%
Pe Ell UGA	14	0	0%
Toledo	631	624	98.9%
Toledo UGA	63	33	52.6%
Vader	629	514	81.7%
Vader UGA	245	92	37.7%
Winlock	1,424	0	0%
Winlock UGA	416	0	0%
UI-Cispus River	1,012	0	0%
UI-Newaukum Watershed	6,886	0	0%
UI-Cowlitz Watershed (N. of Dams)	4,455	314	14.2%
UI-Nisqually Watershed	848	0	0%
UI-Skookumchuck Watershed	120	0	0%
UI-Upper Chehalis Watershed	14,034	466	30.1%
UI-Cowlitz Watershed (S. of Dams)	14,345	3,272	22.8%
Total	**82,036**	**21,823**	**26.6%**

[1] UI = Unincorporated

Table 8-5. Structure and Content Values Vulnerable to Dam Failure.

Jurisdiction[1]	Value of Structure Exposed	Value of Contents Exposed	Value (Structure and Contents)	% of Total Value
Centralia	$2,116,763,979	$1,676,877,441	$3,793,641,420	77.2%
Centralia UGA	$270,694,091	$180,834,799	$451,528,891	33.3%
Chehalis	$334,127,582	$338,727,669	$672,855,251	19.5%
Chehalis UGA	$0	$0	$0	0%
Morton	$0	$0	$0	0%
Morton UGA	$0	$0	$0	0%
Mossyrock	$97,506,684	$78,161,175	$175,667,860	99.8%
Mossyrock UGA	$6,056,455	$3,028,227	$9,084,682	100%
Napavine	$0	$0	$0	0%
Napavine UGA	$0	$0	$0	0%
Pe Ell	$0	$0	$0	0%
Pe Ell UGA	$0	$0	$0	0%
Toledo	$94,548,911	$70,990,105	$165,539,016	93.8%
Toledo UGA	$1,673,240	$836,620	$2,509,860	5.5%
Vader	$48,398,406	$30,538,878	$78,937,284	87.4%

Vader UGA	$7,486,408	$4,501,540	$11,987,948	50.6%
Winlock	$0	$0	$0	0%
Winlock UGA	$0	$0	$0	0%
UI-Cispus River	$0	$0	$0	0%
UI-Newaukum Watershed	$0	$0	$0	0%
UI-Cowlitz Watershed (N. of Dams)	$43,405,788	$24,218,597	$67,624,384	6.5%
UI-Nisqually Watershed	$0	$0	$0	0%
UI-Skookumchuck Watershed	$7,185,849	$3,592,925	$10,778,774	80.5%
UI-Upper Chehalis Watershed	$47,130,689	$29,460,689	$76,591,378	3.2%
UI-Cowlitz Watershed (S. of Dams)	$347,013,090	$209,443,032	$556,456,122	22.4%
Total	**$3,421,991,172**	**$2,651,211,698**	**$6,073,202,870**	**28.4%**

[1] UI = Unincorporated

Table 8-6. Number of Structures in Dam Inundation Area.

Jurisdiction[1]	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Centralia	4,221	400	49	0	56	19	28	**4,773**
Centralia UGA	693	47	2	0	4	3	1	**750**
Chehalis	54	115	12	0	1	2	0	**184**
Chehalis UGA	0	0	0	0	0	0	0	**0**
Morton	0	0	0	0	0	0	0	**0**
Morton UGA	0	0	0	0	0	0	0	**0**
Mossyrock	316	39	0	0	6	2	8	**371**
Mossyrock UGA	43	0	0	0	0	0	0	**43**
Napavine	0	0	0	0	0	0	0	**0**
Napavine UGA	0	0	0	0	0	0	0	**0**
Pe Ell	0	0	0	0	0	0	0	**0**
Pe Ell UGA	0	0	0	0	0	0	0	**0**
Toledo	270	29	0	0	4	4	7	**314**
Toledo UGA	10	0	0	0	0	0	0	**10**
Vader	223	7	0	1	4	3	0	**238**
Vader UGA	40	2	0	0	0	0	0	**42**
Winlock	0	0	0	0	0	0	0	**0**
Winlock UGA	0	0	0	0	0	0	0	**0**
UI-Cispus River	0	0	0	0	0	0	0	**0**
UI-Newaukum Watershed	0	0	0	0	0	0	0	**0**
UI-Cowlitz Watershed (N. of Dams)	223	7	0	0	1	1	0	**233**
UI-Nisqually Watershed	0	0	0	0	0	0	0	**0**
UI-Skookumchuck Watershed	33	0	0	0	0	0	0	**33**
UI-Upper Chehalis Watershed	184	8	1	0	0	0	0	**194**
UI-Cowlitz Watershed (S. of Dams)	1,535	56	0	16	3	2	0	**1,612**
Total	**7,845**	**710**	**64**	**17**	**79**	**37**	**44**	**8,796**

[1] UI = Unincorporated

Table 8-7. Systems Vulnerable to Dam Failure.

Jurisdiction[1]	Communications	Energy	Hazardous Material	Health & Medical	Safety & Security	Schools	Transportation	Total
Centralia	2	0	0	21	3	6	39	**71**
Centralia UGA	0	0	0	6	0	1	2	**9**
Chehalis	0	0	0	3	2	0	6	**11**
Chehalis UGA	0	0	0	0	0	0	0	**0**
Morton	0	0	0	0	0	0	0	**0**
Morton UGA	0	0	0	0	0	0	0	**0**
Mossyrock	0	0	0	2	2	3	1	**8**
Mossyrock UGA	0	0	0	0	0	0	1	**1**
Napavine	0	0	0	0	0	0	0	**0**
Napavine UGA	0	0	0	0	0	0	0	**0**
Pe Ell	0	0	0	0	0	0	0	**0**
Pe Ell UGA	0	0	0	0	0	0	0	**0**
Toledo	0	0	0	0	5	3	8	**10**
Toledo UGA	0	0	0	0	0	0	0	**0**
Vader	0	0	0	1	2	0	0	**3**
Vader UGA	0	0	0	1	0	0	2	**3**
Winlock	0	0	0	0	0	0	0	**0**
Winlock UGA	0	0	0	0	0	0	0	**0**
UI- Cispus River	0	0	0	0	0	0	0	**0**
UI- Newaukum Watershed	0	0	0	0	0	0	0	**0**
UI- Cowlitz Watershed (N. of Dams)	0	1	0	0	2	0	3	**10**
UI- Nisqually Watershed	0	0	0	0	0	0	0	**0**
UI- Skookumchuck Water	0	0	0	0	0	0	4	**4**
UI- Upper Chehalis Watershed	1	0	0	1	0	0	12	**14**
UI- Cowlitz Watershed (S. of Dams)	0	6	0	1	4	0	31	**43**
Total	**3**	**7**	**0**	**38**	**20**	**13**	**106**	**187**

[1] UI = Unincorporated

Table 8-8. Displaced Population, and Short-Term Shelter.

Jurisdiction[1]	Displaced Population	People Requiring Short-Term Shelter
Centralia	10,878	455
Centralia UGA	1,297	73

Chehalis	58	2
Chehalis UGA	0	0
Morton	0	0
Morton UGA	0	0
Mossyrock	737	22
Mossyrock UGA	79	3
Napavine	0	0
Napavine UGA	0	0
Pe Ell	0	0
Pe Ell UGA	0	0
Toledo	583	13
Toledo UGA	28	2
Vader	418	10
Vader UGA	40	3
Winlock	0	0
Winlock UGA	0	0
UI-Cispus River	0	0
UI-Newaukum Watershed	0	0
UI-Cowlitz Watershed (N. of Dams)	172	13
UI-Nisqually Watershed	0	0
UI-Skookumchuck Watershed	68	2
UI-Upper Chehalis Watershed	217	10
UI-Cowlitz Watershed (S. of Dams)	1,498	102
Total	**16,071**	**710**

[1] UI = Unincorporated

Table 8-9. Structure and Content Values Impacted by Dam Failure.

Jurisdiction[1]	Value of Structure Exposed	Value of Contents Exposed	Value (Structure and Contents)	% of Total Value
Centralia	$467,100,198	$621,310,167	$1,088,410,365	22.2%
Centralia UGA	$19,778,194	$11,891,778	$31,669,972	2.3%
Chehalis	$15,767,653	$49,963,957	$65,731,611	1.9%
Chehalis UGA	$0	$0	$0	0.0%
Morton	$0	$0	$0	0.0%
Morton UGA	$0	$0	$0	0.0%
Mossyrock	$82,102,917	$70,699,948	$152,802,865	86.8%
Mossyrock UGA	$5,330,748	$2,453,163	$7,783,911	85.7%
Napavine	$0	$0	$0	0.0%
Napavine UGA	$0	$0	$0	0.0%
Pe Ell	$0	$0	$0	0.0%
Pe Ell UGA	$0	$0	$0	0.0%
Toledo	$74,363,063	$62,431,723	$136,794,786	77.5%
Toledo UGA	$1,309,578	$631,570	$1,941,147	4.3%
Vader	$37,337,106	$25,128,526	$62,465,632	69.2%
Vader UGA	$6,146,647	$3,713,421	$9,860,068	41.6%
Winlock	$0	$0	$0	0.0%
Winlock UGA	$0	$0	$0	0.0%
UI-Cispus River	$0	$0	$0	0.0%
UI-Newaukum Watershed	$0	$0	$0	0.0%
UI-Cowlitz Watershed (N. of Dams)	$34,186,403	18,001,937	52,188,340	5%

UI-Nisqually Watershed	$0	$0	$0	0.0%
UI-Skookumchuck Watershed	$3,391,480	$1,728,546	$5,120,026	38.3%
UI-Upper Chehalis Watershed	$10,491,429	$12,405,144	$22,896,573	.9%
UI-Cowlitz Watershed (S. of Dams)	$268,326,116	$157,664,753	$425,990,869	17.1%
Total	**$1,025,631,532**	**$1,038,024,633**	**$2,063,656,166**	**9.6%**

1 UI = Unincorporated

Table 8-10. Systems Exposed Dam Failure.

Type of System	Number of Facilities Affected	Average % of Total Value Damaged	
		Structure	Content
Safety and Security	10	78.9%	100%
Schools	11	60%	78.8%
Health and Medical	31	40.7%	65.6%
Energy	7	65%	51.7%
Communications	3	17%	49.2%
Transportation	50	1.6%	55.1%
Hazardous Materials	0	N/A	N/A
Total/Average	**112**	**43.9%**	**66.7%**

Table 8-11. Estimate Tons of Debris Due to Dam Failure.

Jurisdiction[1]	Debris (tons)
Centralia	89,396
Centralia UGA	4,242
Chehalis	845
Chehalis UGA	0
Morton	0
Morton UGA	0
Mossyrock	25,364
Mossyrock UGA	1,175
Napavine	0
Napavine UGA	0
Pe Ell	0
Pe Ell UGA	0
Toledo	12,453
Toledo UGA	297
Vader	8,391
Vader UGA	1,553
Winlock	0
Winlock UGA	0
UI-Cispus River	0
UI-Newaukum Watershed	0
UI-Cowlitz Watershed (N. of Dams)	5,046
UI-Nisqually Watershed	0
UI-Skookumchuck Watershed	808
UI-Upper Chehalis Watershed	2,494
UI-Cowlitz Watershed (S. of Dams)	49,202
Total	**201,266**

1 UI = Unincorporated

Table 9-8. Earthquake Structure Loss Potential Cascadia M9.34 and Nisqually M7.2

Estimated Earthquake Loss Value						
	Cascadia M9.3			Nisqually M7.2		
Jurisdiction	**Structural**	**Contents**	**Total**	**Structural**	**Contents**	**Total**
Centralia	$366,584,938	$156,437,400	**$523,022,338**	$174,907,412	$83,814,977	**$258,722,389**
Centralia UGA	$61,833,983	$31,530,216	**$93,364,199**	$15,180,835	$8,615,043	**$23,795,878**
Chehalis	$321,074,018	$149,571,414	**$470,645,432**	$83,456,123	$46,739,449	**$130,195,573**
Chehalis UGA	$106,176,448	$44,282,562	**$150,459010**	$18,804,082	$11,762,997	**$30,567,079**
Morton	$33,558,298	$18,133,199	**$51,691,497**	$16,070,589	$9,167,635	**$25,238,224**
Morton UGA	$8,289,848	$5,212,412	**$13,502,259**	$2,755,175	$1,837,818	**$4,592,993**
Mossyrock	$3,880,335	$1,685,116	**$5,565,451**	$681,114	$500,077	**$1,181,191**
Mossyrock UGA	$311,323	$64,570	**$375,894**	$49,870	$21,822	**$71,692**
Napavine	$22,450,598	$8,327,689	**$30,778,287**	$3,793,865	$2,345,662	**$6,139,527**
Napavine UGA	$61,148	$14,664	**$75,812**	$5,396	$3,008	**$8,403**
Pe Ell	$19,388,033	$7,159,709	**$26,547,742**	$6,178,937	$2,711,008	**$8,889,945**
Pe Ell UGA	$195,115	$53,383	**$248,498**	$68,897	$21,574	**$90,471**
Toledo	$14,905,726	$5,627,934	**$20,533,659**	$4,571,751	$2,155,278	**$6,727,029**
Toledo UGA	$2,274,953	$668,115	**$2,943,068**	$205,008	$110,752	**$315,760**
Vader	$5,350,487	$1,463,999	**$6,814,486**	$280,829	$142,034	**$422,863**
Vader UGA	$2,255,839	$498,871	**$2,754,710**	$63,592	$26,243	**$89,835**
Winlock	$31,571,400	$14,920,824	**$46,492,224**	$8,566,354	$4,848,669	**$13,415,023**
Winlock UGA	$3,661,211	$1,490,888	**5,152,100**	$520,240	$274,236	**$794,476**
Unincorporated	$352,333,273	$110,652,802	**$462,986,075**	$81,665,476	$34,183,463	**$115,848,939**
Total	**$1,356,156,976**	**$557,795,765**	**$1,913,952,741**	**$417,825,545**	**$209,281,744**	**$627,107,288**

Table 9-9. Earthquake Structure Loss Potential 100-Year Probabilistic and St. Helens M7.0.

Estimated Earthquake Loss Value						
	100- Year Probabilistic			St. Helens M7.0		
Jurisdiction	**Structural**	**Contents**	**Total**	**Structural**	**Contents**	**Total**
Centralia	$30,725,381	$17,591,014	**$48,316,395**	$7,433,937	$5,352,643	**$12,786,579**
Centralia UGA	$8,157,717	$5,640,952	**$13,798,669**	$774,897	$580,595	**$1,355,492**
Chehalis	$14,774,618	$9,071,031	**$23,845,649**	$6,650,872	$5,082,657	**$11,733,529**
Chehalis UGA	$3,848,760	$2,903,146	**$6,751,906**	$1,721,266	$1,341,516	**$3,062,782**
Morton	$303,876	$283,666	**$587,542**	$37,813,222	$20,783,541	**$58,596,763**
Morton UGA	$205,923	$203,760	**$409,683**	$9,201,900	$5,838,794	**$15,040,694**
Mossyrock	$218,793	$179,067	**$397,859**	$2,184,506	$1,291,668	**$3,476,174**
Mossyrock UGA	$16,311	$8,518	**$24,829**	$191,174	$63,031	**$254,305**
Napavine	$964,884	$671,634	**$1,636,518**	$316,624	$211,969	**$528,594**
Napavine UGA	$2,294	$1,374	**$3,668**	$843	$407	**$1,250**
Pe Ell	$136,234	$108,857	**$245,091**	$126,201	$86,559	**$212,759**
Pe Ell UGA	$1,485	$1,003	**$2,488**	$1,421	$793	**$2,214**
Toledo	$164,851	$131,881	**$296,733**	$390,306	$272,640	**$662,946**

Toledo UGA	$49,043	$31,637	**$80,680**	$48,557	$30,841	**$79,399**
Vader	$78,831	$49,510	**$128,341**	$39,327	$24,950	**$64,277**
Vader UGA	$25,067	$11,959	**$37,026**	$10,044	$5,157	**$15,201**
Winlock	$649,723	$549,060	**$1,198,782**	$595,729	$467,188	**$1,062,917**
Winlock UGA	$115,344	$86,827	**$202,171**	$67,724	$43,053	**$110,777**
Unincorporated	$13,169,760	$7,294,542	**$20,464,302**	$32,247,361	$14,086,612	**$46,333,972**
Total	**$73,608,895**	**$44,819,437**	**$118,428,333**	**$99,815,910**	**$55,564,613**	**$155,380,523**

Table 9-10. Critical Facility Impacted by Mt. St. Helens M7.0.

		Number of Building with 50% or Great Probability of Achieving Damage Level				
Category	**# of Critical Facilities**	**No Damage**	**Slight Damage**	**Moderate Damage**	**Extensive Damage**	**Complete Damage**
Safety and Security	61	52	3	4	2	0
Schools	44	39	3	2	0	0
Health and Medical	133	120	2	11	0	0
Energy	207	199	6	2	0	0
Communications	42	22	7	1	2	0
Transportation	421	420	1	0	0	0
Hazardous Materials	0	0	0	0	0	0
Total	**908**	**852**	**22**	**20**	**4**	**0**

Table 9-11. Critical Facilities Impacted by Nisqually M7.2.

		Number of Building with 50% or Great Probability of Achieving Damage Level				
Category	**# of Critical Facilities**	**No Damage**	**Slight Damage**	**Moderate Damage**	**Extensive Damage**	**Complete Damage**
Safety and Security	61	35	17	9	0	0
Schools	44	29	10	5	0	0
Health and Medical	133	80	53	0	0	0
Energy	207	180	27	0	0	0
Communications	42	21	4	6	1	0
Transportation	421	420	1	0	0	0
Hazardous Materials	0	0	0	0	0	0
Total	**908**	**765**	**112**	**20**	**1**	**0**

Table 9-12. Critical Facilities Impacted by Cascadia M9.3.

		Number of Building with 50% or Great Probability of Achieving Damage Level				
Category	**# of Critical Facilities**	**No Damage**	**Slight Damage**	**Moderate Damage**	**Extensive Damage**	**Complete Damage**
Safety and Security	61	2	3	8	37	11
Schools	44	2	0	5	31	6
Health and Medical	133	2	11	86	34	0
Energy	207	2	0	9	190	6

Communications	42	4	0	8	13	7
Transportation	421	397	22	2	0	0
Hazardous Materials	0	0	0	0	0	0
Total	**908**	**409**	**36**	**118**	**305**	**30**

Table 9-13. Critical Facilities Impacted by 100-Year Earthquake.

Category	# of Critical Facilities	Number of Building with 50% or Great Probability of Achieving Damage Level				
		No Damage	Slight Damage	Moderate Damage	Extensive Damage	Complete Damage
Safety and Security	61	61	0	0	0	0
Schools	44	44	0	0	0	0
Health and Medical	133	133	0	0	0	0
Energy	207	207	0	0	0	0
Communications	42	40	2	0	0	0
Transportation	421	421	0	0	0	0
Hazardous Materials	0	0	0	0	0	0
Total	**908**	**906**	**2**	**0**	**0**	**0**

Table 10-5. 100-year Floodplain Population Exposure.

Jurisdiction[1]	Impact	Estimated Population	Population Exposed	% of Population Exposed
Centralia	High	18,193	7,803	42.9%
Centralia UGA	Medium	4,020	633	15.7%
Chehalis	Medium	7,440	821	11.0%
Chehalis UGA	Low	2,598	54	2.1%
Morton	Low	1,036	14	1.4%
Morton UGA	Medium	233	31	13.4%
Mossyrock	None	768	0	0.0%
Mossyrock UGA	Low	79	4	4.7%
Napavine	Low	1,888	16	0.8%
Napavine UGA	None	17	0	0.0%
Pe Ell	Low	642	38	5.9%
Pe Ell UGA	None	14	0	0.0%
Toledo	High	631	162	25.6%
Toledo UGA	Low	63	3	5.3%
Vader	Low	629	12	1.8%
Vader UGA	Low	245	5	1.9%
Winlock	Low	1,424	27	1.9%
Winlock UGA	Low	416	16	3.9%
UI-Cispus River	Medium	1,012	246	24.3%
UI-Newaukum Watershed	Low	6,886	379	5.5%
UI-Cowlitz Watershed (N. of Dams)	Medium	4,455	503	11.2%
UI-Nisqually Watershed	Low	848	57	6.7%
UI-Skookumchuck Watershed	High	120	79	65.9%
UI-Upper Chehalis Watershed	Medium	14,034	1,666	11.9%
UI-Cowlitz Watershed (S. of Dams)	Low	6,990	695	4.8%
Total	**Medium**	**82,036**	**13,264**	**16.2%**

[1] UI = Unincorporated County

Table 10-6. Structures and Contents Value in the 100-year Floodplain.

Jurisdiction[1]	Building Exposed	Value of Structure	Value of Contents	Value (Structure and Contents)	% of Total Value Exposed
Centralia	2,775	$1,098,779,277	$887,233,779	$1,986,013,056	40.4%
Centralia UGA	227	$64,227,127	$37,580,907	$101,808,033	7.5%
Chehalis	424	$518,816,101	$516,898,114	$1,035,714,215	30.0%
Chehalis UGA	34	$21,562,278	$23,840,305	$45,402,583	2.5%
Morton	24	$26,421,276	$25,990,124	$52,411,399	9.8%
Morton UGA	24	$39,979,091	$57,611,136	$97,590,227	68.7%
Mossyrock	0	$0	$0	$0	0.0%
Mossyrock UGA	2	$191,573	$95,786	$287,359	3.2%
Napavine	11	$13,264,498	$13,097,316	$26,361,814	6.4%
Napavine UGA	0	$0	$0	$0	0.0%
Pe Ell	19	$3,278,844	$1,664,569	$4,943,413	3.3%
Pe Ell UGA	0	$0	$0	$0	0.0%
Toledo	76	$21,439,400	$15,157,349	$36,596,748	20.7%
Toledo UGA	1	$68,292	$34,146	$102,438	0.2%
Vader	5	$611,107	$305,553	$916,660	1.0%
Vader UGA	2	$100,427	$50,213	$150,640	0.6%
Winlock	17	$6,085,714	$4,961,159	$11,046,873	2.6%
Winlock UGA	6	$1,053,408	$526,704	$1,580,113	1.7%
UI-Cispus River	303	$65,233,367	$41,251,559	$106,484,926	25.2%
UI-Newaukum Watershed	157	$36,142,794	$18,071,397	$54,214,190	5.2%
UI-Cowlitz Watershed (N. of Dams)	503	125,072,923	$102,219,784	$227,292,707	21.8%
UI-Nisqually Watershed	51	$8,607,969	$4,320,079	$12,928,048	6.3%
UI-Skookumchuck Watershed	27	$6,390,522	$3,195,261	$9,585,783	71.6%
UI-Upper Chehalis Watershed	703	$184,232,220	113,308,031	$297,540,253	12.5%
UI-Cowlitz Watershed (S. of Dams)	336	$65,696,167	$34,717,632	$100,413,799	$4.0%
Total	**5,594**	**$2,307,254,373**	**$1,902,130,905**	**$4,209,385,279**	**19.7%**

Table 10-7. Number of Structures in the Floodplain.

Jurisdiction[1]	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Centralia	2,461	213	36	0	34	8	23	**2,775**
Centralia UGA	219	6	1	0	0	1	0	**227**
Chehalis	247	139	30	0	2	6	0	**424**
Chehalis UGA	25	3	5	0	1	0	0	**34**
Morton	7	11	0	0	0	2	4	**24**
Morton UGA	17	0	5	0	0	2	0	**24**
Mossyrock	0	0	0	0	0	0	0	**0**
Mossyrock UGA	2	0	0	0	0	0	0	**2**
Napavine	6	3	0	0	2	0	0	**11**
Napavine UGA	0	0	0	0	0	0	0	**0**
Pe Ell	18	1	0	0	0	0	0	**19**

Pe Ell UGA	0	0	0	0	0	0	0	**0**
Toledo	70	3	0	0	0	0	3	**76**
Toledo UGA	1	0	0	0	0	0	0	**1**
Vader	5	0	0	0	0	0	0	**5**
Vader UGA	2	0	0	0	0	0	0	**2**
Winlock	11	4	0	0	1	1	0	**17**
Winlock UGA	6	0	0	0	0	0	0	**6**
UI-Cispus River	273	25	0	0	0	5	0	**303**
UI-Newaukum Watershed	157	0	0	0	0	0	0	**157**
UI-Cowlitz Watershed (N. of Dams)	350	9	1	5	3	2	0	**370**
UI-Nisqually Watershed	50	1	0	0	0	0	0	**51**
UI-Skookumchuck Watershed	27	0	0	0	0	0	0	**27**
UI-Upper Chehalis Watershed	670	20	1	1	4	2	5	**703**
UI-Cowlitz Watershed (S. of Dams)	326	9	0	0	0	1	0	**336**
Total	**4,950**	**447**	**79**	**6**	**47**	**30**	**35**	**5,594**

[1] UI = Unincorporated County

Table 10-8. Critical Facilities Located within 100-year Floodplain.

Jurisdiction[1]	Communications	Energy	Hazardous Material	Health & Medical	Safety & Security	Schools	Transportation	Total
Lewis County	**3**	**13**	**0**	**24**	**28**	**2**	**244**	**313**
Centralia	2	0	0	16	2	0	33	**53**
Centralia UGA	0	0	0	1	0	0	2	**3**
Chehalis	0	0	0	3	1	0	14	**18**
Chehalis UGA	0	0	0	0	0	0	3	**3**
Morton	0	0	0	0	0	0	0	**0**
Morton UGA	0	0	0	0	0	0	0	**0**
Mossyrock	0	0	0	0	0	0	0	**0**
Mossyrock UGA	0	0	0	0	0	0	1	**1**
Napavine	0	0	0	0	0	0	3	**3**
Napavine UGA	0	0	0	0	0	0	0	**0**
Pe Ell	0	0	0	0	0	0	2	**2**
Pe Ell UGA	0	0	0	0	0	0	0	**0**
Toledo	0	0	0	0	3	1	0	**4**
Toledo UGA	0	0	0	0	0	0	0	**0**
Vader	0	0	0	0	0	0	1	**1**
Vader UGA	0	0	0	0	0	0	0	**0**
Winlock	0	0	0	0	0	0	1	**1**
Winlock UGA	0	0	0	0	0	0	0	**0**

UI- Cispus River	0	0	0	1	1	0	11	**13**
UI- Newaukum Watershed	0	0	0	0	0	0	19	**19**
UI- Cowlitz Watershed (N. of Dams)	0	2	0	1	2	0	18	**23**
UI- Nisqually Watershed	0	0	0	0	0	0	6	**6**
UI- Skookumchuck Water	0	0	0	0	0	0	4	**4**
UI- Upper Chehalis Watershed	1	8	0	2	15	1	84	**111**
UI- Cowlitz Watershed (S. of Dams)	0	3	0	0	3	0	42	**48**
Total	**3**	**13**	**0**	**24**	**28**	**2**	**244**	**313**

[1] UI = Unincorporated County

Table 10-9. Displaced Populations.

Jurisdiction[1]	Displaced Population	People Requiring Short-Term Shelter
Centralia	3,802	251
Centralia UGA	187	21
Chehalis	375	16
Chehalis UGA	6	1
Morton	1	0
Morton UGA	10	1
Mossyrock	0	0
Mossyrock UGA	1	0
Napavine	6	0
Napavine UGA	0	0
Pe Ell	6	1
Pe Ell UGA	0	0
Toledo	77	5
Toledo UGA	1	0
Vader	2	0
Vader UGA	0	0
Winlock	3	1
Winlock UGA	1	0
UI-Cispus River	105	8
UI-Newaukum Watershed	42	9
UI-Cowlitz Watershed (N. of Dams)	79	13
UI-Nisqually Watershed	5	1
UI-Skookumchuck Watershed	66	2
UI-Upper Chehalis Watershed	537	40
UI-Cowlitz Watershed (S. of Dams)	57	13
Total	**5,371**	**383**

[1] UI = Unincorporated County

Table 10-10. Estimated Flood Loss for the 100-Year Flood Event.

Jurisdiction[1]	Estimated Flood Loss: Structure	Contents	Total	% of Total Assessed Value
Centralia	$20,351,655	$21,988,736	**$42,240,391**	.9%
Centralia UGA	$2,417,749	$1,899,365	**$4,317,114**	.3%
Chehalis	$30,528,056	$90,915,256	**$121,443,312**	3.5%
Chehalis UGA	$483,656	$422,409	**$906,065**	0%
Morton	$140,095	$104,936	**$245,031**	0%
Morton UGA	$830,201	$305,098	**$1,135,299**	.8%
Mossyrock	$0	$0	**$0**	0%
Mossyrock UGA	$0	$0	**$0**	0%
Napavine	$10,453	$20,905	**$31,358**	0%
Napavine UGA	$0	$0	**$0**	0%
Pe Ell	$170,988	$94,532	**$265,520**	.2%
Pe Ell UGA	$0	$0	**$0**	0%
Toledo	$2,112,758	$6,584,154	**$8,696,913**	4.9%
Toledo UGA	$0	$0	**$0**	0%
Vader	$0	$0	**$0**	0%
Vader UGA	$45,010	$24,520	**$69,530**	.3%
Winlock	$182,365	$542,260	**$724,625**	.2%
Winlock UGA	$184,010	$52,636	**$236,647**	.3%
UI-Cispus River	$6,684,265	$5, 504,156	**$12,191,421**	2.9%
UI-Newaukum Watershed	$1,121,425	$598,440	**$1,719,864**	.1%
UI-Cowlitz Watershed (N. of Dams)	$6,420,444	$5,893,022	**$12,313,466**	1.1%
UI-Nisqually Watershed	$225,284	$92,371	**$317,655**	.2%
UI-Skookumchuck Watershed	$472,823	$255,576	**$728,400**	5.4%
UI-Upper Chehalis Watershed	$12,517,404	$14,119,996	**$26,637,401**	1.1%
UI-Cowlitz Watershed (S. of Dams)	$11,559,563	$6,399,568	**$17,959,132**	.7%
Total	**$96,461,207**	**$155,817,937**	**$252,279,143**	**1.2%**

[1] UI = Unincorporated County

Table 10-11. Flood Loss Potential to Critical Facilities.

	Number of Facilities Affected	Average % of Total Value Damaged: Structure	Content
Safety and Security	7	5.89	17.58
Schools	2	7.05	38.64
Health and Medical	25	5.61	7.88
Energy	13	27.29	48.33
Communications	3	4.55	15.93
Transportation	80	1.37	28.35
Hazardous Material	0	N/A	N/A
Total/Average	130	8.63	26.12

Table 10-12. Estimated Flood-Caused Debris.

Jurisdiction[1]	Debris to be Removed (tons)
Centralia	11,526
Centralia UGA	1,143
Chehalis	2,193
Chehalis UGA	185
Morton	211
Morton UGA	1,209
Mossyrock	0
Mossyrock UGA	1
Napavine	0
Napavine UGA	0
Pe Ell	203
Pe Ell UGA	0
Toledo	571
Toledo UGA	6
Vader	2
Vader UGA	26
Winlock	16
Winlock UGA	13
UI-Cispus River	2,080
UI-Newaukum Watershed	941
UI-Cowlitz Watershed (N. of Dams)	3,458
UI-Nisqually Watershed	89
UI-Skookumchuck Watershed	262
UI-Upper Chehalis Watershed	9,157
UI-Cowlitz Watershed (S. of Dams)	2,825
Total	**36,118**

[1] UI = Unincorporated County

Table 11-1. Population in Areas Most Vulnerable to Landslides.

Jurisdiction	Total Population	Slopes 15-35%		Slopes greater than 35%	
		Population Exposed	% of Population Exposed	Population Exposed	% of Population Exposed
Centralia	18,193	358	2.0%	10	0.1%
Centralia UGA	4,020	306	7.6%	6	0.1%
Chehalis	7,440	881	11.8%	40	0.5%
Chehalis UGA	2,598	280	10.8%	4	0.2%
Morton	1,036	52	5.0%	2	0.2%
Morton UGA	233	18	7.9%	2	0.8%
Mossyrock	768	24	3.2%	0	0.0%
Mossyrock UGA	79	0	0.0%	0	0.0%
Napavine	1,888	58	3.1%	0	0.0%
Napavine UGA	17	0	0.0%	0	0.0%
Pe Ell	642	21	3.3%	0	0.0%
Pe Ell UGA	14	0	0.0%	0	0.0%
Toledo	631	9	1.5%	0	0.0%
Toledo UGA	63	10	15.8%	0	0.0%

Vader	629	0	0.0%	0	0.0%
Vader UGA	245	9	3.8%	0	0.0%
Winlock	1,424	115	8.1%	7	0.5%
Winlock UGA	416	11	2.6%	0	0.0%
Unincorporated	41,700	2,861	6.9%	256	0.6%
Total	**82,036**	**5,016**	**6.1%**	**327**	**0.4%**

Table 11-3. Structures Exposed to Slope 15-35%.

	Number of Structures in Hazard Area							
Jurisdiction	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Centralia	113	0	0	0	1	0	0	**114**
Centralia UGA	106	0	0	0	0	0	0	**106**
Chehalis	265	7	1	0	1	0	0	**274**
Chehalis UGA	130	0	0	0	1	0	0	**131**
Morton	25	0	0	0	0	0	0	**25**
Morton UGA	10	0	0	0	0	0	0	**10**
Mossyrock	10	0	0	0	0	0	0	**10**
Mossyrock UGA	0	0	0	0	0	0	0	**0**
Napavine	22	0	0	0	0	0	0	**22**
Napavine UGA	0	0	0	0	0	0	0	**0**
Pe Ell	10	0	0	0	0	0	0	**10**
Pe Ell UGA	0	0	0	0	0	0	0	**0**
Toledo	4	1	0	0	0	0	0	**5**
Toledo UGA	3	0	0	0	0	0	0	**3**
Vader	0	0	0	0	0	0	0	**0**
Vader UGA	4	1	0	0	0	0	0	**5**
Winlock	47	7	0	0	1	1	0	**56**
Winlock UGA	4	0	0	0	0	0	0	**4**
Unincorporated	1,385	18	0	1	0	1	0	**1,405**
Total	**2,138**	**34**	**1**	**1**	**4**	**2**	**0**	**2,180**

Table 11-4. Structures Exposed Slope Greater than 35%.

	Number of Structures in Hazard Area							
Jurisdiction	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Centralia	3	0	0	0	0	0	0	**3**
Centralia UGA	2	0	0	0	0	0	0	**2**
Chehalis	12	0	0	0	0	0	0	**12**
Chehalis UGA	2	0	0	0	0	0	0	**2**
Morton	1	0	0	0	0	0	0	**1**
Morton UGA	1	0	0	0	0	0	0	**1**
Mossyrock	0	0	0	0	0	0	0	**0**
Mossyrock UGA	0	0	0	0	0	0	0	**0**
Napavine	0	0	0	0	0	0	0	**0**
Napavine UGA	0	0	0	0	0	0	0	**0**
Pe Ell	0	0	0	0	0	0	0	**0**
Pe Ell UGA	0	0	0	0	0	0	0	**0**
Toledo	0	0	0	0	0	0	0	**0**
Toledo UGA	0	0	0	0	0	0	0	**0**
Vader	0	0	0	0	0	0	0	**0**
Vader UGA	0	0	0	0	0	0	0	**0**

Winlock	3	1	0	0	0	0	0	**4**
Winlock UGA	0	0	0	0	0	0	0	**0**
Unincorporated	124	20	0	0	0	0	0	**144**
Total	**148**	**21**	**0**	**0**	**0**	**0**	**0**	**169**

Table 11-5. Structure and Contents Value on Slopes 15-35%.

Jurisdiction	Value of Structure Exposed	Value of Content Exposed	Total Value (Structure and Content)	% of Total Value
Centralia	$28,495,823	$14,814,030	$43,309,853	0.9%
Centralia UGA	$34,633,963	$17,316,981	$51,950,944	3.8%
Chehalis	$135,867,004	$82,433,426	$218,300,430	6.3%
Chehalis UGA	$53,753,864	$27,304,717	$81,058,581	4.4%
Morton	$5,195,944	$2,597,972	$7,793,916	1.5%
Morton UGA	$2,018$,587	$1,009,294	$3,027,881	2.1%
Mossyrock	$829,967	$414,983	$1,244,950	0.7%
Mossyrock UGA	$0	$0	$0	0.0%
Napavine	$5,773,983	$2,886,992	$8,660,975	2.1%
Napavine UGA	$0	$0	$0	0.0%
Pe Ell	$1,429,032	$714,516	$2,143,549	1.4%
Pe Ell UGA	$0	$0	$0	0.0%
Toledo	$870,087	$646,280	$1,516,367	0.9%
Toledo UGA	$558,444	$279,222	$837,666	1.8%
Vader	$0	$0	$0	0.0%
Vader UGA	$530,206	$400,495	$930,702	3.9%
Winlock	$19,337,063	$12,522,968	$31,860,031	7.4%
Winlock UGA	$575,573	$287,786	$863,359	0.9%
Unincorporated	$313,147,644	$160,349,677	$473,497,321	6.3%
Total	**$603,017,184**	**$323,979,340**	**$926,996,524**	**4.3%**

Table 11-6. Structure and Contents Value on Slopes Greater than 35%.

Jurisdiction	Value of Structure Exposed	Value of Content Exposed	Total Value (Structure and Content)	% of Total Value
Centralia	$582,637	$291,319	$873,956	0.0%
Centralia UGA	$714,684	$357,342	$1,072,026	0.1%
Chehalis	$4,789,553	$2,394,776	$7,184,329	0.2%
Chehalis UGA	$782,727	$391,364	$1,174,091	0.1%
Morton	$115,037	$57,519	$172,556	0.0%
Morton UGA	$181,666	$90,833	$272,499	0.2%
Mossyrock	$0	$0	$0	0.0%
Mossyrock UGA	$0	$0	$0	0.0%
Napavine	$0	$0	$0	0.0%
Napavine UGA	$0	$0	$0	0.0%
Pe Ell	$0	$0	$0	0.0%
Pe Ell UGA	$0	$0	$0	0.0%
Toledo	$0	$0	$0	0.0%
Toledo UGA	$0	$0	$0	0.0%
Vader	$0	$0	$0	0.0%
Vader UGA	$0	$0	$0	0.0%

Winlock	$723,643	$560,004	$1,283,646	0.3%
Winlock UGA	$0	$0	$0	0.0%
Unincorporated	$31,558,705	$20,783,921	$52,342,625	0.7%
Total	**$39,448,652**	**$24,927,077**	**$64,375,729**	**0.3%**

Table 11-7. Critical Facilities Exposed to Slopes 15-35%.

Jurisdiction	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health and Medical	Safety and Security	Transportation	Total
Centralia	0	0	0	0	0	0	0	**0**
Centralia UGA	2	0	0	0	0	0	0	**2**
Chehalis	0	0	0	0	0	0	0	**0**
Chehalis UGA	0	0	0	0	0	0	1	**1**
Morton	0	0	0	0	0	0	1	**1**
Morton UGA	0	0	0	0	0	0	0	**0**
Mossyrock	0	0	0	0	0	0	0	**0**
Mossyrock UGA	0	0	0	0	0	0	0	**0**
Napavine	0	0	0	0	0	0	0	**0**
Napavine UGA	0	0	0	0	0	0	0	**0**
Pe Ell	0	0	0	0	0	0	0	**0**
Pe Ell UGA	0	0	0	0	0	0	0	**0**
Toledo	0	0	0	0	0	0	0	**0**
Toledo UGA	0	0	0	0	0	0	0	**0**
Vader	0	0	0	0	0	0	0	**0**
Vader UGA	0	0	0	0	0	0	0	**0**
Winlock	0	0	0	0	0	0	0	**0**
Winlock UGA	0	0	0	0	0	0	0	**0**
Unincorporated	2	4	0	0	0	1	23	**30**
Total	**4**	**4**	**0**	**0**	**0**	**1**	**25**	**34**

Table 11-8. Critical Facilities Exposed to Slopes greater than 35%.

Jurisdiction	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health and Medical	Safety and Security	Transportation	Total
Centralia	0	0	0	0	0	0	0	**0**
Centralia UGA	0	0	0	0	0	0	0	**0**
Chehalis	0	0	0	0	1	0	0	**1**
Chehalis UGA	0	0	0	0	0	0	0	**0**
Morton	0	0	0	0	0	0	0	**0**
Morton UGA	0	0	0	0	0	0	0	**0**
Mossyrock	0	0	0	0	0	0	0	**0**
Mossyrock UGA	0	0	0	0	0	0	0	**0**
Napavine	0	0	0	0	0	0	0	**0**
Napavine UGA	0	0	0	0	0	0	0	**0**
Pe Ell	0	0	0	0	0	0	0	**0**
Pe Ell UGA	0	0	0	0	0	0	0	**0**
Toledo	0	0	0	0	0	0	0	**0**
Toledo UGA	0	0	0	0	0	0	0	**0**
Vader	0	0	0	0	0	0	0	**0**
Vader UGA	0	0	0	0	0	0	0	**0**

Winlock	0	0	0	0	0	0	0	**0**
Winlock UGA	0	0	0	0	0	0	0	**0**
Unincorporated	5	13	0	0	0	2	10	**30**
Total	**5**	**13**	**0**	**0**	**1**	**2**	**10**	**31**

APPENDIX F. FEMA APPROVAL LETTER AND PLAN ADOPTION RESOLUTIONS FROM PLANNING PARTNERS

To Be Provided with Final Release