


2019 Kittitas County Hazard Mitigation Plan

VOLUME 1: PLANNING-AREA-WIDE ELEMENTS

Kittitas County Public Works Department

January 2019

Kittitas County

Hazard Mitigation Plan
Volume 1: Planning-Area-Wide Elements

January 2019

Dewberry
JACOBS

Kittitas County

HAZARD MITIGATION PLAN
VOLUME 1: PLANNING-AREA-WIDE ELEMENTS

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EXECUTIVE SUMMARY

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The Disaster Mitigation Act (DMA) is federal legislation that promotes proactive pre-disaster planning by making it a condition of receiving financial assistance under the Robert T. Stafford Act. The DMA established a Pre-Disaster Mitigation Program and new requirements for the national post-disaster Hazard Mitigation Grant Program.

The DMA encourages state and local authorities to work together on pre-disaster planning, and it promotes sustainability as a strategy for disaster resistance. Sustainable hazard mitigation addresses the sound management of natural resources and local economic and social resiliency, and it recognizes that hazards and mitigation must be understood in a broad social and economic context. The planning network called for by the DMA helps local governments articulate accurate needs for mitigation, resulting in faster allocation of funding and more cost-effective risk-reduction projects.

A planning partnership made up of Kittitas County and local governments worked together to create this Kittitas County Hazard Mitigation Plan to fulfill the DMA requirements for all fully participating partners.

PLAN PURPOSE

Several factors initiated this planning effort for Kittitas County and its planning partners:

- The Kittitas County area has had significant exposure to numerous natural hazards that have caused millions of dollars in past damage.
- Limited local resources make it difficult to be pre-emptive in risk reduction initiatives. Being able to leverage federal financial assistance is paramount to successful hazard mitigation in the area.
- The partners wanted to be proactive in preparedness for the impacts of natural hazards.

With these factors in mind, Kittitas County committed to the preparation and subsequent update of the plan by attaining funding for the effort through grants, establishing the planning partnership, and securing technical assistance to facilitate a planning process that would comply with multiple program requirements.

THE PLANNING PARTNERSHIP

The planning partnership assembled for this plan consists of Kittitas County, four incorporated cities and nine special purpose districts defined as “local governments” under the Disaster Mitigation Act. This partnership represents approximately 50 percent of eligible local governments in the planning area. Of these 13 planning partners, all completed the required phases of this plan’s development. Jurisdictional annexes for these 13 partners are included in Volume 2 of the plan. Jurisdictions not covered by this process can link to this plan at a future date by following the linkage procedures identified in Appendix B of Volume 2 of this plan.

PLAN DEVELOPMENT METHODOLOGY

Development and update of the Kittitas County Hazard Mitigation Plan included seven phases:

- **Phase 1—Organize resources**—Under this phase, grant funding was secured to fund the effort, the planning partnership was formed and a steering committee of planning partners and other stakeholders was assembled to oversee development of the plan. Also under this phase were coordination with local, state and federal agencies, and a comprehensive review of existing programs that may support or enhance hazard mitigation.

- **Phase 2—Assess risk**—Risk assessment is the process of measuring the potential loss of life, personal injury, economic injury, and property damage resulting from natural hazards. This process focuses on the following parameters:
  - Hazard identification and profiling
  - The impact of hazards on physical, social and economic assets
  - Vulnerability identification
  - Estimates of the cost of damage or costs that can be avoided through mitigation.

  Phase 2 occurred simultaneously with Phase 1, with the two efforts using information generated by one another.
- **Phase 3—Involve the public**—Under this phase, a public involvement strategy was developed that used multiple media to give the public multiple opportunities to provide comment on the plan. The strategy focused on three primary objectives:
  - Assess the public's perception of risk.
  - Assess the public's perception of vulnerability to those risks.
  - Identify mitigation strategies that will be supported by the public.
- **Phase 4—Identify goals, objectives and actions**—Under this phase, the steering committee and planning team confirmed goals and objectives for the planning area from the last plan, as well as a range of potential mitigation actions for each natural hazard. A "mitigation catalog" was used by each planning partner to guide the selection of recommended mitigation initiatives to reduce the effects of hazards on new development and existing inventory and infrastructure. A process was created under this phase for prioritizing, implementing, and administering action items based in part on a review of project benefits versus project costs.
- **Phase 5—Develop a plan maintenance strategy**—Under this phase, a strategy for long-term mitigation plan maintenance was updated, with the following components:
  - A method for monitoring, evaluating, and updating the plan on a five-year cycle
  - A protocol for a progress report to be completed annually on the plan's accomplishments
  - A process for incorporating requirements of the mitigation plan into other planning mechanisms
  - Ongoing public participation in the mitigation plan maintenance process
  - "Linkage procedures" that address potential changes in the planning partnership.
- **Phase 6—Develop the plan**—The steering committee assembled key information into a document to meet DMA requirements. The document was produced in two volumes: Volume 1 including all information that applies to the entire planning area; and Volume 2, including jurisdiction-specific information.
- **Phase 7—Implement and adopt the plan**—Once pre-adoption approval has been granted by the Washington Emergency Management Division and the Federal Emergency Management Agency (FEMA), the final adoption phase will begin. Each planning partner will be required to adopt the plan according to its formal adoption protocol.

MITIGATION GUIDING PRINCIPLE, GOALS AND OBJECTIVES

The following guided the steering committee and the planning partnership in selecting the initiatives recommended in this plan:

- **Guiding Principle—**Through partnerships, reduce the vulnerability to natural hazards in order to protect the health, safety, welfare and economy of the communities within Kittitas County.

Based on this guiding principle, the following goals were established:

1. Protect life, property and the environment.
2. Continuously build and support local capacity to enable the public to mitigate, prepare for, respond to and recover from the impact of hazards and disasters.
3. Establish a hazard and disaster resilient economy.
4. Promote public awareness, engage public participation and enhance partnerships through education and outreach.
5. Encourage the development and implementation of long-term, cost-effective mitigation projects.

Objectives were confirmed from the last plan and modified minimally to meet multiple goals, acting as a bridge between the mitigation goals and actions and helping to establish priorities. The objectives are as follows:

1. Reduce natural hazard-related risks and vulnerability to populations, critical facilities and infrastructure within the planning area.
2. Minimize the impacts of natural hazards on current and future land uses by encouraging use of incentives for hazard mitigation (e.g., National Flood Insurance Program, Community Rating System).
3. Prevent or discourage new development in hazardous areas or ensure that if building occurs in high-risk areas it is done in such a way as to minimize risk.
4. Integrate hazard mitigation policies into land use plans within the planning area.
5. Update the plan annually to integrate local hazard mitigation plans and the results of disaster- and hazard-specific planning efforts.
6. Educate the public on the risk exposure to natural hazards and ways to increase the public's capability to prepare, respond, recover and mitigate the impacts of these events.
7. Use the best available data, science and technologies to improve understanding of the location and potential impacts of natural hazards, the vulnerability of building types, and community development patterns and the measures needed to protect life safety.
8. Retrofit, purchase, or relocate structures in high hazard areas including those known to be repetitively damaged.
9. Establish a partnership among all levels of government and the business community to improve and implement methods to protect property.
10. Encourage hazard mitigation measures that result in the least adverse effect on the natural environmental and that use natural processes.

MITIGATION INITIATIVES

For the purposes of this document, mitigation initiatives are defined as activities designed to reduce or eliminate losses resulting from natural hazards. The mitigation initiatives are the key element of the hazard mitigation plan. It is through the implementation of these initiatives that the planning partners can strive to become disaster-resistant through sustainable hazard mitigation.

Although one of the driving influences for preparing this plan update was continued grant funding eligibility, its purpose is more than just access to federal funding. It was important to the planning partnership and the steering committee to look at initiatives that will work through all phases of emergency management. Some of the initiatives outlined in this plan are not grant eligible—grant eligibility was not the focus of the selection. Rather, the focus was the initiatives' effectiveness in achieving the goals of the plan and whether they are within each jurisdiction's capabilities.

This planning process resulted in the identification 174 mitigation actions to be targeted for implementation by individual planning partners. These initiatives and their priorities can be found in Volume 2 of this plan. In addition, the steering committee and the planning partnership identified a series of countywide initiatives benefiting the whole partnership that will be implemented by pooling resources based on capability. These countywide initiatives are summarized in Table ES-1.

CONCLUSION

Full implementation of the recommendations of this plan update will take time and resources. The measure of the plan's success will be the coordination and pooling of resources within the planning partnership. Keeping this coordination and communication intact will be the key to successful implementation of the plan. Teaming together to seek financial assistance at the state and federal level will be a priority to initiate projects that are dependent on alternative funding sources. This plan was built upon the effective leadership of a multi-disciplined steering committee and a process that included public input and support. The plan will succeed for the same reasons.

Table ES-1-1. Countywide Mitigation Initiatives, 2019-2024

Initiative #	Initiative Description	Hazards Addressed	Lead Agency	Possible Funding Sources or Resources	Timeline
1	Continue to maintain a countywide hazard mitigation plan website to house the plan and plan updates, in order to provide the public an opportunity to monitor plan implementation and progress. Each planning partner may support the initiative by including an initiative in its action plan and creating a web link to the website. Updates will occur annually, or more often as appropriate.	All Hazards	Kittitas County Department of Public Works	General Fund	Short Term / Annually, 2019-2024
2	Leverage public outreach partnering capabilities to inform and educate the public about hazard mitigation and preparedness.	All Hazards	Kittitas County Department of Public Works/ All Planning Partners	General Fund	Short Term / Ongoing
3	Coordinate all mitigation planning and project efforts, including grant application support, to maximize all resources available to the planning partnership, with the County mentoring other jurisdictions with less grant application experience.	All Hazards	Kittitas County Department of Public Works	General Fund, FEMA mitigation grants	Short Term / 2019-2024
4	Support the collection of improved data (hydrologic, geologic, topographic, volcanic, historical, etc.) to better assess risks and vulnerabilities.	All Hazards	Kittitas County Department of Public Works	General Fund, FEMA mitigation grants	Short Term / 2019-2024
5	Provide coordination and technical assistance in grant application preparation that includes assistance in cost vs. benefit analysis for grant-eligible projects.	All Hazards	Kittitas County Department of Public Works	General Fund, FEMA mitigation grants	Short Term / Annually
6	Where appropriate, support retrofitting, purchase, or relocation of structures or infrastructure located in hazard-prone areas to protect structures/infrastructure from future damage, with repetitive loss and severe repetitive loss properties as priority when applicable.	All Hazards	All Planning Partners	FEMA mitigation grants	Long Term
7	Continue to maintain the steering committee as a viable committee to monitor the progress of the hazard mitigation plan, provide technical assistance to planning partners and oversee the implementation and update of the plan.	All Hazards	Kittitas County Department of Public Works	General Fund	Short Term / 2019-2024

Initiative #	Initiative Description	Hazards Addressed	Lead Agency	Possible Funding Sources or Resources	Timeline
8	Integrate mitigation plan requirements and actions into other appropriate planning mechanisms such as comprehensive plans and capital improvement plans.	All Hazards	Kittitas County / All Planning Partners	General Fund	At each update cycle
9	Support mitigation projects that will result in protection of public or private property from natural hazards. Eligible projects include but are not limited to: 1. Acquisition of flood prone property 2. Elevation of flood prone structures 3. Minor structural flood control projects 4. Relocation of structures from hazard prone areas 5. Retrofitting of existing buildings, facilities, and infrastructure 6. Retrofitting of existing building and facilities for shelter 7. Critical infrastructure protection measures 8. Stormwater management improvements 9. Advanced warning systems and hazard gauging systems (weather radios, reverse-911, stream gauges, I-flows) 10. Targeted hazard education 11. Wastewater and water supply system hardening and mitigation.	All Hazards	Kittitas County Department of Public Works / All Planning Partners	General Fund, FEMA mitigation grants	Annually, 2019-2024
10	Develop a system and designate responsible parties for capturing damage data after hazard events, to assist with capturing Public and Individual Assistance expenditures and to catalogue damages for use in developing future projects including. This data will assist with Benefit/Cost Analysis.	All Hazards	Kittitas County Department of Public Works / All Planning Partners	General Fund	Ongoing
11	With Kittitas County as lead, to provide guidance to other jurisdictions, evaluate the benefits of other jurisdictions joining the NFIP Community Rating System.	Flood	Kittitas County Department of Public Works / All Planning Partners	General Fund	Short Term / 2019-2021
12	Evaluate Countywide critical facilities list and GIS layer and update as appropriate, to continue improving the risk assessment in this plan.	All Hazards	Kittitas County Department of Public Works / All Planning Partners	General Fund	Short Term / 2019-2014

Initiative #	Initiative Description	Hazards Addressed	Lead Agency	Possible Funding Sources or Resources	Timeline
13	Increase stakeholder and public participation in the Kittitas County Hazard Mitigation Plan update process.	All Hazards	Kittitas County Department of Public Works / All Planning Partners	General Fund	2024
14	Prioritize Kittitas County's list of potential acquisitions of flood-prone properties.	Flood	Kittitas County Department of Public Works	FMAG Grant	2020
15	To more accurately show flood risks, develop maps that show alluvial fans, channel migration zones, and areas of cross-basin flow transfers	Flood	Kittitas County Department of Public Works and Information Technology	General Fund, FEMA mitigation grants	Long Term
16	Improve public health responses to hazard events. For example, testing drinking water for contamination after flood events or distributing masks and closing outdoor events when air quality declines due to wildfire.	Flood and Wildfire	Kittitas County Department of Public Health	General Fund	Short Term

PART 1—THE PLANNING PROCESS

CHAPTER 1.
INTRODUCTION TO THE PLANNING PROCESS

1.1 WHY PREPARE THIS PLAN?

1.1.1 The Big Picture

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

The federal Disaster Mitigation Act (DMA) of 2000 (Public Law 106-390) required state and local governments to develop hazard mitigation plans as a condition for federal disaster grant assistance. Prior to 2000, federal disaster funding focused on disaster relief and recovery, with limited funding for hazard mitigation planning. The DMA increased the emphasis on planning for disasters before they occur.

The DMA encourages state and local authorities to work together on pre-disaster planning, and it promotes sustainability and resilience 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. The enhanced planning network called for by the DMA helps local governments articulate accurate needs for mitigation, resulting in faster allocation of funding and more cost-effective risk reduction projects.

1.1.2 Local Concerns

Several factors initiated the original planning effort and continue to be concerns for this update: planning effort:

- Kittitas County has had significant exposure to several natural hazards that have caused millions of dollars in damage in the past.
- Limited local resources make it difficult to be pre-emptive in risk reduction initiatives. Being able to leverage federal financial assistance is paramount to successful hazard mitigation in the area.
- Kittitas County and local jurisdictions want to be proactive in preparing for and reducing the impacts of natural hazards and disasters.

With these factors in mind, Kittitas County committed to the preparation and subsequent update of this plan by attaining grant funding for the effort and then securing technical assistance to facilitate a planning process that would comply with all program requirements. Kittitas County recognized that disasters are not always contained within political boundaries and therefore invited multiple local jurisdictions (municipalities and special purpose districts) within the county to participate as partners in the hazard mitigation planning update process.

1.1.3 Purposes for Planning

This hazard mitigation plan identifies resources, information, and strategies for reducing risk from natural hazards. Elements and strategies in the plan were selected because they meet a program requirement and because they best meet the needs of the planning partners and their citizens. One of the benefits of multi-jurisdictional planning is the ability to pool resources and eliminate redundant activities within a planning area that has uniform risk exposure and vulnerabilities. The Federal Emergency Management Agency (FEMA) encourages multi-jurisdictional planning under its guidance for the DMA. The plan update will continue to help guide and coordinate mitigation activities throughout Kittitas County. It was developed to meet the following objectives:

- Meet or exceed requirements of the DMA.
- Enable all planning partners to continue using federal grant funding to reduce risk through mitigation.
- Meet the needs of each planning partner as well as state and federal requirements.
- Create a risk assessment that focuses on Kittitas County hazards of concern.
- Create a single updated 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.
- Meet the Floodplain Management Planning requirements of FEMA’s Community Rating System (CRS), allowing Kittitas County to continue participation in the CRS and enhance their CRS classification in the future.
- Coordinate existing plans and programs so that high-priority initiatives and projects to mitigate possible disaster impacts are funded and implemented.

1.2 WHO WILL BENEFIT FROM THIS PLAN?

All citizens and businesses of Kittitas County are the ultimate beneficiaries of this hazard mitigation plan. The plan reduces 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 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.

1.3 HOW TO USE THIS PLAN

This plan update 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 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 public survey 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 METHODOLOGY

To update the Kittitas County Hazard Mitigation Plan, the County followed a process similar to that of the original plan development in 2012. This process had the following primary objectives:

- Secure grant funding
- Form a planning team
- Establish a planning partnership
- Define the planning area
- Establish a steering committee
- Coordinate with other agencies
- Review existing programs
- Engage the public.

For the 2019 plan update, there was an emphasis on increasing the number of stakeholders and planning partners participating in the process, incorporating the most up-to-date data, and meeting the requirements to earn credit under the CRS for Floodplain Management Planning. These objectives are discussed in the following sections.

2.1 GRANT FUNDING

This plan update was supplemented by a Hazard Mitigation Grant Program (HMGP) grant from FEMA in 2016. Kittitas County was the applicant agent for the grant. The grant was applied for in 2015 and was awarded August 11, 2016. The FEMA grant covers 75% of the cost for development of this plan; the County covers 25 percent of the cost through in-kind contributions. This plan is an update to the approved 2012 Kittitas County Hazard Mitigation Plan.

2.2 FORMATION OF THE CORE PLANNING TEAM

Kittitas County hired Dewberry as the primary contractor and Jacobs as the subcontractor to assist with development and implementation of the plan. The Dewberry project manager assumed the role of the lead planner, reporting directly to a County-designated project manager. A core planning team was formed to lead the planning effort, made up of the following members:

- Mark Cook, Kittitas County Public Works, Director
- Karen Hodges, Kittitas County Public Works
- Jason Ecklund, GIS Coordinator, Kittitas County Information Technology
- Darren Higashiyama, Operations Commander, Kittitas County Emergency Management, Sheriff's Office
- Taylor Gustafson, Environmental / Transportation Planner, Kittitas County Public Works
- Scott Choquette, Dewberry, Project Manager
- Jessica Fleck, Dewberry, Resilience Planner

- Katie Murray, Dewberry, Resilience Planner
- Jillian Browning, Dewberry, GIS Professional
- Betsi Phoebus, Jacobs, Senior Environmental Planner
- Craig Broadhead, Jacobs, Environmental Solutions, Inland Northwest Group Lead

The planning team met weekly throughout the update process to ensure consistent communication among all partners and organizations.

2.3 THE PLANNING PARTNERSHIP

Kittitas County opened this planning effort to all eligible local governments in the county. For the 2019 plan update, the planning team made a presentation at a stakeholder meeting on July 16, 2018 to kick off the update process and solicit planning partners. Key meeting objectives were as follows:

- Provide an overview of the purpose and process of hazard mitigation planning
- Review the 2012 Kittitas County Hazard Mitigation Plan
- Introduce the Planning Team
- Outline the County work plan
- Outline planning partner expectations
- Seek commitment to the planning partnership, via letters of intent
- Seek volunteers for the steering committee
- Solicit for external stakeholder participation

Each jurisdiction wishing to join the planning partnership was asked to provide a "letter of intent" to participate in the planning process. That letter designated a primary and secondary point of contact for the jurisdiction and confirmed the jurisdiction's commitment to the process and understanding of expectations. Linkage procedures have been established (see Volume 2 of this plan) for any jurisdiction wishing to link to the Kittitas County plan in the future. The municipal planning partners covered under this plan are shown in Table 2-1. The special purpose district planning partners are shown in Table 2-2.

Table 2-1. County and City Planning Partners

Jurisdiction	Point of Contact	Title
Kittitas County	Karen Hodges	Planner III
City of Cle Elum	Edwin Mills	Fire Chief
City of Ellensburg	Kirsten Sackett	Community Development Director
Town of South Cle Elum	Jim DeVere	Mayor
City of Roslyn	Michelle Geiger	Planning and Building Official

Table 2-2. Special Purpose District Planning Partners

District	Point of Contact	Title
Fire District #1	Brandon Schmidt	Fire Chief
Fire District #7	Roy Palmer	Fire Chief
Fire District #51	Jay Wiseman	Fire Chief
Snoqualmie Pass Utility District	Tom Hastings	General Manager

District	Point of Contact	Title
Kittitas PUD #1	Matt Boast	General Manager
Kittitas School District #403	Bryan Nash	Maintenance Supervisor
Cle Elum – Roslyn School District	Mark Soderstrom	Director
Kittitas County Conservation District	Anna Lael	District Manager

2.4 DEFINING THE PLANNING AREA

The planning area consists of all of Kittitas County. All partners to this plan have jurisdictional authority over specific locations within this planning area.

2.5 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 update. The members of this committee included key planning partner staff and other stakeholders from within the planning area. 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 21 members at the kickoff meeting. Table 2-3 lists the committee members.

Table 2-3. Steering Committee Members

Name	Title	Jurisdiction/Agency	Representing
Mark Cook	Director	Kittitas County Public Works	Kittitas County
Karen Hodges	Planner III	Kittitas County Public Works	Kittitas County
Jason Eklund	GIS Coordinator	Kittitas County Information Technology	Kittitas County
Darren Higashiyama	Operations Commander	Kittitas County Sheriff’s Office	Kittitas County
Taylor Gustafson	Environmental / Transportation Planner	Kittitas County Public Works	Kittitas County
Edwin Mills	Fire Chief	City of Cle Elum	City of Cle Elum
Lucy Temple	City Planner	City of Cle Elum	City of Cle Elum
Kirsten Sackett	Community Development Director	City of Ellensburg	City of Ellensburg
Ryan Lyyski	Director, Public Works and Utilities	City of Ellensburg	City of Ellensburg
Jon Morrow	Stormwater Manager	City of Ellensburg	City of Ellensburg
Jim DeVere	Mayor	Town of South Cle Elum	Town of South Cle Elum
Michelle Geiger	Planning and Building Official	City of Roslyn	City of Roslyn
Brandon Schmidt	Fire Chief	Fire District #1	Fire District #1
Roy Palmer	Fire Chief	Fire District #7	Fire District #7
Bill Dickinson	Fire Commissioner	Fire District #7	Fire District #7

Name	Title	Jurisdiction/Agency	Representing
Jay Wiseman	Fire Chief	Fire District #51	Fire District #51
Tom Hastings	General Manager	Snoqualmie Pass Utility District	Snoqualmie Pass Utility District
Matt Boast	General Manager	Kittitas PUD #1	Kittitas PUD #1
Kelly Carlson	Administrative Assistant	Kittitas PUD #1	Kittitas PUD #1
Bryan Nash	Maintenance Supervisor	Kittitas School District #403	Kittitas School District #403
Mark Soderstrom	Director	Cle Elum – Roslyn School District	Cle Elum – Roslyn School District
Anna Lael	District Manager	Kittitas County Conservation District	Kittitas County Conservation District
Rose Shriner	GIS Specialist	Kittitas County Conservation District	Kittitas County Conservation District

Leadership roles and ground rules were established during the kick off meeting. The steering committee agreed to meet as needed throughout the course of the plan's update. The planning team facilitated each steering committee meeting, which addressed a set of objectives based on an established work plan. The steering committee met three times from July 2018 through January 2019, with several additional jurisdiction-level working meetings between the planning team and individual jurisdictions. Meeting agendas, notes and attendance logs are available in Appendix B. All steering committee meetings were open to the public.

2.6 COORDINATION WITH OTHER AGENCIES

Title 44 of the Code of Federal Regulations (44 CFR) 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.
- **Stakeholder Notification**—The following stakeholders were invited to participate in the plan process through meeting attendance and review of the draft plan:
  - Central Washington University
  - All Departments of Kittitas County
  - Suncadia Planned Unit Development
  - All Fire Districts in Kittitas County
  - All School Districts in Kittitas County
  - Kittitas County Conservation District
  - United States Forest Service
  - WA Department of Natural Resources
  - WA Department of Fish and Wildlife

  - Washington Farm and Forestry Association
  - Kittitas Conservation Trust
  - The Nature Conservancy
  - Private Land Owners
  - Cities of Ellensburg, Kittitas, Roslyn and Cle Elum, and the Town of South Cle Elum
- **Pre-Adoption Review**—All the agencies listed above were provided an opportunity to review and comment on this plan, primarily through the hazard mitigation plan webpage of the Kittitas County Public Works website. Each agency was sent an e-mail message informing them that draft portions of the plan were available for review.

2.7 STEERING COMMITTEE AND STAKEHOLDER MEETINGS

The following sections describe the steering committee and stakeholder meetings that took place throughout the planning process. For details on each meeting, including PowerPoint presentations, agendas, and sign-in sheets, see Appendix B.

Steering Committee Kick-Off Meeting

The planning team made a presentation at a stakeholder meeting on July 16, 2018 to kick off the update process and solicit planning partners. The planning team provided an overview of the purpose and process of hazard mitigation planning, reviewed the 2012 Kittitas County Hazard Mitigation Plan, outlined the County work plan and planning partner expectations, sought commitment to the planning partnership, and sought volunteers for the steering committee.

Stakeholder Meeting

On July 18, 2018, the planning team made a presentation to the Kittitas Fire Adapted Communities Coalition. This presentation was an overview version of the presentation delivered at the kick-off meeting, followed by solicitation of input from stakeholders. In addition to local fire districts from within Kittitas County, stakeholders present at the meeting included the United States Forest Service, WA Department of Natural Resources, Washington Farm and Forestry Association, the Nature Conservancy, private land owners, the Kittitas Conservation Trust, and the Suncadia Planned Unit Development.

Stakeholder and Public Input Points at Risk MAP Meetings

On August 6 and 7, 2018, in Thorp and Ellensburg, respectively, Core Planning Team members staffed a Hazard Mitigation Plan Update booth at FEMA-sponsored Risk MAP open house meetings. At the combined meetings 29 attendees were encouraged to participate in future meetings, were directed to the County Hazard Mitigation Webpage and were given an overview of the process.

Steering Committee HIRA Review and Mitigation Strategy Development Meeting

The planning team held a meeting with all planning partners on November 8, 2018 to review the draft Hazard Identification and Risk Assessment update. Previous county-wide mitigation initiatives were reviewed by the steering committee, to determine whether they should be continued in this plan update. Five new mitigation initiatives were suggested by participants and reviewed by the committee. Each activity was evaluated according to the STAPLE/E evaluation methodology.

Stakeholder Meeting

On December 12, 2018, Core Planning Team staff again met with the Kittitas Fire Adapted Communities Coalition (see list of participating stakeholders, above). At this meeting the draft plan was presented and review comments were solicited.

Steering Committee Draft Plan Review Meeting

A steering committee and stakeholder meeting was held on January 9, 2019 to review the draft plan and solicit additional input. Emphasis was given to reviewing county-wide mitigation initiatives and discussing the addition of new initiatives. Three new mitigation initiatives, in addition to the five added during the HIRA meeting, were suggested, reviewed, and approved. All mitigation initiatives were ranked by meeting attendees using the STAPLE/E evaluation methodology to indicate which initiatives should be prioritized by the County. The results of this exercise were used to supplement the benefit-cost ranking of the mitigation initiatives, and can be seen in Table 18-3.

Jurisdictional Subcommittee Meetings

In addition to the four Steering Committee and Stakeholder Meetings discussed above, a series of ten Jurisdictional Subcommittee working sessions were held between members of the core Planning Team from the County and jurisdictional representatives. The purpose of those meetings were to supplement the larger group meetings and to work on updating the jurisdictional annexes, including evaluation of risks unique to the jurisdictions, changes in capabilities, disposition of 2012 mitigation strategies, and development of new mitigation strategies. Table 2-4 provides a list of those meetings and the dates on which they were held.

2.8 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. 44 CFR 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.

2.8.1 Strategy

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

- Use an online public survey to determine if the public's perception of risk and support of hazard mitigation has changed since the initial planning process.
- Attempt to reach as many planning area citizens as possible using multiple media.
- Identify and involve planning area stakeholders.
- Hold multiple public meetings throughout the update process.

Stakeholders and the Steering Committee

Stakeholders are the individuals, agencies and jurisdictions that have a vested interest in the recommendations of the hazard mitigation plan, including planning partners. The effort to include stakeholders in this process included stakeholder participation on the steering committee.

All members of the steering committee live or work in Kittitas County. Committee members represented water districts, flood task forces, government agencies, disaster/emergency coordinators, fire, utility and school districts. The steering committee met three times during the course of the plan's development and all meetings were posted and open to the public. Protocols for managing public comments were established in the ground rules developed by the steering committee. Figure 2-1 below shows the discussion among committee members following the November 8th, 2018 steering committee meeting.

Figure 2-1. Discussion Following the November 8th, 2018 Meeting in Ellensburg

Public Survey

A hazard mitigation plan public survey (see Figure 2-2) was developed by the planning team. The survey was used to gauge household preparedness for natural hazards and the level of knowledge of tools and techniques that assist in reducing risk and loss from natural hazards. This survey was designed to help identify areas vulnerable to one or more natural hazards, based on the experiences of Kittitas County residents. The answers to its 15 questions helped guide the steering committee in evaluating goals, objectives and mitigation strategies. The survey was web-based, and was posted on both the Home page and the Hazard Mitigation Planning page of the Kittitas County Public Works website. The survey link was also posted on the Kittitas County Commissioner’s Facebook page. Screenshots of the postings of the plan online are displayed in Figure 2-3 and Figure 2-4. The survey was also sent out to a email list of over 375 recipients by Kittitas County Public Works personnel. 59 questionnaires were completed during the course of this planning process. The complete questionnaire and a summary of its findings can be found in Appendix B of this volume. Survey input was used to inform the risk assessment and mitigation strategy development.

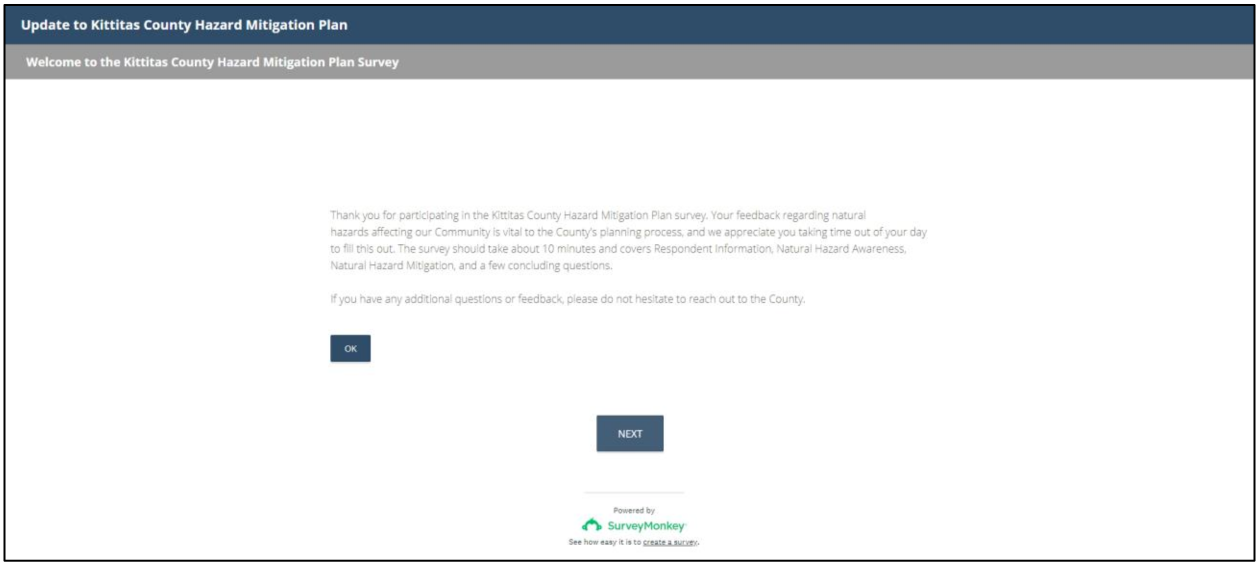


Figure 2-2. Page 1 of Online Public Survey

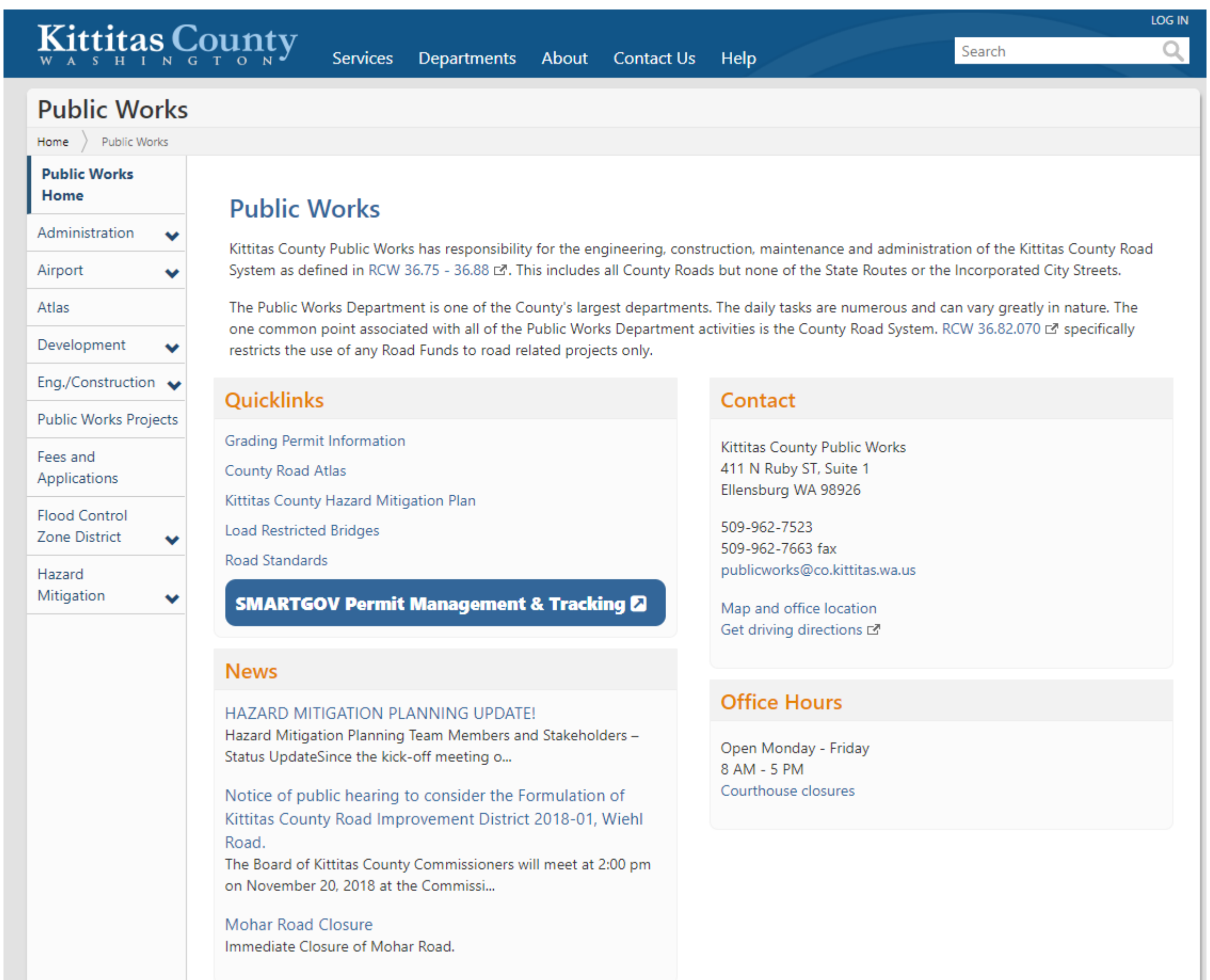
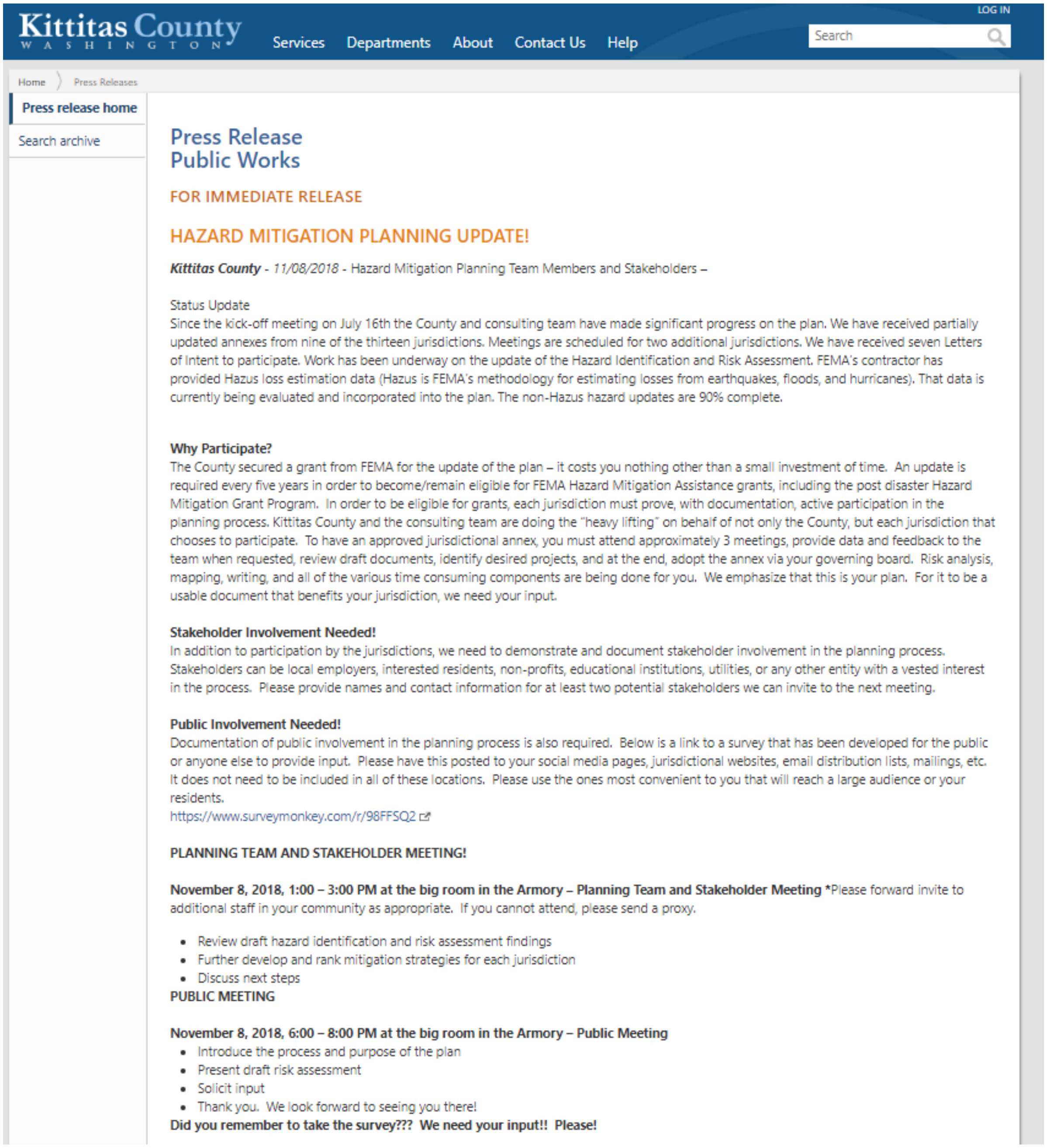


Figure 2-3. Kittitas County Public Works Home Page, with Link to Hazard Mitigation Planning Update Page



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FOR IMMEDIATE RELEASE

HAZARD MITIGATION PLANNING UPDATE!

Kittitas County - *11/08/2018* - Hazard Mitigation Planning Team Members and Stakeholders –

Status Update
Since the kick-off meeting on July 16th the County and consulting team have made significant progress on the plan. We have received partially updated annexes from nine of the thirteen jurisdictions. Meetings are scheduled for two additional jurisdictions. We have received seven Letters of Intent to participate. Work has been underway on the update of the Hazard Identification and Risk Assessment. FEMA's contractor has provided Hazus loss estimation data (Hazus is FEMA's methodology for estimating losses from earthquakes, floods, and hurricanes). That data is currently being evaluated and incorporated into the plan. The non-Hazus hazard updates are 90% complete.

Why Participate?
The County secured a grant from FEMA for the update of the plan – it costs you nothing other than a small investment of time. An update is required every five years in order to become/remain eligible for FEMA Hazard Mitigation Assistance grants, including the post disaster Hazard Mitigation Grant Program. In order to be eligible for grants, each jurisdiction must prove, with documentation, active participation in the planning process. Kittitas County and the consulting team are doing the "heavy lifting" on behalf of not only the County, but each jurisdiction that chooses to participate. To have an approved jurisdictional annex, you must attend approximately 3 meetings, provide data and feedback to the team when requested, review draft documents, identify desired projects, and at the end, adopt the annex via your governing board. Risk analysis, mapping, writing, and all of the various time consuming components are being done for you. We emphasize that this is your plan. For it to be a usable document that benefits your jurisdiction, we need your input.

Stakeholder Involvement Needed!
In addition to participation by the jurisdictions, we need to demonstrate and document stakeholder involvement in the planning process. Stakeholders can be local employers, interested residents, non-profits, educational institutions, utilities, or any other entity with a vested interest in the process. Please provide names and contact information for at least two potential stakeholders we can invite to the next meeting.

Public Involvement Needed!
Documentation of public involvement in the planning process is also required. Below is a link to a survey that has been developed for the public or anyone else to provide input. Please have this posted to your social media pages, jurisdictional websites, email distribution lists, mailings, etc. It does not need to be included in all of these locations. Please use the ones most convenient to you that will reach a large audience or your residents.
https://www.surveymonkey.com/r/98FFSQ2

PLANNING TEAM AND STAKEHOLDER MEETING!

November 8, 2018, 1:00 – 3:00 PM at the big room in the Armory – Planning Team and Stakeholder Meeting *Please forward invite to additional staff in your community as appropriate. If you cannot attend, please send a proxy.

- Review draft hazard identification and risk assessment findings
- Further develop and rank mitigation strategies for each jurisdiction
- Discuss next steps

PUBLIC MEETING

November 8, 2018, 6:00 – 8:00 PM at the big room in the Armory – Public Meeting
- Introduce the process and purpose of the plan
- Present draft risk assessment
- Solicit input
- Thank you. We look forward to seeing you there!

Did you remember to take the survey??? We need your input!! Please!

Figure 2-4. Press Release for the Hazard Mitigation Planning Update, with Link to Public Survey

Public Meetings

November 8, 2018 Public Meeting #1

The first public meeting was scheduled for the evening of November 8, 2018 at the Ellensburg Armory. A press release, website posting, social media, and email were used to invite the public to attend. The purpose of the meeting was to introduce the update process, describe progress to date, receive input on the draft risk assessment, and encourage input using the public survey. Despite best efforts, no one attended the meeting outside of core planning team members.

January 9, 2019 Public Meeting #2

During the public comment period, a meeting was held on January 9th, 2019 to inform the public about the draft plan and how to review and comment on it. The draft plan was presented, with an emphasis on county-wide mitigation initiatives. The meeting was open to the public and was advertised as such on the Hazard Mitigation Plan website, the City of Ellensburg website, and Kittitas County Public Works press releases. There were 16 attendees, who all participated in a ranking exercise of the hazards addressed in this plan by placing dots stickers on each hazard they perceived as having a high impact on Kittitas County. A sign in sheet and the results of this exercise are available in Appendix B. Figure 2-5 shows the attendees of this meeting.

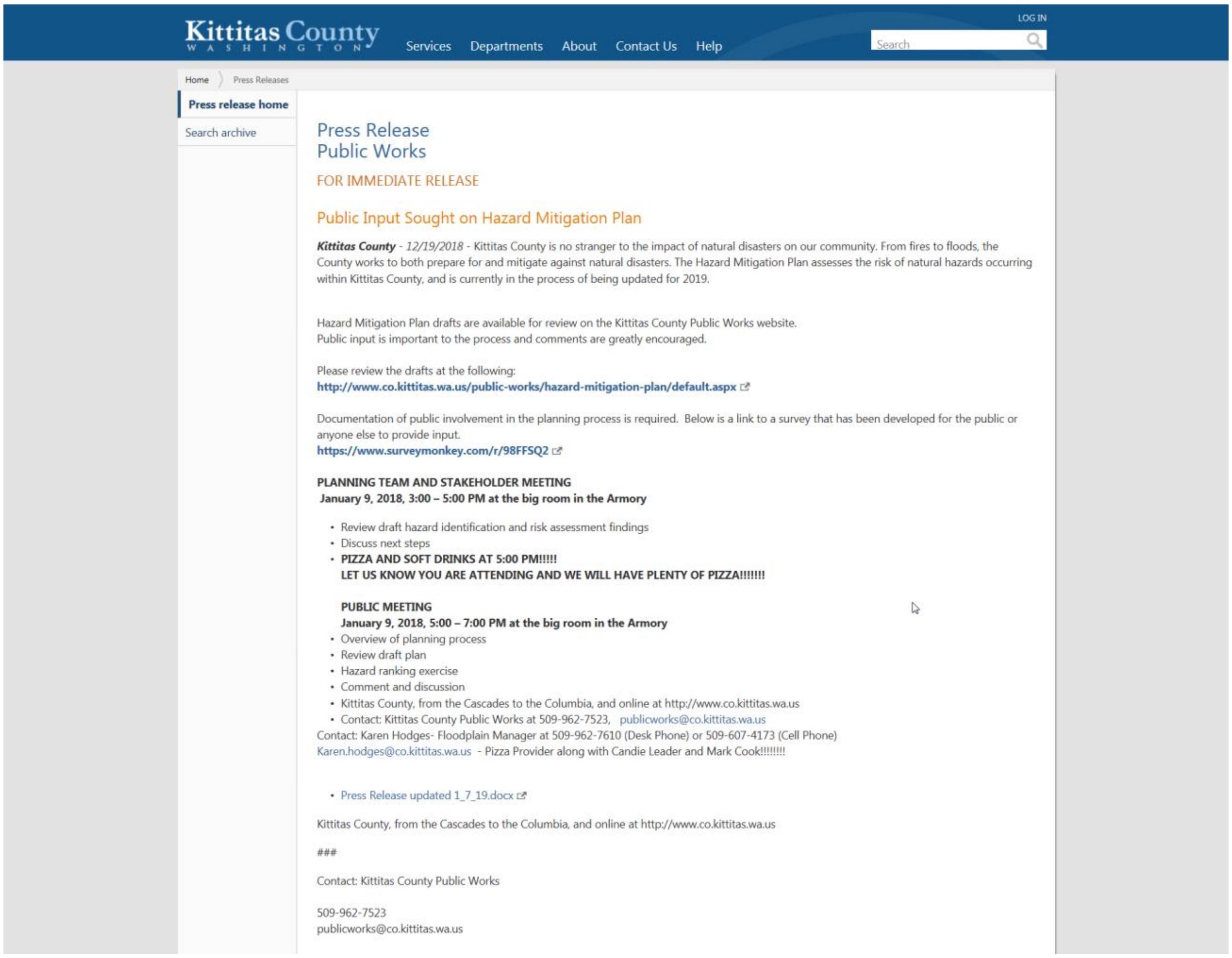
Figure 2-5. January 9, 2019 Public Meeting Attendees

During the January 9th, 2019 Stakeholder Meeting, public participation was discussed in detail, and stakeholders provided suggestions for increasing public engagement in the next plan update process. Suggestions included emails, social media posts, and posters, as well as co-hosting meetings with other groups, and holding meetings where people already attend, such as local clubs (Rotary, Kiwanis, etc.). There was also a suggestion to use Kittitas County's new OpenGov portal to further engage the public. Recommended future stakeholders included WA Department of Ecology Floodplain by Design, STARR II, the Farm Bureau, Puget Sound Energy, major developers and landholders in Kittitas County, Kittitas County Field and Stream, Irrigation Districts, Economic Business Development Authority, and the Chamber of Commerce, among others. For a full list of suggested future stakeholders, see Appendix B.

Press Releases

Press releases were distributed to all media outlets over the course of the plan's development as key milestones were achieved and prior to each public meeting. The planning effort received the following press coverage:

- Press release advertising the November 8th, 2018 meeting to review the Hazard Identification and Risk Assessment portion of the plan. This press release also contained a link to the public survey (see Figure 2-4 above).
- Press release advertising the January 9th, 2019 stakeholder and public meetings. This press release also included information on and links to the draft plan for review (see Figure 2-6 below).
- City of Ellensburg web press release advertising the January 9th, 2019 public and stakeholder meetings (see Figure 2-7 below).



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FOR IMMEDIATE RELEASE

Public Input Sought on Hazard Mitigation Plan

Kittitas County - *12/19/2018* - Kittitas County is no stranger to the impact of natural disasters on our community. From fires to floods, the County works to both prepare for and mitigate against natural disasters. The Hazard Mitigation Plan assesses the risk of natural hazards occurring within Kittitas County, and is currently in the process of being updated for 2019.

Hazard Mitigation Plan drafts are available for review on the Kittitas County Public Works website.
Public input is important to the process and comments are greatly encouraged.

Please review the drafts at the following:
http://www.co.kittitas.wa.us/public-works/hazard-mitigation-plan/default.aspx

Documentation of public involvement in the planning process is required. Below is a link to a survey that has been developed for the public or anyone else to provide input.
https://www.surveymonkey.com/r/98FFSQ2

PLANNING TEAM AND STAKEHOLDER MEETING
January 9, 2018, 3:00 – 5:00 PM at the big room in the Armory

- Review draft hazard identification and risk assessment findings
- Discuss next steps
- **PIZZA AND SOFT DRINKS AT 5:00 PM!!!!!**
  LET US KNOW YOU ARE ATTENDING AND WE WILL HAVE PLENTY OF PIZZA!!!!!!!

  PUBLIC MEETING
  January 9, 2018, 5:00 – 7:00 PM at the big room in the Armory
- Overview of planning process
- Review draft plan
- Hazard ranking exercise
- Comment and discussion
- Kittitas County, from the Cascades to the Columbia, and online at http://www.co.kittitas.wa.us
- Contact: Kittitas County Public Works at 509-962-7523, publicworks@co.kittitas.wa.us

Contact: Karen Hodges- Floodplain Manager at 509-962-7610 (Desk Phone) or 509-607-4173 (Cell Phone)
Karen.hodges@co.kittitas.wa.us - Pizza Provider along with Candie Leader and Mark Cook!!!!!!!!

- Press Release updated 1_7_19.docx

Kittitas County, from the Cascades to the Columbia, and online at http://www.co.kittitas.wa.us

###

Contact: Kittitas County Public Works

509-962-7523
publicworks@co.kittitas.wa.us

Figure 2-6. Kittitas County Press Release, December 19, 2018

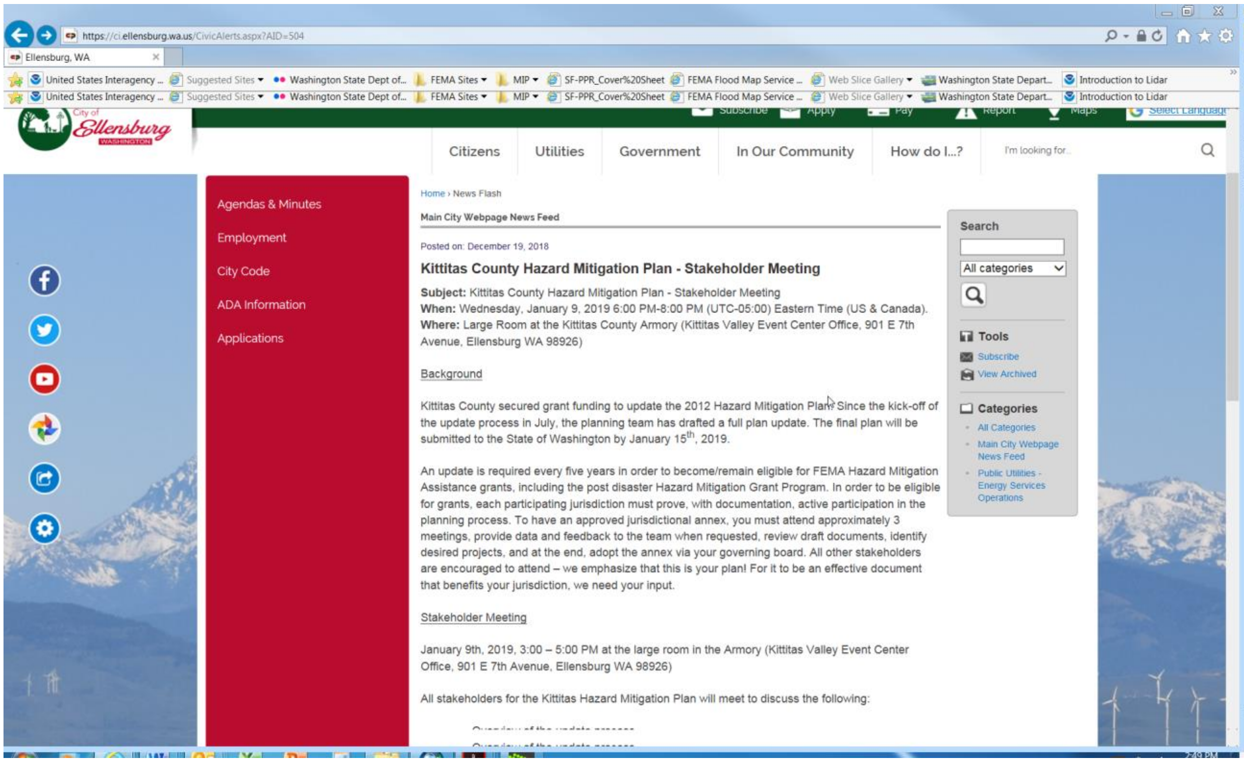


Figure 2-7. City of Ellensburg Website Press Release

Internet

The Kittitas County Public Works, Hazard Mitigation Plan website was updated to keep the public posted on plan development milestones, give the public access to the plan, and allow the public to provide comments on the draft 2019 plan. The page can be easily accessed in the left panel of the Kittitas County Public Works Home page, or at the following link:

https://www.co.kittitas.wa.us/public-works/hazard-mitigation-plan/default.aspx

Information on the plan development process, the public survey, and the draft plan was made available to the public on the site throughout the process, as seen in Figure 2-8 below. This website acted as the primary means for the public to provide comment on the draft plan. A public comment period was opened on December 19, 2018 and ran through January 14, 2019. A press release was distributed by Kittitas County and the City of Ellensburg advising them of the public comment period and how to view the plan and provide comments via the website. The County will continue to keep this website active after the plan update’s completion to keep the public informed about successful mitigation projects and future plan updates.

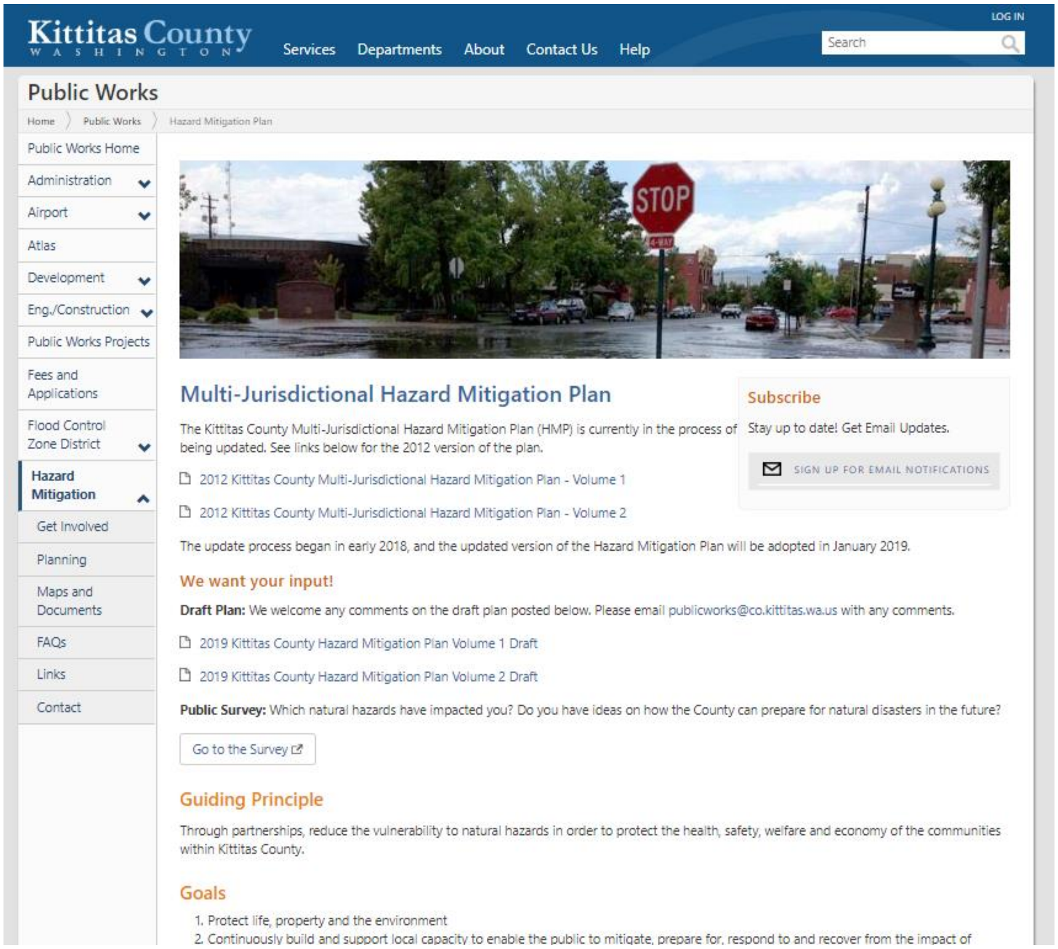


Figure 2-8. Kittitas County Hazard Mitigation Plan website, with Links to Draft Plan

Comments on the draft plan were received from Kittitas County Department of Public Health staff, related to the testing of drinking water after flooding events and providing masks and closing outdoor events when air quality declines due to wildfires. These comments were used to develop a new mitigation initiative related to public health concerns. Comments were also received from Jay McGowan, the Mayor of Cle Elum, encouraging consideration of coal mine tailings assessment and mitigation. As this comment was received after the public comment period, it was not able to be incorporated into this plan update. The planning team recommends this be considered in the next plan update.

2.8.2 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. When considering the pubic survey, Risk MAP open houses, and the January public meeting, a total of 104 members of the public were exposed to the update process.

2.9 PLAN DEVELOPMENT CHRONOLOGY/MILESTONES

Table 2-4 summarizes important milestones in the development of the plan update, many of which are described in more detail in previous subsections. .

Table 2-4. Plan Development Milestones

Date	Event	Description	Attendance
August 8, 2015	County submits grant application	Seek funding for plan development process	N/A
August 11, 2016	County receives notice of grant award	Funding secured.	N/A
October 26, 2017	County initiates contractor procurement	Seek a planning expert to facilitate the process	N/A
January 9, 2018	County selects Dewberry to facilitate plan development	Facilitation contractor secured	N/A
May 11, 2018	Contract signed with Dewberry	Notice to proceed with support work	N/A
July 16, 2018	Kick-off stakeholder meeting	Presentation on plan process given to potential planning partners.	11
July 18, 2018	Steering Committee meeting #1	Introduced the planning process to stakeholders	19
August 6, 2018	Public Outreach	Hazard Mitigation Plan booth held at FEMA Open House meeting - Thorp	14
August 7, 2018	Public outreach	Hazard Mitigation Plan booth held at FEMA Open House meeting - Ellensburg	15
September 14, 2018	Planning team met with South Cle Elum POC	Planning team met one-on-one with POC to update the planning partner’s annex.	2
September 14, 2018	Planning team met with Cle Elum – Roslyn School District POC	Planning team met one-on-one with POC to update the planning partner’s annex.	2
September 19, 2018	Planning team met with Fire District #7 POC	Planning team met one-on-one with POC to update the planning partner’s annex.	2
September 21, 2018	Planning team met with the City of Roslyn POC	Planning team met one-on-one with POC to update the planning partner’s annex.	2
September 24, 2018	Planning team met with Ellensburg POC	Planning team met one-on-one with POC to update the planning partner’s annex.	3
September 25, 2018	Planning team met with Kittitas School District POC	Planning team met one-on-one with POC to update the planning partner’s annex.	2
September 27, 2018	Planning team met with Kittitas PUD #1 POC	Planning team met one-on-one with POC to update the planning partner’s annex.	2
October 16, 2018	Planning team met with Fire District #51 POC	Planning team met one-on-one with POC to update the planning partner’s annex.	2
October 17, 2018	Planning team met with Fire District #1 POC	Planning team met one-on-one with POC to update the planning partner’s annex.	2
November 5, 2018	Public Outreach	County press release advertising the Nov 8th meetings, included public survey link	375
November 5, 2018	Public Outreach	Post to the Kittitas County Board of Commissioners Facebook page, advertising the Nov 8th meetings, included public survey link	348
November 8, 2018	Steering committee meeting #2	Meeting to review the draft HIRA and mitigation strategies	17
November 8, 2018	Public meeting	Meeting to review the draft HIRA and mitigation strategies	0
December 6, 2018	Planning team met with Unincorporated Kittitas County POC	Planning team met one-on-one with POC to update the planning partner’s annex.	3
December 11, 2018	Planning team met with South Cle Elum secondary POC to finalize annex	Planning team met one-on-one with POC to update the planning partner’s annex.	2

Date	Event	Description	Attendance
December 12, 2018	Agency Outreach	Planning team met with KC Community Development Services	2
December 12, 2018	Stakeholder Outreach	Draft plan presented to Kittitas Fire Adapted Communities Coalition	15
December 13, 2018	Draft Plan	Draft plan posted to Hazard Mitigation Plan webpage	N/A
December 13, 2018	Draft Plan	Draft plan provided by planning team to steering committee	N/A
December 19, 2018	Public Outreach	County press release advertising the Jan 9th meetings, included link to draft plan	375
January 9, 2018	Steering committee meeting #3	Provide comments on draft plan, confirm and add additional county-wide mitigation initiatives, review public comment process	10
January 9, 2018	Public Meeting	Presentation on draft plan and public comment process.	16
December 19, 2018	Public comment period	Initial public comment period of draft plan opens. Draft plan posted on plan website with press release notifying public of plan availability	N/A
TBD	Plan submittal	Draft plan submitted to WA EMD for pre-adoption review and approval.	N/A
TBD	Adoption (public)	Adoption window of final plan opens	N/A
TBD	Plan approval	Final plan approved by FEMA	N/A

CHAPTER 3.
GUIDING PRINCIPLE, GOALS AND OBJECTIVES

Hazard mitigation plans must identify goals for reducing long-term vulnerabilities to identified hazards (44 CFR Section 201.6.c(3i)). The steering committee established a mission statement, 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 mission statement, goals, objectives and actions in this plan all support each other. Goals were selected to support the mission statement. Objectives were selected that met multiple goals. All Goals and Objectives from the 2012 plan were vetted and re-affirmed by the planning partners for this update. Actions were prioritized based on the action meeting multiple objectives.

3.1 GUIDING PRINCIPLE

A guiding principle focuses the range of objectives and actions to be considered. This is not a goal because it does not describe a hazard mitigation outcome, and it is broader than a hazard-specific objective. The guiding principle for the Kittitas County Hazard Mitigation Plan is as follows:

> Through partnerships, reduce the vulnerability to natural hazards in order to protect the health, safety, welfare and economy of the communities within Kittitas County

3.2 GOALS

The following are the mitigation goals for this plan:

1. Protect life, property and the environment.
2. Continuously build and support local capacity to enable the public to mitigate, prepare for, respond to and recover from the impact of hazards and disasters.
3. Establish a hazard and disaster resilient economy.
4. Promote public awareness, engage public participation and enhance partnerships through education and outreach.
5. Encourage the development and implementation of long-term, cost-effective mitigation projects.

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

3.3 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. Reduce natural hazard-related risks and vulnerability to populations, critical facilities and infrastructure within the planning area.
2. Minimize the impacts of natural hazards on current and future land uses by encouraging use of incentives for hazard mitigation (i.e. National Flood Insurance Program, Community Rating System).
3. Prevent or discourage new development in hazardous areas or ensure that if building occurs in high-risk areas it is done in such a way as to minimize risk.
4. Integrate hazard mitigation policies into land use plans within the planning area.

5. Update the plan annually to integrate local hazard mitigation plans and the results of disaster- and hazard-specific planning efforts.
6. Educate the public on the risk exposure to natural hazards and ways to increase the public's capability to prepare, respond, recover and mitigate the impacts of these events.
7. Use the best available data, science and technologies to improve understanding of the location and potential impacts of natural hazards, the vulnerability of building types, and community development patterns and the measures needed to protect life safety.
8. Retrofit, purchase, or relocate structures in high hazard areas including those known to be repetitively damaged.
9. Establish a partnership among all levels of government and the business community to improve and implement methods to protect property.
10. Encourage hazard mitigation measures that result in the least adverse effect on the natural environmental and that use natural processes.

CHAPTER 4.
KITTITAS COUNTY PROFILE

Kittitas County is located in south-central Washington (see Figure 4-1.). The county covers 2,315 square miles of highly varied terrain and climates. It is the 25th most populous county in the state and the eighth largest in area. The county is bounded to the north by Chelan and Snohomish Counties, to the south by Yakima County, to the east by Grant County, and to the west by King and Pierce Counties. The Pacific Crest Trail in the Cascade Range forms its western boundary, and the Columbia River forms its eastern boundary.

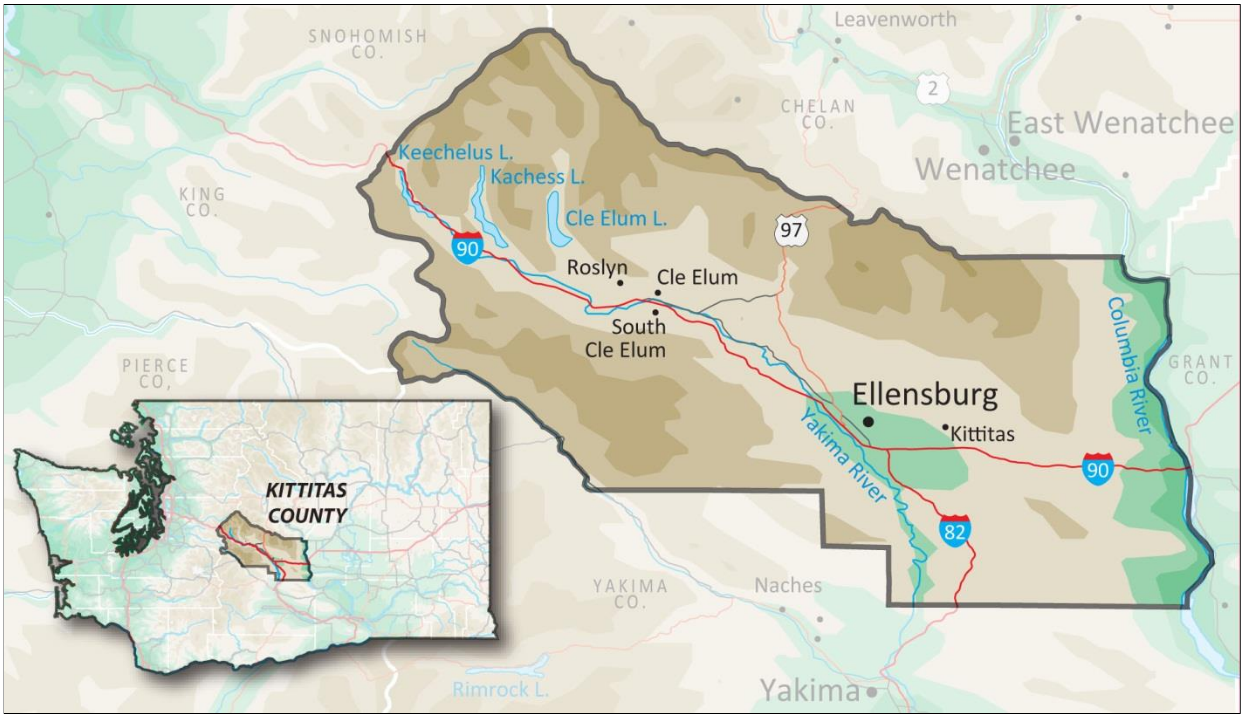


Figure 4-1. Main Features of Kittitas County

4.1. JURISDICTIONS AND ATTRACTIONS

Kittitas County contains 10 U.S. Census recognized communities, five of which are incorporated jurisdictions (Cle Elum, Ellensburg, Kittitas, Roslyn and South Cle Elum). The other areas include the towns of Easton, Ronald, Snoqualmie Pass, Thorp and Vantage. Ellensburg, in the southeast part of the county, is the county seat.

Kittitas County is one of the most geographically diverse areas in the Pacific Northwest. Its diverse terrain offers many recreational opportunities:

- Skiing, cross-country, snow-shoeing, snowmobiling
- Rafting, kayaking, boating, waterskiing
- Camping, horseback riding
- Fishing
- Hiking

- Biking
- Golf

In addition, the county offers historic attractions from the early days of Washington's mining and railroading industries in cities such as Roslyn, Cle Elum, Liberty, Easton, Thorp and Ellensburg. Ellensburg is also home to Central Washington University and the Ellensburg Rodeo.

4.2. HISTORICAL OVERVIEW

Kittitas County was part of the land ceded by the Yakama Tribe in 1855. Briefly part of Ferguson County (now defunct), then Yakima County, Kittitas County was established on November 24, 1883. The Kittitas Valley became a stopping place for cowboys driving herds north to mining camps in Canada and northwest to Seattle/Tacoma. By the late 1860s, cattle ranchers established land claims and cattle became the area's foremost industry. Significant points in the County's history included the completion of a wagon road over Snoqualmie Pass in 1867, the arrival of the Northern Pacific Railroad in 1887, the discovery of gold in Swauk Creek in 1873 and coal near Cle Elum in 1883, and the 1932 completion of the Kittitas (irrigation) Project. Today the main industries are agriculture (including timothy hay to feed racehorses), manufacturing (food processing, lumber and wood products), and government (including employment at Central Washington University).

Interpretations of the meaning of the word Kittitas vary, but the name probably refers to the region's soil composition. If this is the case, Kittitas could mean shale rock, white chalk, or white clay. Another interpretation is that the bread made from the root kous was called kit-tit. Kous grew in the Kittitas Valley. "Tash" is generally accepted to mean "place of existence."

The first inhabitants of the Kittitas Valley were the Psch-wan-wap-pams (stony ground people), also known as the Kittitas band of the Yakama or Upper Yakama. Although the Kittitas were distinct from the Yakima (later renamed Yakama) Tribe, settlers and the federal government (for treaty purposes) grouped the Kittitas with the larger Yakama Tribe. The Kittitas Valley was one of the few places in Washington where both camas (sweet onion) and kous (a root used to make a bread) grew. These were staples that could be dried, made into cakes, and saved for winter consumption. Yakama, Cayous, Nez Perce, and other tribes gathered in the valley to harvest these foods, fish, hold council talks, settle disputes, socialize, trade goods, race horses, and play games. The west side of the Columbia River at what would eventually become the eastern border of Kittitas County was home to some dozen Wanapum villages.

Fur trader Alexander Ross was one of the earliest non-Native Americans to describe the Kittitas Valley. Along with a clerk, two French Canadian trappers, and the trappers' wives, Ross entered the Kittitas Valley in 1814 to trade for horses.

The abundant bunchgrass and clear streams of the Kittitas Valley gave rise to a prosperous cattle industry. Much of this success was foretold by local Indians who, before the advent of white settlement, grazed horses in the valley and sold them to neighboring tribes and white explorers and traders who passed through. As early as 1861, white ranchers from the Yakima Valley grazed their cattle in the Kittitas Valley before continuing on to mine districts in the north-central region and British Columbia. The mining towns eventually began raising their own cattle, but Puget Sound demand filled the vacuum; the cattle were herded to the Sound through Snoqualmie or Naches Pass.

By the late 1860s, cattle ranchers established land claims in Kittitas itself. Over the next 10 years, especially in the late 1870s, new ranches flourished and large herds of cattle grazed everywhere. The resulting overproduction led to declining beef prices. Prices, however, rose to earlier levels after the severe winter of 1880-81 killed more than half the herds. Although the number of cattle eventually returned to early levels, overgrazing was beginning to take its toll on the range. As a result, the federal government began to regulate grazing in 1897. This led to a gradual shift from open grazing to fenced pastures and hay feeding.

Two events—better rail transportation around the turn of the century and irrigation projects in the 1930s—helped expand the county's cattle industry. The railroads provided more effective transport of cattle to the nation's eastern markets. Irrigation projects enhanced the quality of pastures and spurred the growth of row crops, whose by-products were converted into inexpensive cattle feed. By the 1960s, the number of Kittitas County cattle had more than doubled, to approximately 70,000. However, price controls and rising feed costs in the early 1970s prompted many ranchers to change from cattle to hay and grain production.

4.3. PHYSICAL SETTING

4.3.1 Geology

Kittitas County possesses a diverse topography that is dominated by the Cascade and Wenatchee Mountains. From the high Cascades, the land slopes generally downward to the east and south to the Columbia River. The eastern part of the county consists of low, rolling to moderately steep glacial terraces and long, narrow valleys. The southeast section of the county is characterized by moderately steep to steep glacial terraces and steep, rough, broken mountain foothills.

The major geological features of Kittitas County are the Cascade and Wenatchee Mountains on the west and north portions, the south-central Yakima River Valley, and the Boylston and Saddle Mountains at the southeastern edge along the Columbia River. Within these elevations, slope, geologic and soil conditions vary dramatically, including steep mountain peaks, foothills, broad rich valleys, and near-desert areas.

Alpine and continental glaciers moved through this region shaping the mountains and depositing materials to create the geology and soils of the region. The primary types of glacial deposits in the county are outwash and till. Outwash consists of unconsolidated sand, gravel and rocks and results from runoff of melting glaciers. Outwash is usually loose and highly permeable. Glacial till, or hardpan, consists of unsorted clay, sand, grave, or rock that has been compacted by the weight of the glacial ice into a highly impervious, concrete-like material.

Bedrock geology in the county is varied. Underlying the Cle Elum River drainage is the non-marine sedimentary Swauk formation dating back to the Tertiary period of geologic time from 1.6 to 65 million years ago. Composed of conglomerate sandstone and shale interbeds, the Swauk formation extends as far north as Lake Wenatchee. As these interbeds were later subjected to the mountain-building forces during the emergence of the Cascades, a complex range of land forms was produced that created a history of geologic instability present to this day. Other major bedrock formations in Kittitas County include metamorphic rocks, granite intrusions, and thick sequences of volcanic and marine sedimentary rock.

4.3.2 Slope Stability

Slope stability refers to the potential of land slippage due to factors such as steepness, composition of materials, and water content within soils. Slopes that have been landscaped and altered from their natural vegetated state or saturated by septic tanks are also subject to sliding. Slumping can also occur when water infiltrates the soil and comes in contact with an impermeable layer. Although the upper layers of soil may not become saturated, water perches on the impermeable layer and causes a slippery interface resulting in the downward and outward movement of weak rock or unconsolidated material. Much of the western and northern portions of the county contain slopes of 15 percent or greater. Slopes less than 15 percent are generally found in the river basins in the eastern portions of the county.

4.3.3 Soils

Kittitas County soils were formed by the forces of water, heat, time, vegetation and animal life, acting on the geologic parent material. The principal parent material consists of sands and gravels associated with glacial till and outwash. Highly organic soils were developed in a moist climate under a rich covering of vegetation. Figure shows county soil maps that are available through the USDA (USDA 2010).

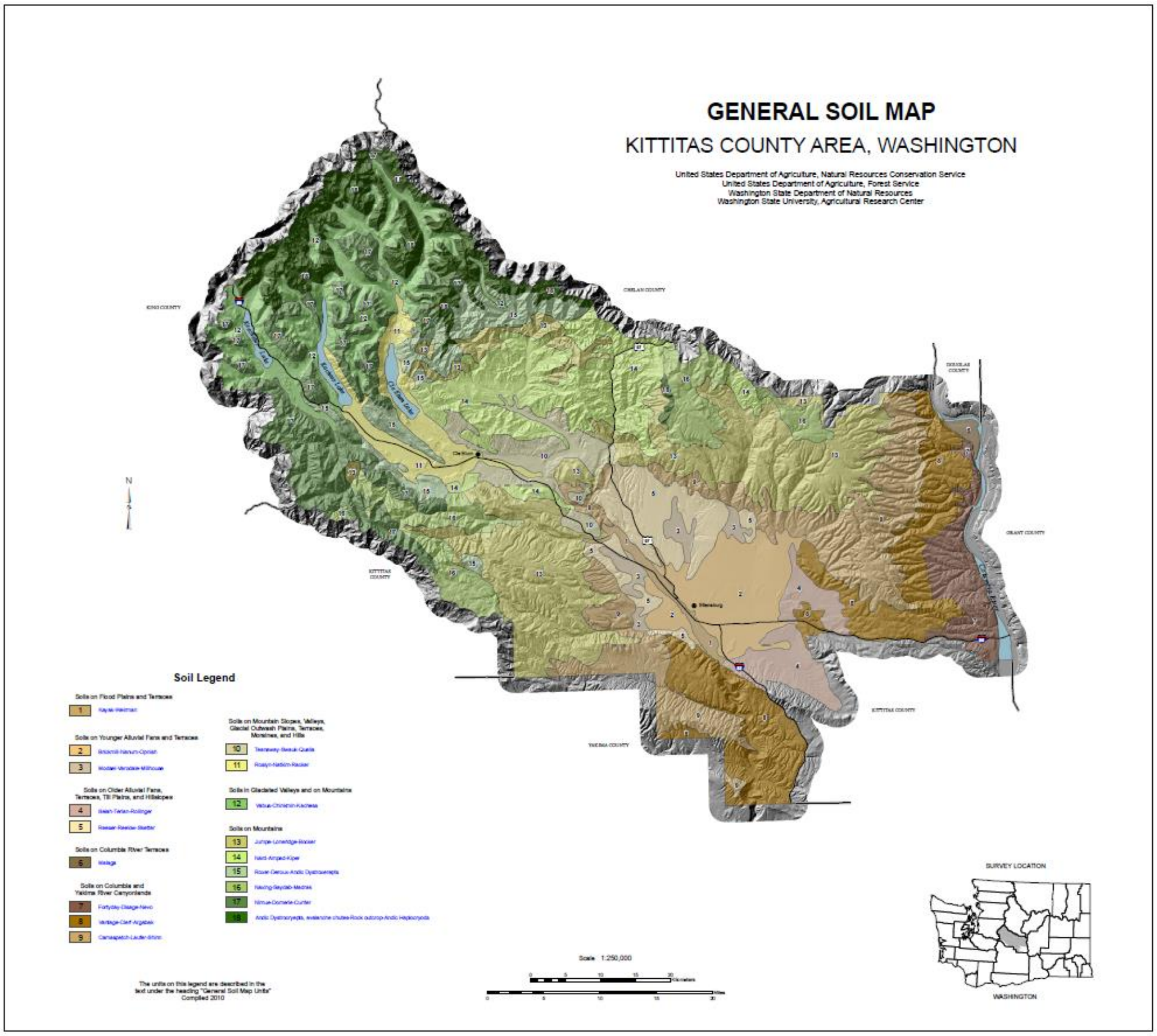


Figure 4-2. USDA Soil Map of Kittitas County

While this analysis is useful for planning and is helpful in determining general capacity of areas to support agricultural, residential, recreational and other land uses, it cannot be used directly for assessing the actual use of any particular site. The glaciated character of the soils creates too much variation within any particular soil type. Nonetheless, the soil maps are useful for determining general limitations and character of soils. Knowledge of soil characteristics and capabilities can assist in wise public and private investments, and can be useful in determining suitability of land for various uses. Still, planning-level mapping should not be substituted for specific onsite field inspections, which may produce findings different from more general accounts.

The load-bearing capacity of soil, its hydric properties, erosion potential, and other characteristics all play a significant role in the development of land. Hydric properties in soils indicate the existence of wetlands and signal the potential for other environmental concerns. Soil suitability for structural support and stability is also important in determining the potential for development. Area soil types vary considerably:

- Soils in western mountainous portion of the county are more suited for growing forest products than food-crop farming. These soils are strongly acidic, gravelly or rocky, saturated most of the year, and occur in steep areas at high elevations.
- Soils in the foothill areas with streams are ideal for growing native trees.
- Soils in the Yakima River Valley are more suited to agriculture and those on the south slopes of the valley are used for extensive fruit growing.
- Other areas have been designated as critical areas due to erosion and landslide potentials.

Suitability for Septic Tanks and Drainfields

For developments dependent on septic tank systems for on-site wastewater treatment, soils are important in determining the degree of development feasible without contaminating groundwater and surface water supplies. Areas well-suited for liquid waste disposal contain gravelly, sandy soils approximately 4 to 6 feet in depth sitting over an impermeable layer, such as till. Several factors severely limit septic tank use in Kittitas County:

- Shallow soils cover much of the western portion of the county. If soils are too shallow, the decomposition process of septic tank effluent does not proceed far enough to avoid contaminating surface water or groundwater.
- High water tables exist in river valley areas, rendering the underground reservoirs susceptible to contamination from failing septic systems.
- Rainfall varies widely from one end of the county to the other.

Depth-to-Seasonal Water Table

Depth to seasonal water table is a measurement from the surface to the water table during the wet months of the year. A shallow depth between the ground surface and the water table may cause both foundation and septic tank effluent disposal problems. A high seasonal water table may inhibit septic tank effluent from being properly treated in the soil. It may also cause foundations to “float” on their footings, resulting in structural damage to buildings.

Glacially cemented hardpan layers and shallow depth to bedrock account for portions of the county having a shallow depth-to-seasonal water table, (0 to 3 feet below the ground level.) These areas are not perched water tables. They can be either level or sloped areas with a hardpan layer underneath.

Aquifer Recharge Potential

Aquifer recharge potential is the relative ability of the soil and underlying geology to transport rainwater into underground aquifers. This classification considers the water-intake rate of topsoil and the permeability of subsoils and parent materials. While it is not known if water falling on these areas actually reaches the aquifers, it is not unreasonable to assume that these areas do play a role in recharging underground water reservoirs. Aquifer recharge areas contain some of the most permeable soils.

Conflicts persist regarding appropriate land use consistent with soil capabilities for on-site wastewater treatment. Rooftops, driveways, walkways, and frontage roads all reduce the amount of land surface available to receive rainwater. In areas of extreme permeability, septic tank effluent may percolate faster than the ability of soil microorganisms to purify it, thus increasing the chance of groundwater contamination. Proper precautions should be taken when developing areas considered to have aquifer recharge potential so that the function of these areas may be maintained without depleting or contaminating groundwater supplies. The ability of soils to allow replenishment of groundwater reservoirs becomes an increasingly important consideration as more demand is placed on groundwater for commercial and domestic use.

Large areas of high aquifer recharge potential are found in the Yakima River Basin and its tributaries within Kittitas County. However, no critical aquifer recharge locations have been identified in Kittitas County, according to the Interim Critical Areas Development Ordinance 94-22.

Agricultural Suitability

The suitability of soils for agricultural production has been classified by the USDA NRCS Soil Conservation Service into eight classes. These categories are determined by expected crop yields and required soil management techniques. Generally speaking, Class 1 through Class 4 soils produce the highest yields with the least amount of soil management. Class 5 through Class 8 soils require more costly soil management and lower yields are expected. Kittitas County contains a considerable diversity of soils with varying agricultural properties for growing crops and trees.

4.3.4 Seismic Features

Seismic events could pose limited landslide and liquefaction hazards in areas where steep or exposed slopes occur. Landslides occur when the structural integrity of a geological formation is damaged. There are known areas of landslide activity, which may or may not have resulted from seismic events, along the Yakima River. Soil liquefaction occurs when soil loses its strength and bearing capacity during an earthquake. This is most likely to occur on non-cohesive soils with high moisture content. These soils are poorly compacted and, in combination with moist conditions, are subject to liquefying during an earthquake. Structures built on liquefiable soils are subject to greater shaking and damage during an earthquake, but this damage can be minimized by engineering and construction methods.

Kittitas County has little potential for seismic events other than secondary effects from activity occurring west of the Cascades. The Uniform Building Code rates seismic risk from 1 (low risk) to 4 (high risk). Most of Kittitas County is within Seismic Zone 2. The Snoqualmie Pass area is within Zone 3.

4.3.5 Climate

Eastern Washington climate is a function of maritime and continental influences. The Yakima River basin’s location just east of the Cascade crest places it in a rain shadow, with hotter summers, colder winters, a shorter growing season, and less precipitation than areas of similar latitude west of the Cascades. Temperatures generally increase and precipitation generally decreases from northwest to southeast and from high to low elevation.

Temperatures

Because of the variation in elevation, temperatures vary greatly in the Yakima River basin. In the Kittitas Valley, summers tend to be hot, with wide divergent fluctuations, and mild to severe winters. Data is scarce for higher elevations; however, those areas are generally characterized by cool summers and cold winters. For example, in the Subalpine Fir forest zone, which extends from approximately 2,000 feet to the timberline, mean July temperatures in the range of 55ºF to 65ºF can be expected.

Precipitation

As is typical of areas in the lee of large coastal mountain ranges, the Yakima River basin is generally arid. Precipitation varies with elevation and distance from the Cascades, from 150 inches annually at the Cascade crest to 10 inches at the Columbia River. Disparities in precipitation rates from one area to another affect runoff rates and the character of rivers in different drainages, which influence flooding and land-use potential.

Summers in Kittitas County tend to be dry; approximately two-thirds of the county's precipitation occurs between October and April, with much in the form of snow. In the winter, considerable snow often accumulates in the higher elevations. In the Kittitas Valley, snow season generally ranges from November through February, with significant variation from one season to the next.

4.3.6 Land Use

Kittitas County is characterized as rural, forested and range-land, with some densely populated areas. Settlers originally came to this area to take advantage of opportunities for logging, sawmills, farming and services for the resource industries. Today, traditional economic sectors such as logging and other forest-related industries are in decline due to restrictions on logging and the transition of land to conservation and parks. A large part of the growing economy is based on tourism and recreational activities. Much of the developed landscape reflects this and consists of vacation/recreational housing, single family units, highway-oriented service/retail commercial development, and recreational uses such as golf courses and parks. Most remaining nonfederal and non-state land is privately held forest and some agricultural land.

In the Snoqualmie Pass area, resource allocation, in the form of timber harvesting, is the predominant land use, with sporadic areas used for recreational purposes. Resource allocation is also predominant at the mid-elevations; however, residential development becomes more common in these areas. At lower elevations, agricultural activities are the main land use, with residential development intermixed. The Yakima Training Center, located in the southeastern portion of the county, makes up a large percentage of the ownership in the lower Kittitas Valley—approximately 164,132 acres. Table 4-1 lists existing zoning as identified in the 2016 County Comprehensive Plan.

Table 4-1. Zoning by Acreage

Type of Land Use	Land Use Designations	Acres	Zoning Classification	Acres
Resource	Commercial Agriculture	291,614.3	Commercial Agriculture	291,614.3
	Commercial Forest	800,511.3	Commercial Forest	800,511.3
	Mineral	5,745	Zoning Classification Varies	5,750.7
Rural	Rural Residential	30,013	Agriculture 5	11,932.5
			Rural 5	18,228.2
			General Commercial	4.5
			Planned Unit Development	0
	Rural Working	329,982	Agriculture 20	113,251.6

Rural			Forest and Range	220,236.6
	Rural Recreation	10,535	Master Planned Resort	6,445.5
			General Commercial	17.4
			Highway Commercial	0
			Rural Recreation	3,938.8
			Planned Unit Development	107.1
	LAMIRDS	1,168	Residential	384.1
			Residential 2	41.9
			Agriculture 3	34.7
			Agriculture 20	22.8
			Rural 3	18.6
			Rural 5	141.3
			Limited Commercial	12.9
			General Commercial	193.5
			Highway Commercial	18.8
			Light Industrial	36.3
			General Industrial	4.7
			Forest and Range	77.5
			Rural Recreation	12.9
			Planned Unit Development	139.6
Urban	Urban	7,000	Residential	140.3
			Rural Residential	0
			Urban Residential	2,522.9
			Historic Trailer Court	24.2
			Agriculture 3	213.8
			Rural 3	408

Urban			Rural 5	14.1
			Limited Commercial	3.8
			General Commercial	103.6
			Highway Commercial	50.6
			Light Industrial	1,645.9
			General Industrial	607.9
			Forest and Range	559
			Planned Unit Development	13.5

Under current zoning, densities range from one unit per 6,000 square feet to one unit per 80 acres. The Suburban zone allows a density of one unit per acre. For example, the Suburban zone allows a density of one unit per acre, while the Agricultural-3, Rural- 5, and Agricultural-20 Zones allow for a density range of one unit per three acres, five acres, or twenty acres, respectively. The lowest density in the County is in the Commercial Forest Zone where the assigned density is one unit per 80 acres.

4.4. 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. Kittitas County has experienced 11 events since 1964 for which presidential disaster declarations were issued. These events are listed in Table 4-2.

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. Seismic activity in the county has been recorded from the 1930s through the present, though earthquake damage has been low.

Table 4-2. Presidential Disaster Declarations for Hazard Events in Kittitas County

Type of Event	Disaster Declaration #	Date
Heavy Rains & Flooding	DR-185	12/29/1964
Severe Storms, Flooding	DR-492	12/13/1975
Severe Storms, Mudslides, Flooding	DR-545	12/10/1977
Volcanic Eruption (Mt. St. Helens)	DR-623	5/21/1980
Flooding, Severe Storm	DR-883	11/26/1990

Type of Event	Disaster Declaration #	Date
Storms/High Winds/Floods	DR-1079	01/03/1996
Severe Storms/Flooding	DR-1100	02/02/1996
Severe Winter Storms/Flooding	DR-1159	01/17/1997
Earthquake (Nisqually)	DR-1361	03/01/2001
Severe Winter Storm, Landslides, Mudslides, and Flooding	DR-1817	01/30/2009
Severe Winter Storm and Record and Near Record Snow	DR-1825	03/02/2009
Severe Winter Storm, Flooding, Landslides, and Mudslides	DR-1963	03/25/2011
Wildfires	DR-4188	08/11/2014
Severe Storms, Straight-Line Winds, Flooding, Landslides, and Mudslides	DR-4249	01/15/2016

4.5. CRITICAL FACILITIES AND INFRASTRUCTURE

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

- A critical facility is a local (non-state or federal) facility or infrastructure in either the public or private sector that provides essential products and services to the general public, such as preserving the quality of life in Kittitas County and fulfilling important public safety, emergency response, and disaster recovery functions. Loss of a critical facility would result in a severe economic or catastrophic impact and would affect the County’s ability to provide essential services that protect life and property. The critical facilities profiled in this plan include the following:
  - Government facilities, such as departments, agencies, and administrative offices
  - Emergency response facilities, including police, fire, and emergency operations centers
  - Educational facilities, including K-12
  - Medical and care facilities, such as hospitals, nursing homes, continuing care retirement facilities and housing likely to contain occupants who may not be sufficiently mobile to avoid death or injury during a hazard event
  - Community gathering places, such as parks, museums, libraries, and senior centers
  - Public and private utilities and infrastructure vital to maintaining or restoring normal services to areas damaged by hazard events

– Structures or facilities that produce, use, or store highly volatile, flammable, explosive, toxic, and/or water-reactive materials.

Figure 4-3 shows the location of critical facilities in unincorporated areas of the county. Critical facilities within the cities participating in this plan are shown in maps for each city provided in Volume 2 of the plan. Due to the sensitivity of this information, a detailed list of facilities is not provided. The list is on file with each planning partner. Figure 4-3 provides a summary of the general types of critical facilities in each municipality and unincorporated county areas. All critical facilities were analyzed for exposure to all hazards to help rank risk and identify mitigation actions. The risk assessment for each hazard discusses critical facilities with regard to that hazard.

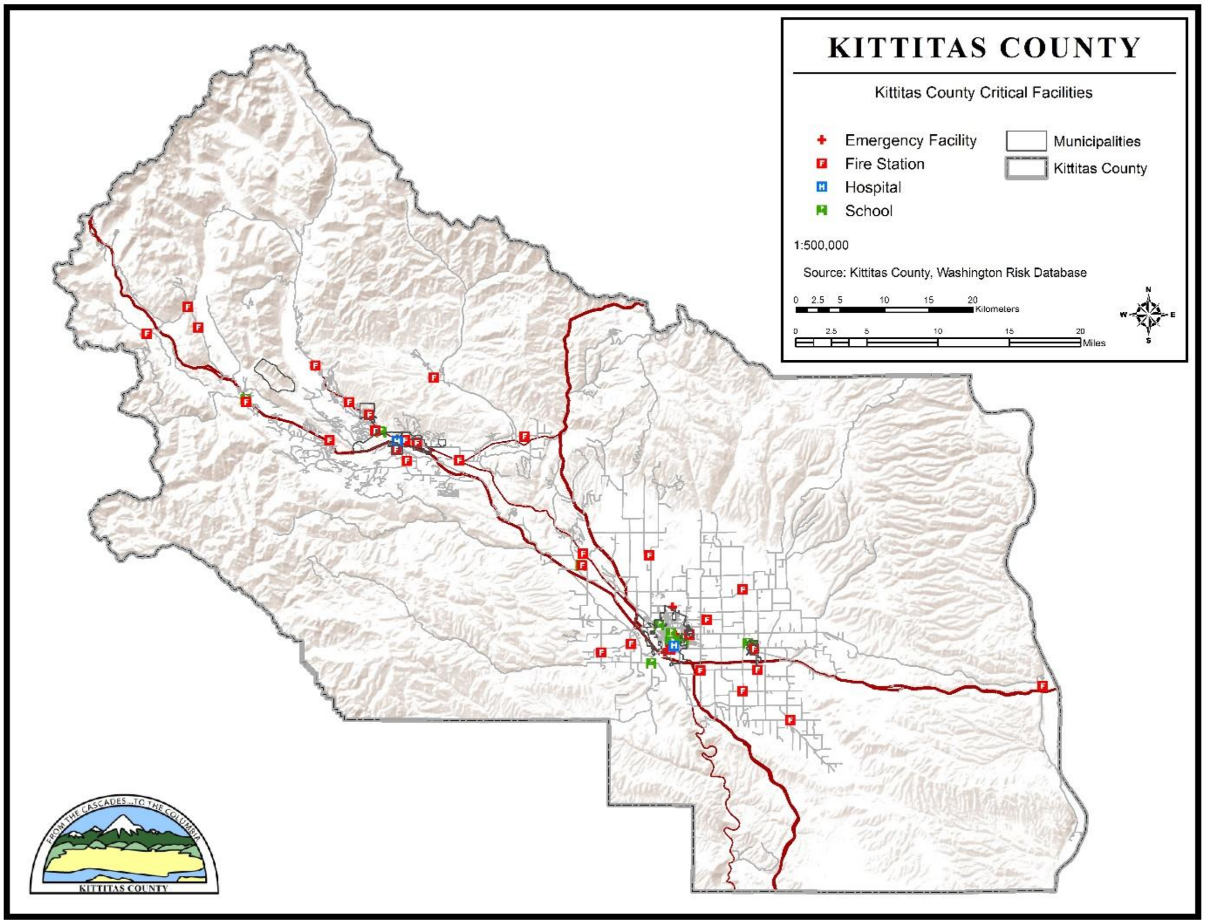


Figure 4-3. Kittitas County Critical Facilities

Table 4-3. Kittitas County Critical Facilities

Jurisdiction	Fire Station	Hospital	Emergency Facility	School	Total
Cle Elum	2	2	0	0	4
Ellensburg	2	2	3	6	13
Kittitas	1	0	0	3	4
Roslyn	1	0	0	0	1
South Cle Elum	1	0	0	0	1
Unincorporated Kittitas County	24	0	1	8	33
Total	**31**	**4**	**4**	**17**	**56**

4.6. 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. These vulnerable populations may vary from the general population in risk perception, living conditions, access to information before, during and after a hazard event, capabilities during an event, and access to resources for post-disaster recovery. Indicators of vulnerability—such as disability, age, poverty, and minority race and ethnicity—often overlap spatially and often in the geographically most vulnerable locations. Detailed spatial analysis to locate areas where there are higher concentrations of vulnerable community members would assist the County in extending focused public outreach and education to these most vulnerable citizens.

4.6.1 Kittitas County Population Characteristics

Current Population

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. Kittitas County is the 23rd largest of Washington's 39 counties. The Washington State Office of Financial Management estimated Kittitas County's population at 45,600 as of April 1, 2018.

Population changes are useful socio-economic indicators. A growing population generally indicates a growing economy, while a decreasing population signifies economic decline. Figure 4-4 shows the growth rate of Kittitas County from 1961 to 2011 compared to that of the State of Washington. Between 2000 and 2010, Washington's population grew by 14.8 percent (about 1.26 percent per year) while Kittitas County's population increased by 23.8 percent (1.96 percent per year). The County's population increased an average of 2.15 percent per year between 1990 and 2010, a total of 53 percent during that period. In 2017, Kittitas County experienced the largest percentage increase in annual growth of all the counties at 2.9 percent. The state had an overall population growth of 1.76 percent in 2017, which is the largest percentage increase since 2007.

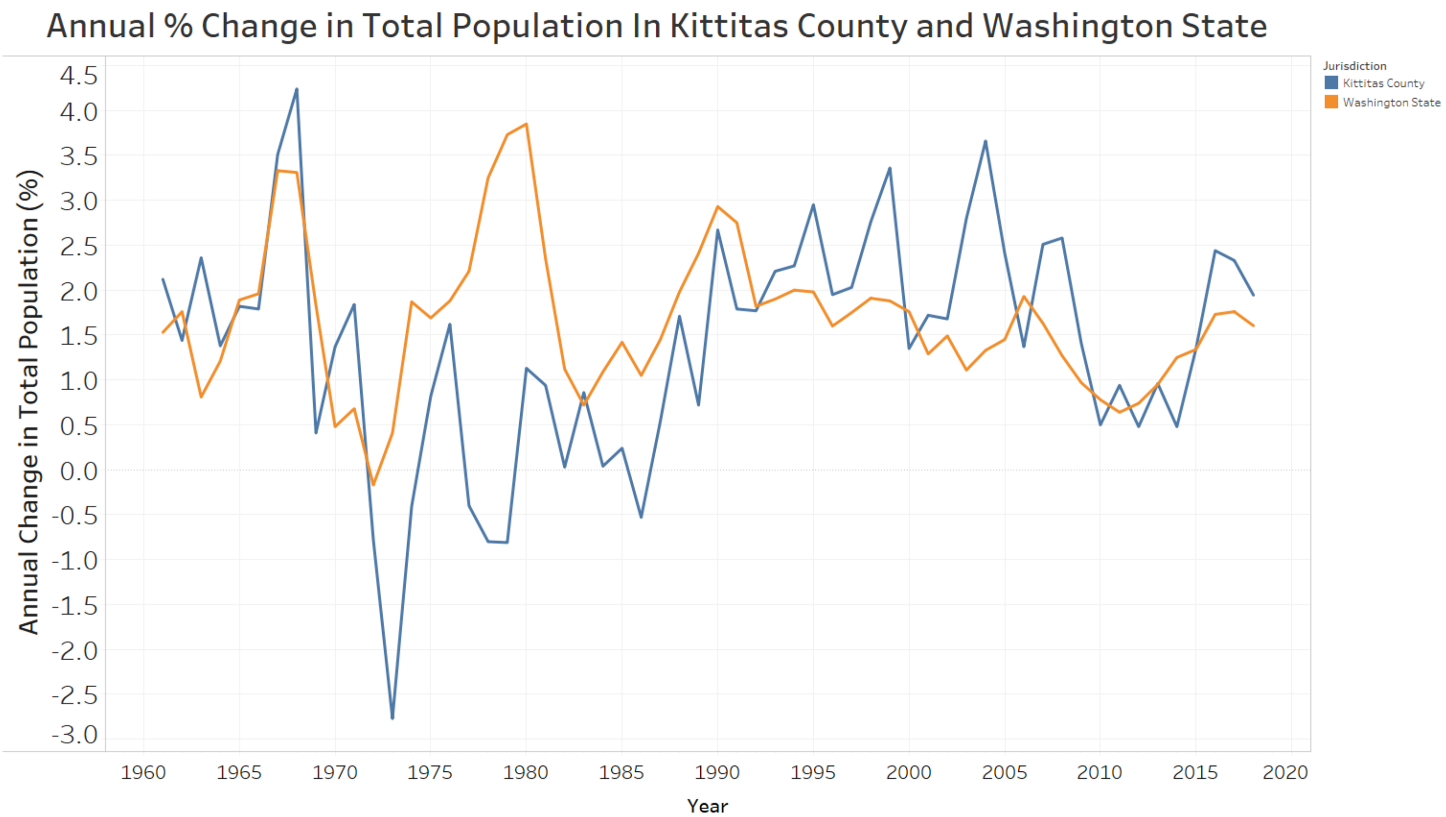


Figure 4-4. Annual % Change in Total Population in Kittitas County and Washington State

Table 4-4 shows the population of incorporated municipalities and the combined unincorporated areas in Kittitas County from 2002 to 2018. In 2018, about 46 percent of Kittitas County's residents lived outside incorporated areas.

Table 4-4. City and County Population Data

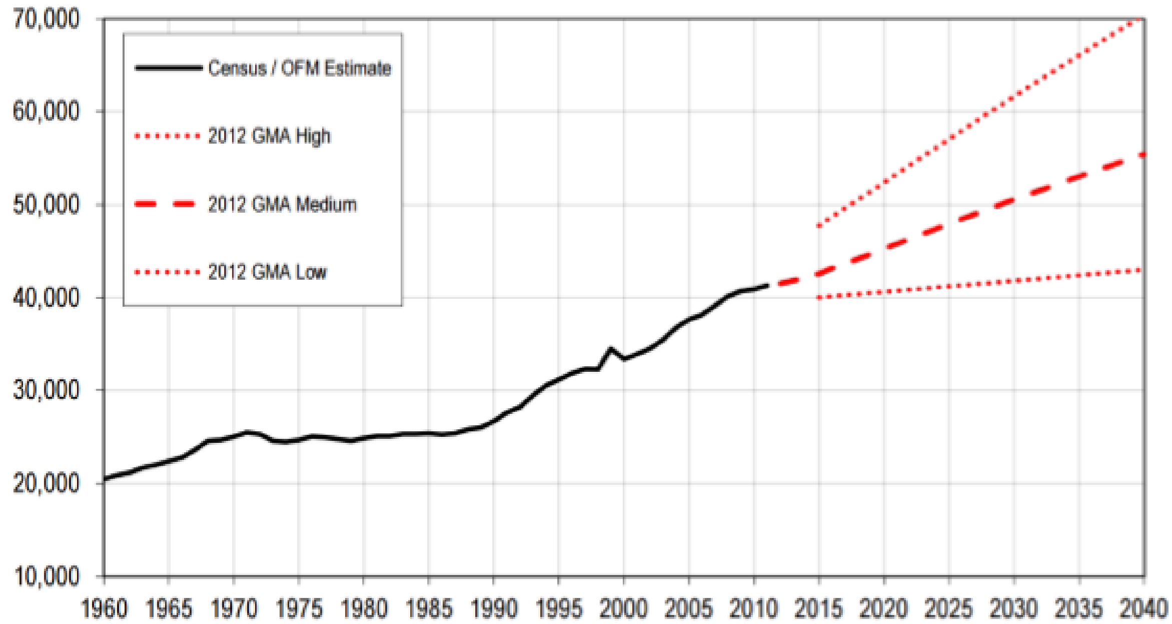
Year	Cle Elum	Ellensburg	Kittitas	Roslyn	Unincorporated Kittitas County	Kittitas County Total
2002	1,775	15,830	1,100	1,020	14,520	**34,800**
2003	1,775	15,940	1,120	1,020	14,785	**35,200**
2004	1,785	16,390	1,130	1,020	14,910	**35,800**
2005	1,800	16,700	1,135	1,020	15,375	**36,600**
2006	1,810	17,080	1,135	1,020	15,780	**37,400**
2007	1,835	17,220	1,135	1,020	16,510	**38,300**
2008	1,865	17,330	1,145	1,015	17,465	**39,400**

Year	Cle Elum	Ellensburg	Kittitas	Roslyn	Unincorporated Kittitas County	Kittitas County Total
2009	1,870	17,230	1,150	1,015	18,060	**39,900**
2010	1,870	17,326	1,182	1,015	18,532	**40,500**
2011	1,875	18,250	1,460	895	18,315	**41,300**
2012	1,865	18,320	1,450	895	18,440	**41,500**
2013	1,870	18,370	1,450	895	18,785	**41,900**
2014	1,870	18,440	1,475	895	18,890	**42,100**
2015	1,865	18,810	1,455	890	19,120	**42,670**
2016	1,870	19,310	1,460	890	19,650	**43,710**
2017	1,875	19,550	1,500	890	20,385	**44,730**
2018	1,875	19,660	1,515	900	21,120	**45,600**

Washington State Office of Financial Management, Population Estimates

Population Projections

In 2012, Washington State Office of Financial Management (OFM) released three separate population growth projections for Kittitas County: Low, Medium, and High. Figure 4-5 shows Kittitas County population between 1960 and 2011 along with OFM’s High, Medium, and Low growth projections. A population projection memo by BERK Consulting suggests that Kittitas County may see large increases in population due to three major factors: 1) emergence as a retirement destination 2) increased student enrollment at Central Washington University and 3) transportation improvements allowing easier passage to King County. However, it is also noted that this positive growth trend may be countered by negative trends such as the lack of job growth, water right restrictions and an increase in climate change related events such as wildfires.



Source: Washington State Office of Financial Management, 2012

Figure 4-5. Kittitas County Population and Projected Growth

Historic and projected rates of average annual population growth are shown in Figure 4-6. OFM's High projection assumes an average annual growth rate of 2.13% between 2015 and 2037. This is higher than the rate of growth experienced during any period ending in 2015 and roughly equivalent to the fastest period of sustained growth in recent history (1990 – 2010). The OFM Medium projection assumes a growth rate of 1.08%, higher than experienced in the county between 2010 and 2015 (0.84%), but lower than the historic growth rate for all other time periods ending in 2015.

Period	Average Annual Growth Rate
1960 - 2015	1.34%
1970 - 2015	1.15%
1980 - 2015	1.55%
1990 - 2015	1.89%
2000 - 2015	1.65%
2010 - 2015	0.84%

OFM Projections (2015* - 2037)	Average Annual Growth Rate
OFM High	2.13%
OFM Medium	1.08%
OFM Low	0.00%

* Population growth rates calculated by comparing estimated 2015 population to OFM projected 2037 population.

Source: Washington State Office of Financial Management, 2015 and 2012

Figure 4-6. Kittitas County Average Annual Rate of Population Growth

4.6.2 Income

In the United States, individual households are expected to use private resources to prepare for, respond to and recover from disasters to some extent. This means that households living in poverty are automatically disadvantaged when confronting hazards. Additionally, the poor typically occupy more poorly built and inadequately maintained housing. Mobile or modular homes, for example, are more susceptible to damage in earthquakes and floods than other types of housing. In urban areas, the poor often live in older houses and apartment complexes, which are more likely to be made of un-reinforced masonry, a building type that is particularly susceptible to damage during earthquakes. Furthermore, residents below the poverty level are less likely to have insurance to compensate for losses incurred from natural disasters. This means that residents below the poverty level have a great deal to lose during an event and are the least prepared to deal with potential losses. 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 U.S. Census Bureau's American Community Survey (ACS) estimates for 2012-2016, per capita income in Kittitas County in 2016 was $25,147, and the median household income was $47,898. It is estimated that about 11.8 percent of households receive an income between $100,000 and $149,999 per year and 3.8 percent of the county's household incomes are above $150,000 annually. About 30 percent of the households in Kittitas County make less than $25,000 per year and are therefore below the poverty level.

4.6.3 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 are more likely to live in assisted-living facilities where emergency preparedness occurs at the discretion of facility operators. These facilities are typically identified as "critical facilities" by emergency managers because they require extra notice to implement evacuation. Elderly residents living in their own homes may have more difficulty evacuating their homes and could be stranded in dangerous situations. This population group is more likely to need special medical attention, which may not be readily available during natural disasters due to isolation caused by the event. Specific planning attention for the elderly is an important consideration given the current aging of the American population.

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 Kittitas County is illustrated in Figure 4-7. Based on U.S. Census estimates, 12.8 percent of Kittitas County's population is 65 or older, compared to the state average of 12.3 percent. Of the county's over-65 population, 38.1 percent has disabilities of some kind and 6.3 percent have incomes below the poverty line. It is also estimated that 15.2 percent of the county's population is 14 or younger, compared to the state average of 19.4 percent. Children under 18 account for 18.2 percent of individuals who are below the poverty line.

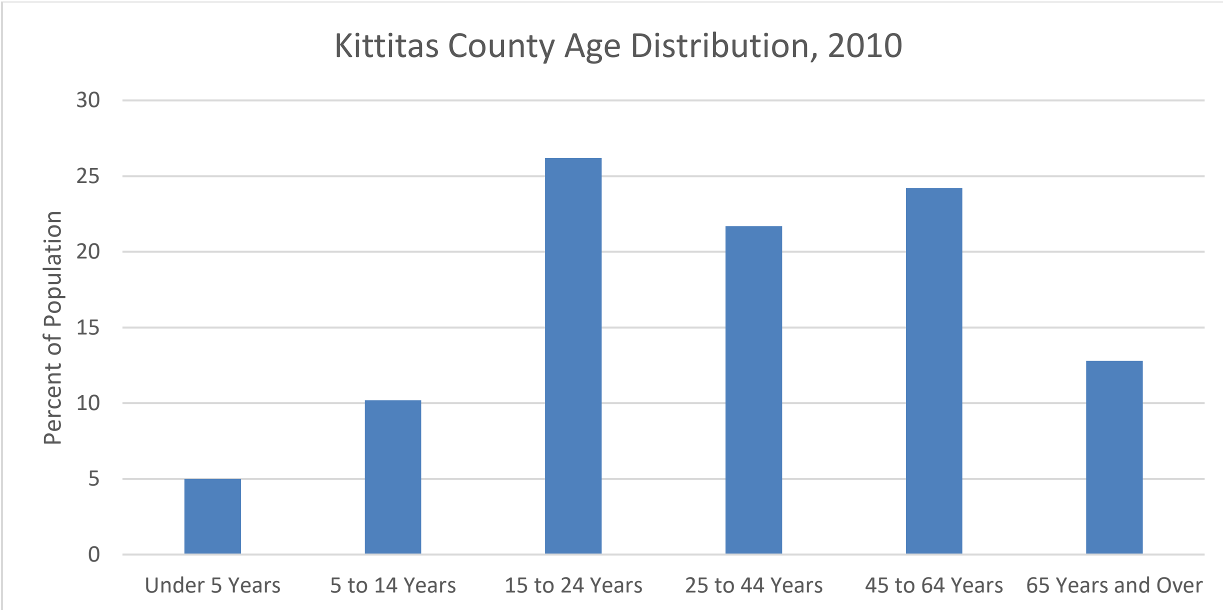


Figure 4-7. Kittitas County Age Distribution, 2010

4.6.4 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. 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 2016 ACS, the racial composition of Kittitas County is predominantly white, at about 73.3 percent. The largest minority population is Black at 12.6 percent. The Hispanic population represents 17.3 percent of the county total. Figure 4-8 shows the racial distribution in Kittitas County.

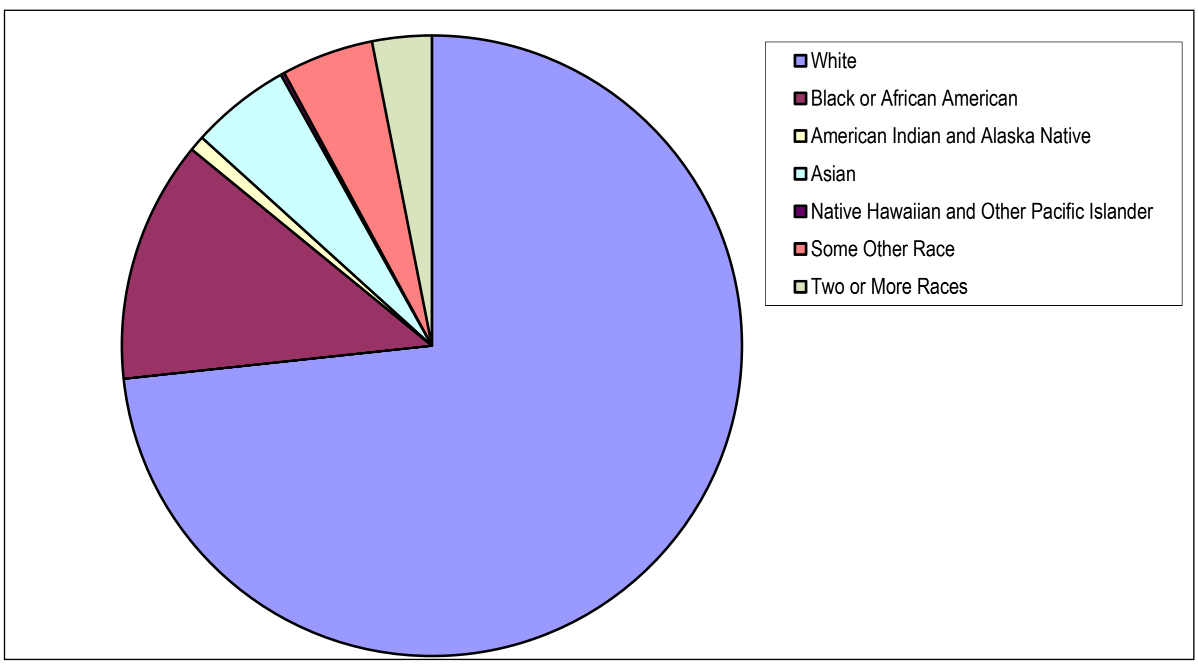


Figure 4-8. Planning Area Race Distribution

Kittitas County has a 6.2 percent foreign-born population. Other than English, the most commonly spoken language in Kittitas County is Spanish. The census estimates 2.8 percent of the county's residents speak English "less than very well."

4.6.5 Disabled Populations

People with disabilities are more likely than the general population to have difficulty responding to a hazard event. As disabled populations are increasingly integrated into society, they are more likely to require assistance during the 72 hours after a hazard event, the period generally reserved for self-help. There is no "typical" disabled person, which can complicate disaster-planning processes that attempt to incorporate them. Disability is likely to be compounded with other vulnerabilities, such as age, economic disadvantage and ethnicity, all of which mean that housing is more likely to be substandard.

Table 4-5 summarizes the estimates of disabled people in Kittitas County. According to 2016 ACS data, 13.2 percent of the county's population has a disability.

Table 4-5. Disability Status of Non-Institutionalized Population

Age	Persons with a Disability	Percent of Age Group
Age 0 to 17 years	349	4.6
Age 18 to 64 years	3,148	10.9
Age 65 years and over	2,126	34.6

4.7. ECONOMY

4.7.1 Industry, Businesses and Institutions

According to the Washington State Department of Employment Security, Kittitas County's economy is strongly based in the State and Local Government industry, with 26 percent of employees, followed by Accommodation and Food Service at 18.1 percent, Retail Trade at 12.1 percent, and Health Services at 8.7 percent. Table 4-6 shows the breakdown of industry types in Kittitas County.

Table 4-6. Industry Employment Distribution

Sector	Number of jobs	Share of employment
1. Accommodation and food services	2,612	18.1%
2. Local government	2,212	15.4%
3. Retail trade	1,746	12.1%
4. State government	1,525	10.6%
5. Health Services	1,250	8.7%
All other industries	5,055	35.1%
Total covered employment	**14,400**	**100%**

The county benefits from a variety of business activity. Major public and private employers include Central Washington University, Kittitas Valley Community Hospital, Ellensburg School District, Kittitas County, Anderson Hay and Grain, Elmview Ellensburg, and Fred Meyer. Central Washington University is the major educational and research institution in the county, with a student enrollment of 11,376 and a staff and faculty of 1,438.

4.7.2 Employment Trends and Occupations

According to the 2016 ACS, about 60 percent of Kittitas County's population 16 years and over is in the labor force. Of the working-age population group (ages 20-64), 75.9 percent of men and 70.2 percent of women are in the labor force. According to the Washington Employment Security Department, unemployment rates in Kittitas County were consistent in the four-year period from 2005 to 2008 (before the "Great Recession"). Rates ranged from a low of 5.4 percent in 2007 to the "high" of 6.3 percent in 2008. During the recession however, the unemployment rate in Kittitas County peaked at 9.8 percent in 2010. Average annual unemployment rates have been on the decline ever since. The unemployment rate fell to 9.3 percent in 2011, to 8.8 percent in 2012, to 7.8 percent in 2013, to 6.9 percent in 2014, 6.3 percent in 2015, and to 6.0 percent in 2016. As of June 15, 2018, Kittitas County's unemployment rate was 4.8 percent.

Figure 4-9 shows the distribution of employment by occupation type according to the 2016 ACS.

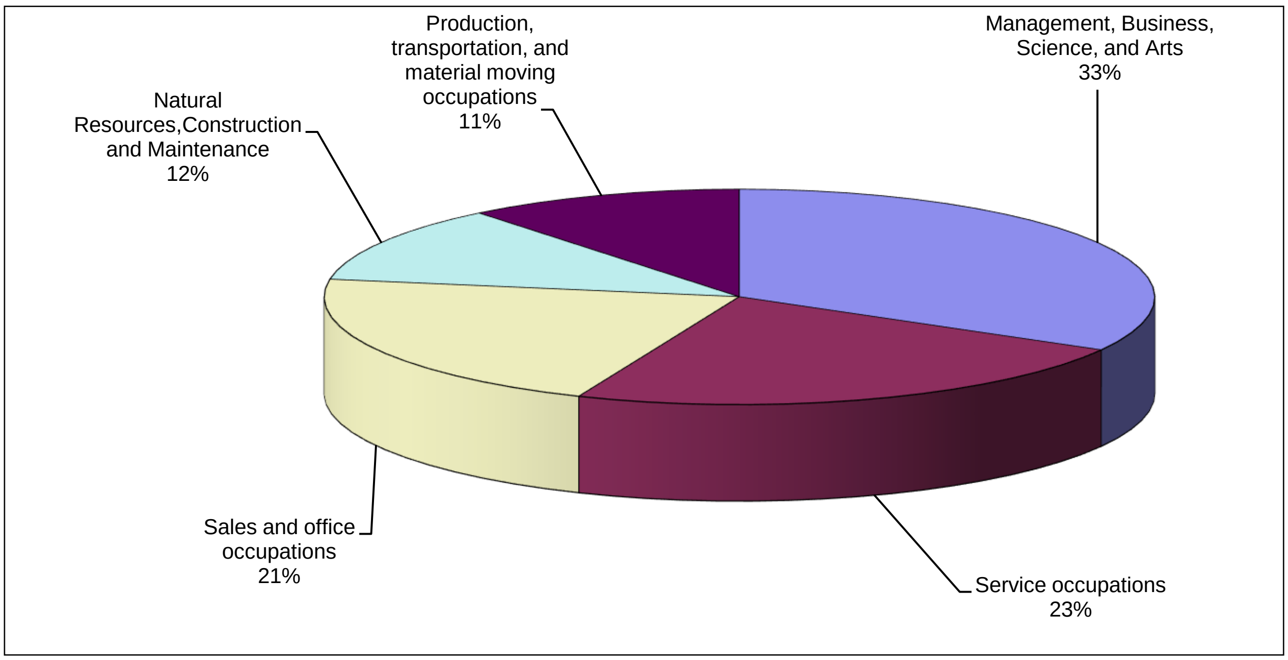


Figure 4-9. Occupations in Kittitas County

The U.S. 2016 ACS estimates that over 73.5 percent of Kittitas County workers commute alone (by car, truck or van) to work, and mean travel time to work is 20.8 minutes (the state average is 26.7 minutes). According to the Washington Employment Security Department, the two largest jobholder age groups in Kittitas County were 55-years and over, and 25-34 years. These two categories accounted for 22.7 percent and 20.9 percent of employment in 2016. A close third was the 45-to-54 year old group, at 18.8 percent. In 2016, women held 49.5 percent of all jobs in Kittitas County. However, there were substantial differences in gender dominance by industry. Male-dominated industries included transportation and warehousing (83.6 percent), construction (83.3 percent) and utilities (75.8 percent). Female-dominated industries included healthcare and social assistance (76.4 percent), finance and insurance (71.1 percent) and educational services (61.9 percent).

4.8. FUTURE DEVELOPMENT

The County and its cities have adopted comprehensive plans that govern land use decision 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 Kittitas County.

All municipal planning partners will seek to incorporate by reference the Kittitas County Hazard Mitigation Plan in their comprehensive plans. This will assure that all future trends in development can be established with the benefits of the information on risk and vulnerability to natural hazards identified in this plan.

CHAPTER 5.
CAPABILITY ASSESSMENT

This chapter provides an overview of the current capabilities of Kittitas County in addressing hazard mitigation. These include federal, state, and local laws and ordinances, government plans and programs, and nongovernmental organizations and resources.

5.1 LAWS AND ORDINANCES

Existing laws, ordinances and plans at the federal, state and local level can support or impact hazard mitigation initiatives identified in this plan. Hazard mitigation plans are required by 44 CFR to include a review and incorporation, if appropriate, of existing plans, studies, reports, and technical information as part of the planning process (Section 201.6.b(3)). Pertinent federal and state laws are described below. Each planning partner has individually reviewed existing local plans, studies, reports, and technical information in its jurisdictional annex, presented in Volume 2.

5.1.1 Federal

Disaster Mitigation Act

The DMA is the current federal legislation addressing hazard mitigation planning. It emphasizes planning for disasters before they occur. It specifically addresses planning at the local level, requiring plans to be in place before Hazard Mitigation Grant Program funds are available to communities. This plan is designed to meet the requirements of DMA, improving the planning partners' eligibility for future hazard mitigation funds. DMA 2000 amended the Robert T. Stafford Disaster Relief and Emergency Assistance Act by repealing the previous mitigation planning provisions and replacing them with a new set of requirements that emphasize the need for State, local, and Indian Tribal entities to closely coordinate mitigation planning and implementation efforts. Table 5-1 details the three grant programs under the Hazard Mitigation Assistance (HMA) program.

Table 5-1. FEMA Grant Programs Available Under the Unified HMA Program

Feature / Program	Hazard Mitigation Grant Program (HMGP)	Flood Mitigation Assistance (FMA)	Pre-Disaster Mitigation (PDM)
Authorization	Section 404 of the Stafford Act Only available after a Presidentially Declared Disaster	Section 1366 of the national Flood Insurance Act of 1968	Section 203 of the Stafford Act
Qualifying Criteria	Must be a project that mitigates damages from a current disaster or past disaster within Kittitas County.	Must be a project that mitigates damages from flooding to structures insured under the NFIP.	Full range of pre-disaster natural hazard mitigation actions in Kittitas County.

Feature / Program	Hazard Mitigation Grant Program (HMGP)	Flood Mitigation Assistance (FMA)	Pre-Disaster Mitigation (PDM)
Approvals	State approval by WA Emergency Management Division. Federal approval from FEMA	State approval by WA Emergency Management Division. Federal approval from FEMA	State approval by WA Emergency Management Division. Federal approval from FEMA
Funding Limits	Tiered percentages based on estimated aggregate amounts of disaster assistance	$20,000 for plans; $20,000 for technical assistance; $300,000 for projects	$4 million for mitigation projects; $400,000 for new plans; $300,000 for plan updates
Time Limits	2 Years for construction; 3 Years for plans	2 Years for construction; 3 Years for plans	2 Years for construction; 3 Years for plans

Endangered Species Act

The 1973 federal Endangered Species Act (ESA) was enacted 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. The ESA outlines procedures for federal agencies to follow when taking actions that may jeopardize listed species. 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. 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 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.”

The following are critical sections of the ESA:

- **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, 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.

- **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.

With the listing of salmon and trout species as threatened or endangered, the Pacific Coast states have been impacted by mandates, programs and policies based on the presumed presence of listed species. Most West Coast jurisdictions must now take into account the impact of their programs on habitat.

The 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. A full array of issues are addressed, not just those subject to CWA regulatory authority. Involvement of stakeholder groups in the development and implementation of strategies for achieving and maintaining water quality and other environmental goals is a hallmark of this approach.

National Flood Insurance Program

The National Flood Insurance Program (NFIP) provides federally backed flood insurance in exchange for communities enacting floodplain regulations. Participation and good standing under NFIP are prerequisites to grant funding eligibility under the Robert T. Stafford Act. The County and most of the partner cities for this plan participate in the NFIP and have adopted regulations that meet the NFIP requirements. At the time of the preparation of this plan, all participating jurisdictions in the partnership were in good standing with NFIP requirements.

5.1.2 State

Growth Management Act

The 1990 Washington State Growth Management Act (Revised Code of Washington (RCW) Chapter 36.70A) mandates that local jurisdictions adopt land use ordinances 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 (GMA) regulates development in these areas, and therefore has the potential to affect hazard vulnerability and exposure at the local level.

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 the Pacific Ocean shoreline and the shorelines of Puget Sound, the Strait of Juan de Fuca, and rivers, streams and lakes above a certain size. It also regulates wetlands associated with these shorelines.

Washington State Building Code

Kittitas County adopts the following codes, as amended by the Washington State Building Code Council pursuant to RCW 19.27 for the purpose of establishing rules and regulations for the construction, alteration, removal, demolition, equipment, use and occupancy, location and maintenance of buildings and structures. International Building Code (IBC), International Residential Code (IRC), International Mechanical Code), International Fire Code (IFC), Uniform Plumbing Code (UPC), Washington State Energy Code, International Property Maintenance Code (IPMC) and International Wildland Urban Interface Code, all either 2015 edition or most current published code. The Washington State Building Code is comprised of national model codes adopted by reference and amended at the state level and others, such as the Washington State Energy Code, are state-written state-specific code.

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 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.

Washington State Floodplain Management Law

Washington's floodplain management law (RCW 86.16, implemented through 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 major challenge to the law in 1978, Maple Leaf Investors v. Ecology, is cited in legal references to floodplain 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.

Flood Control Assistance Account Program

Washington's first flood control maintenance program was passed in 1951, and was called the Flood Control Maintenance Program (FCMP). In 1984, RCW 86.26 (State Participation in Flood Control Maintenance) established the Flood Control Assistance Account Program (FCAAP), which provides funding for local flood hazard management. FCAAP rules are found in WAC 173-145. Ecology distributes FCAAP matching grants to cities, counties and other special districts responsible for flood control. This is one of the few state programs in the U.S. that provides grant funding to local governments for floodplain management. The program has been funded for $4 million per Biennium since its establishment, with additional amounts provided after severe flooding events.

To be eligible for FCAAP assistance, flood hazard management activities must be approved by Ecology in consultation with the Washington Department of Fish and Wildlife (WDFW). A comprehensive flood hazard management plan must have been completed and adopted by the appropriate local authority or be in the process of being prepared in order to receive FCAAP flood damage reduction project funds. This policy evolved through years of the FCMP and early years of FCAAP in response to the observation that poor management in one part of a watershed may cause flooding problems in another part.

Local jurisdictions must participate in the NFIP and be a member in good standing to qualify for an FCAAP grant. Grants up to 75 percent of total project cost are available for comprehensive flood hazard management planning. Flood damage reduction projects can receive grants up to 50 percent of total project cost, and must be consistent with the comprehensive flood hazard management plan. Emergency grants are available to respond to unusual flood conditions. FCAAP can also be used for the purchase of flood prone properties, for limited flood mapping and for flood warning systems. While historically there have been $4 million in funds available per biennium, funding is not available from 2017 to 2019.

5.1.3 Cities and County

Each planning partner has prepared a jurisdiction-specific annex to this plan (see Volume 2). In preparing these annexes, each partner completed a capability assessment that looked at its regulatory, technical and financial capability to carry out proactive hazard mitigation. Refer to these annexes for a review of regulatory codes and ordinances applicable to each planning partner.

5.2 REVIEW OF EXISTING PROGRAMS

5.2.1 Government Plans and Programs

44 CFR 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)). Each of these plans and programs can provide support for hazard mitigation planning, in the form of research, data, existing policies, or goals for the planning area. The following plans and programs impact mitigation within the planning area, and were consulted in the update of this plan:

- Kittitas County Countywide Planning Policies (2016)

  The Countywide Planning Policies are to be used solely to establish a framework from which the comprehensive plans of the County and cities within the county are developed and adopted, pursuant to RCW 36.70A, The Growth Management Act. These policies are adopted to ensure consistency and coordination among the comprehensive plans of the County and the cities.

- Kittitas County Comprehensive Plan (2016)

  The comprehensive plan affects all unincorporated lands of Kittitas County of approximately 1,487,000 acres. The comprehensive plan is intended to conserve lands by protecting them from conflicting land uses, providing sufficient services and ensuring adequate facilities. This plan’s goals and objectives for land use and development, conservation, housing and infrastructure, and economic development were considered in the hazard mitigation planning process.

- Kittitas County Code (Titles 1-20)

The County Code provides detailed regulations, including those related to infrastructure, water, building and construction, environmental policy, zoning, and shorelines, all of which have particular importance to hazard mitigation planning.

- Kittitas County Comprehensive Emergency Management Plan (1999)

  The Comprehensive Emergency Management plan supports the government in its responsibility to preserve lives, protect property and the environment, and ensure public health in times of natural or technological disasters. Through the implementation of this plan, the resources and capabilities of the public, private, and nonprofit sectors can be more efficiently utilized to minimize the loss of life and property and to protect the environmental and economic health of the County.

- Kittitas County Shoreline Master Program (2016)

  The Shoreline Master Program plan outlines goals for conservation, use, and development of shoreline areas. In Kittitas County, shoreline jurisdiction includes all shorelines of the state, upland areas within 200 feet of the ordinary high water mark of those waters, associated wetlands and river deltas, and floodways and contiguous floodplain areas landward 200 feet from such floodways. These regulations have particular implications for the flooding section of the Hazard Identification and Risk Analysis section of this plan.

- Kittitas County Wildfire Protection Plan (2018)

  The Wildfire Protection Plan identifies wildfire response capability, educates homeowners to reduce the ignitability of structures, and evaluates critical infrastructure throughout the county. This plan identifies prioritized areas for hazardous fuel reduction treatments on Federal, State, and private land, and builds on existing efforts to restore healthy forest conditions within the county. This plan was considered during discussion of the Wildfire section of the Hazard Identification and Risk Assessment for Kittitas County.

- Washington State Enhanced Hazard Mitigation Plan (2018)

  The Washington State Enhanced Hazard Mitigation (SEHMP) Plan profiles hazards, identifies risks and vulnerabilities and proposes strategies and actions to reduce risks to people, property, the economy, the environment, infrastructure and first responders. The Washington SEHMP is a multi-agency statewide document. It incorporates best practices, programs and knowledge from multiple state agencies, tracks progress in achieving mitigation goals through state and local programs and strategies. It also communicates that progress among agency partners and elected leadership. 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. This plan provided guidance for the Kittitas County hazard mitigation planning process.

- Preparing for a Changing Climate (2012)

  Prepared by the Washington State Department of Ecology, this report lays out a framework to protect communities, natural resources, and the economy from the impacts of climate change and build the State’s capacity to adapt to expected climate changes. It describes how existing and new state policies and programs can better prepare Washington to respond to the impacts of climate change, and calls on state agencies to make climate adaptation a standard part of agency planning.

- Washington State Infrastructure Protection Plan (2008)

  The Washington State Infrastructure Protection Plan brings together the voluntary efforts of all levels of government, private sector, and non-governmental organizations. Together they provide the mechanism for identifying critical assets, systems, networks and functions; understanding threats; assessing vulnerabilities and consequences; prioritizing protection initiatives; and enhancing information sharing efforts and applying protective measures within and across sectors.

- Resilient Washington State: A Framework for Minimizing Loss and Improving Statewide Recovery after an Earthquake (2012)

  Written by the Washington State Emergency Management Council's Seismic Safety Committee, this report provides a general assessment of the recovery capacity of the state's major systems and infrastructure, including estimates of the time it is likely to take for each component to recover following a serious earthquake, a target timeframe for each component recovery, and the top 10 recommendations for improving statewide resilience.

- Comprehensive plans for each incorporated planning partner

  An assessment of all planning partners' regulatory, technical and financial capabilities to implement hazard mitigation initiatives is presented in Chapter 18 and in the individual jurisdiction-specific annexes in Volume 2.

5.2.2 Nongovernmental Resources

In addition to extensive governmental resources and the planning partners detailed in Volume 2, Kittitas County has access to many organizations that may provide resources related to hazard mitigation. The following are organizations whose work relates to land conservation, resilience, climate impacts, or natural disasters, and has applicability to hazard mitigation in Kittitas County:

– Washington Wild

  Washington Wild defends, protects and restores wild lands and waters in Washington State through advocacy, education and civic engagement. By educating, empowering and mobilizing communities, Washington Wild builds powerful grassroots networks that has helped protect nearly three million acres of wild lands and waters throughout the state.

– Kittitas Conservation Trust

  Formed in 2002, the mission of the Kittitas Conservation Trust (KCT) is to protect and enhance fish and wildlife habitat, open space, and recreational assets in the upper Yakima River basin. KCT works together with interested landowners and governmental agency partners to identify high-value conservation resources in the basin.

– Kittitas Fire Adapted Communities Coalition

  A group of stakeholders in Kittitas County that meets to discuss goals for community wildfire resiliency and to share, learn, and coordinate efforts toward meeting these goals. Goals include updating the Kittitas County Community Wildfire Protection Plan (CWPP), mapping accomplishments and priority needs to improve wildfire resiliency, modeling fire simulations for high priority neighborhoods as part of the CWPP and GIS projects, and conducting community outreach that results in greater engagement and participation in wildfire risk reduction.

– The Nature Conservancy – Washington

  The Nature Conservancy has helped to preserve more than 800,000 acres in Washington, and is currently stewarding more than 100,000 acres. Included in these areas is the Yakima River Preserve in Kittitas County, which follows the Yakima River as it runs from Ellensburg south to Yakima.

– Washington Coastal Hazards Resilience Network

The Washington Coastal Hazards Resilience Network (CHRN) is a network of hazards and climate change practitioners from federal and state government agencies, Tribes, academic institutions, consulting firms, and nonprofit organizations that are involved in coastal hazards management and/or producing risk and hazard assessments for marine shorelines in Washington State. The CHRN seeks to improve regional coordination, integration, and understanding of coastal hazards and climate change impacts through effective partnerships. In addition, the network aims to address multi-hazard planning, preparedness, adaptation, response, and recovery as critical needs in Washington State.

– Washington State Coast Resilience Assessment Final Report

Published in 2017 by the William D. Ruckelshaus Center at Washington State University, this report summarizes interviews with a variety of stakeholders on the dynamics, interests, challenges, and opportunities related to coastal resilience in Washington State. The assessment provides a mechanism for the experiences and viewpoints of the participants to inform the next generation of strategies for enhancing coast-wide resilience.

– Pacific Northwest Seismic Network

To monitor earthquake and volcanic activity across the Pacific Northwest, the University of Washington and the University of Oregon cooperatively operate the Pacific Northwest Seismic Network (PNSN). The PNSN is sponsored by the U.S. Geological Survey (USGS), the U.S. Department of Energy, the State of Washington, and the State of Oregon. The PNSN is an organization dedicated to reducing impacts of earthquakes and volcanic eruptions in the states of Washington and Oregon by providing accurate and fast information about earthquakes and ground motions to scientists, engineers, planners, and the public.

– USGS Volcano Hazards Program – Cascades Volcano Observatory

The David A. Johnston Cascades Volcano Observatory (CVO) is part of the USGS Volcano Hazards Program and serves the nation's interest by helping people live knowledgeably with volcanoes. The USGS CVO staff conduct research on many aspects of active volcanism, respond to dangerous volcanic activity in many parts of the world, and maintain a close watch over volcanoes in Washington, Oregon and Idaho.

– Northwest Interagency Coordination Center

The Northwest Interagency Coordination Center serves as the northwest area geographic focal point to provide logistical support and intelligence relative to anticipated and ongoing wildfire activity for all federal and cooperating state wildland fire suppression agencies. The Center facilitates movement of resources between agencies' units and, concurrently, ensures fire suppression capabilities to support large fire potential by monitoring weather and prescribed burning activity within the area.

PART 2 - HAZARD IDENTIFICATION AND RISK ASSESSMENT

CHAPTER 6.
IDENTIFIED HAZARDS OF CONCERN AND RISK ASSESSMENT 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.
- Cost evaluation—Estimate the cost of potential damage or cost that can be avoided by mitigation.

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

6.1. 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 failure
- Drought
- Earthquake
- Flood
- Landslide
- Severe weather
- Volcano
- Wildfire

With the exception of dam failure, technological hazards (e.g., hazardous material incidents) and human-caused hazards (e.g., terrorist acts) are not addressed in this plan. At this time, DMA regulations do not require consideration of such hazards and the planning partnership chose not to include them in this plan.

6.2. CLIMATE CHANGE

Climate includes patterns of temperature, precipitation, humidity, wind and seasons. Climate plays a fundamental role in shaping natural ecosystems, and the human economies and cultures that depend on them. “Climate change” refers to changes over a long period of time. Climate change will have a measurable impact on the occurrence and severity of natural hazards around the world. Impacts include the following:

- Snow cover losses will continue, and declining snowpack will affect snow-dependent water supplies and stream flow levels around the world.
- The risk of drought and the frequency, intensity, and duration of heat waves are expected to increase.
- More extreme precipitation is likely, increasing the risk of flooding.
- The world’s average temperature is expected to increase.

Climate change will affect communities in a variety of ways. Impacts could include an increased risk for extreme events such as drought, storms, flooding, and forest fires; more heat-related stress; and the spread of existing or new vector-born disease into a community. In many cases, communities are already facing these problems to some degree. Climate change changes the frequency, intensity, extent, and/or magnitude of the problems.

According to the Dalton et. al. report “Climate Change in the Northwest,” temperature and precipitation extremes in the Northwest will increase. In the period averaged over 2041 to 2070 there will be more days above maximum temperature thresholds and fewer days below minimum temperature thresholds compared with the 1971–2000 average. For example, the number of days greater than 32 °C (90 °F) increases by 8 days (± 7), and the number of days below freezing decreases by 35 days (± 6). The number of days with greater than 1 in (2.5 cm) of precipitation is projected to increase by 13% (± 7%) and the 20-year and 50-year return period extreme precipitation events are projected to increase 10% (-4 to +22%) and 13% (-5 to +28%), respectively, by mid-century.

According to the US Environmental Protection Agency (EPA), the Northwestern US has experienced warming temperatures and declines in snowpack and streamflow in recent decades. Average annual temperatures have risen by about 1.3 degrees Fahrenheit over the last century, and are expected to increase by 3 to 10 degrees Fahrenheit by the end of this century. Summer precipitation is projected to decline by as much as 30%, with less frequent but heavier downpours. Declines in snowpack will reduce the amount of spring snowmelt that replenishes streams and rivers, which may impact water supply in a season with very little rainfall. Changes in streamflow will have impacts on agriculture, hydropower, municipal and industrial uses, and protection of ecosystems. Due to earlier peak streamflow, summer hydropower generation is projected to decline, but winter hydropower generation may increase. Rising temperatures, combined with changing precipitation patterns, are resulting in reduced soil moisture. This makes forested areas increasingly susceptible to wildfires, insect outbreaks, and disease. An increase in the number and size of wildfires has been observed in recent decades, and is expected to worsen in future years. These changes will have cascading impacts on ecosystems, as well as the timber and bioenergy markets.

This hazard mitigation plan addresses climate change as a secondary impact for each identified hazard of concern. Each chapter addressing one of the hazards of concern includes a section with a qualitative discussion on the probable impacts of climate change for that hazard.

6.3. METHODOLOGY

The risk assessments in Chapter 7 through Chapter 15 describe the risks associated with each identified 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 exposure to each hazard—Exposure was determined by overlaying hazard maps with an inventory of structures, facilities, and systems to determine which of them would be exposed to each hazard.
- Assess the vulnerability of exposed facilities—Vulnerability of exposed structures and infrastructure was determined by interpreting the probability of occurrence of each event and assessing structures, facilities, and systems that are exposed to each hazard. Tools such as GIS and FEMA's hazard-modeling program (Hazus) were used to perform this assessment for the flood, dam failure and earthquake hazards. Outputs similar to those from Hazus were generated for other hazards, using maps generated by the Hazus program.

6.4. RISK ASSESSMENT TOOLS

6.4.1 Earthquake and Flood—Hazus

Overview

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

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

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

The version used for this plan was Hazus 3.2, released by FEMA in October 2016.

Levels of Detail for Evaluation

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

- **Level 1**—All of the information needed to produce an estimate of losses is included in the software's default data. This data is derived from national databases and describes in general terms the characteristic parameters of the planning area.
- **Level 2**—More accurate estimates of losses require more detailed information about the planning area. To produce Level 2 estimates of losses, detailed information is required about local geology, hydrology, hydraulics and building inventory, as well as data about utilities and critical facilities. This information is needed in a GIS format.
- **Level 3—**This level of analysis generates the most accurate estimate of losses. It requires detailed engineering and geotechnical information to customize it for the planning area.

Application for This Plan

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

- **Flood**—A Level 2 User Defined Facility (Flood) analysis was performed. GIS building and assessor data (replacement cost values and detailed structure information) were loaded into Hazus. An updated inventory was used in place of the Hazus defaults for essential facilities. Preliminary Kittitas County Flood Insurance Rate Maps (FIRMs) were used to delineate flood hazard areas and estimate potential losses from the 0.2-, 1-, 2-, 4-, and 10-percent annual change flood events (where flood depth grids were available). Where available, flood depth grids were integrated into the model and vulnerability numbers were generated in Hazus. Where flood depth grids were unavailable, an exposure analysis was performed to identify structures exposed to flood risk.
- **Earthquake**—A Level 2 Advanced Engineering Building Module (AEBM) analysis was performed to assess earthquake risk and exposure. Earthquake shake maps and probabilistic data prepared by Kittitas County and the U.S. Geological Survey (USGS) were used for the analysis of this hazard. An updated general building stock inventory was developed using replacement cost values and detailed structure information from assessor tables. An updated inventory of essential facilities was used in place of the Hazus defaults. Five scenario events were modeled:
  - Magnitude-6.8 event on the Cle Elum Fault
  - Magnitude-7.1 event on the Horse Heavens Fault
  - Magnitude-7.1 on the Mill Creek Fault
  - Magnitude-7.4 on the Rattlesnake Wallula Fault
  - Magnitude-7.4 event on the Saddle Mountain Fault

6.4.2 Dam Failure, Landslide, Severe Weather, Volcano and Wildfire

For some of the hazards evaluated in this risk assessment, historical data was not adequate to model future losses. However, exposure analysis can be performed if geographic information is available on the locations of the hazards and building inventories. An exposure assessment was performed by intersecting structures with geographic hazard data to identify structures exposed to dam failure, landslide, severe weather, volcano, and wildfire.

Local information 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. The primary data source was the Kittitas County GIS database, augmented with state and federal data sets. Additional data sources for specific hazards were as follows:

- **Dam Failure**—Dam failure inundation data was provided by Kittitas County.
- **Landslide—** Kittitas County provided Washington Department of Natural Resources landslide compilation data.
- **Severe Weather—**Severe weather data was downloaded from the Natural Resources Conservation Service and the National Centers for Environmental Information (NCEI).
- **Volcano—**Volcanic hazard data was obtained from the USGS Cascade Volcano Observatory.
- **Wildfire**—Wildfire data was provided by Kittitas County.

6.4.3 Drought and Avalanche

The risk assessment methodologies used for this plan focus on damage to structures. Because drought does not impact structures, the risk assessment for drought was more limited and qualitative than the assessment for the other hazards of concern. Similarly, the avalanche hazard was found to be minimal in developed areas, so the risk assessment for that hazard also was limited and qualitative.

6.4.4 Limitations

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

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

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

CHAPTER 7.
AVALANCHE

7.1. GENERAL BACKGROUND

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

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

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

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

DEFINITIONS

Avalanche—Any mass of loosened snow or ice and/or earth that suddenly and rapidly breaks loose from a snowfield and slides down a mountain slope, often growing and accumulating additional material as it descends.

Slab avalanches—The most dangerous type of avalanche, occurring when a layer of coherent snow ruptures over a large area of a mountainside as a single mass. Like other avalanches, slab avalanches can be triggered by the wind, by vibration, or even by a loud noise, and will pull in surrounding rock, debris and even trees.

Climax avalanches—An avalanche involving multiple layers of snow, usually with the ground as a bed surface.

Loose snow avalanches—An avalanche that occurs when loose, dry snow on a slope becomes unstable and slides. Loose snow avalanches start from a point and gather more snow as they descend, fanning out to fill the topography.

Powder snow avalanches—An avalanche that occurs when sliding snow has been pulverized into powder, either by rapid motion of low-density snow or by vigorous movement over rugged terrain.

Surface avalanches—An avalanche that occurs only in the uppermost snow layers.

Wet snow avalanche—An avalanche in wet snow, also referred to as a wet loose avalanche or a wet slab avalanche. Often the basal shear zone is a water-saturated layer that overlies an ice zone.

7.2. HAZARD PROFILE

7.2.1 Past Events

Avalanches occur frequently each year and kill one to two people annually in the Northwest (about 25 to 35 deaths annually in the U.S.). Avalanches have killed more people in Washington than any other hazard during the past century. In 90 percent of avalanche fatalities, the weight of the victim or someone in the victim's party triggers the slide. Avalanches have killed over 200 people in Washington since 1900, and 72 between 1986 and August 2017, according to the Northwest Avalanche Center. This exceeds the death toll of earthquakes and floods combined. The deadliest avalanche in U.S. history occurred in King County, WA in 1910, with 96 fatalities resulting from the Wellington Avalanche. Records of avalanches within or directly adjacent to Kittitas County are shown in Table 7-1.

Table 7-1. Kittitas County Avalanche History

Date	Location	Description
1996/97	Snoqualmie Pass	Hundreds of travelers stranded after repeated avalanches closed Interstate 90 during the holidays.
1/24/2002	Source Lake, Snoqualmie Pass	2 overnight campers caught while in tent, both self-rescued without major injuries
1/27/2002	Gold Creek, Snoqualmie Pass	1 snowshoer caught, buried and rescued by own dog
3/10/2002	Granite Mt., Snoqualmie Pass	2 skiers out; 1 caught and buried; rescued
3/292003	Granite Mt. Snoqualmie Pass	1 skier caught, partly buried, seriously injured
12/13/2003	Snoqualmie Pass	One snowshoer caught, buried and killed. Victim found 12/20/03
1/12/2005	Alpental Ski Area, Snoqualmie Pass—Central WA Cascades	Two skiers caught and buried/partially buried; one killed and one self-rescued
12/2/2007	Source Lake, Snoqualmie Pass	Three hikers caught, 1 partly buried, injured & self-rescued, 2 completely buried and killed.
4/9/2010	Kendall Peak near Snoqualmie Pass—Central WA Cascades	Two skiers caught and partially buried, 1 slightly injured, 1 critically injured
2/1/2011	Red Mt, Central WA Cascades just north of Snoqualmie Pass	Solo skier triggered cornice collapse and was caught, buried and killed by subsequent fall and loose avalanche
4/6/2011	Phantom path on Mt Snoqualmie, Central WA Cascades just north of Snoqualmie Pass	Party of five triggered 1.5- to 2-foot slab; slab caught and injured two seriously, one with minor injuries
1/21/2012	Alpental, Snoqualmie Pass WA	Three skiers caught and partially buried, all victims able to self-extricate with no injuries
2/19/2012	Alpental, Snoqualmie Pass WA	Two snowboarders caught, 1 fatality
1/15/2013	Chair Peak, Snoqualmie Pass, WA	Two climbers caught, one injured
4/13/2013	Red Mt, near Snoqualmie Pass, WA	Multiple snowshoers caught, 1 fatality
4/13/2013	Granite Mt, Snoqualmie Pass, WA	Three climbers caught, 1 fatality
1/4/2014	Chair Peak, Snoqualmie Pass, WA	Climber triggered and caught in avalanche, partial burial but able to self-rescue
2/22/2014	Chair Peak, Snoqualmie Pass, WA	Three skiers caught by a deep slab and partially buried, but able to self-rescue with no injuries
3/22/2014	Granite Mt, Snoqualmie Pass, WA	Two skiers in party, one skier triggered and caught in avalanche, one fatality
4/27/2014	Slot Couloir, Snoqualmie Mt, near Snoqualmie Pass, WA	Two skiers in party, one skier triggered and caught in avalanche, seriously injured
12/17/2015	Alpental Valley, Snoqualmie Pass area, WA	2 skiers caught, 1 fully buried and the other partially buried in two separate human triggered soft slab avalanches. Both were able to self-rescue and ski out.

Date	Location	Description
12/19/2015	Kendall Peak, Commonweatlh Basin, Snoqualmie Pass area, WA	1 probable avalanche fatality. The terrain in which the victim was found, his body position, information from the coroner's report, and documented human and natural avalanches in the immediate and surrounding terrain all support the likelihood of an avalanche fatality.
12/31/2015	Granite Mt, Snoqualmie Pass, WA	1 snowshoer caught by a small windslab avalanche and carried into the trees and died of trauma injuries.
3/4/2017	Hawkins Mt., Central Cascades, WA	Two snowmobilers, one critical injury, one fatality.
3/4/2017	Avalanche Mountain, Snoqualmie Pass area, WA	Three skiers caught, one injured.
4/11/2017	Red Mt, near Snoqualmie Pass, WA	One solo skier caught and killed.
2/18/2018	Alpental, Snoqualmie Pass area, WA	One snowboarder caught, carried and partially buried at the surface, minor injuries.
2/25/2018	Cottonwood Lake, Snoqualmie Pass area, WA	One snowmobiler was caught, carried and killed by a slab avalanche that released above Cottonwood Lake. The other 4 members in the party of 5 suffered minor injuries and were partially buried.
2/25/2018	Source Lake-Snow Lake Divide, Alpental Valley, Snoqualmie Pass area, WA	Two teenagers were killed by a slab avalanche that released on a south aspect in the Alpental Valley.
3/3/2018	South of Longs Pass, North Fork Teanaway, WA	Four snowmobilers were caught and carried with two riders killed in the avalanche.

7.2.2 Location

The Cascade Range in the western half of Kittitas County receives extensive precipitation due to its size and orientation to the flow of Pacific marine air. In the local maritime climate, it is common for air temperatures to rise above freezing and for precipitation to change from snow to rain during mid-winter storm cycles. Temperatures can change several degrees within minutes, causing abrupt changes in precipitation type. These conditions frequently cause the release of avalanches. Figure 7-1 shows avalanche hazard areas in Washington State, including the westernmost portion of Kittitas County. The majority of this area is included in Unincorporated Kittitas County. The jurisdictions of Roslyn, Cle Elum, and South Cle Elum are located on the edge of this hazard area. Due to their location on the periphery and mitigation efforts, these jurisdictions have very low levels of risk from avalanche.

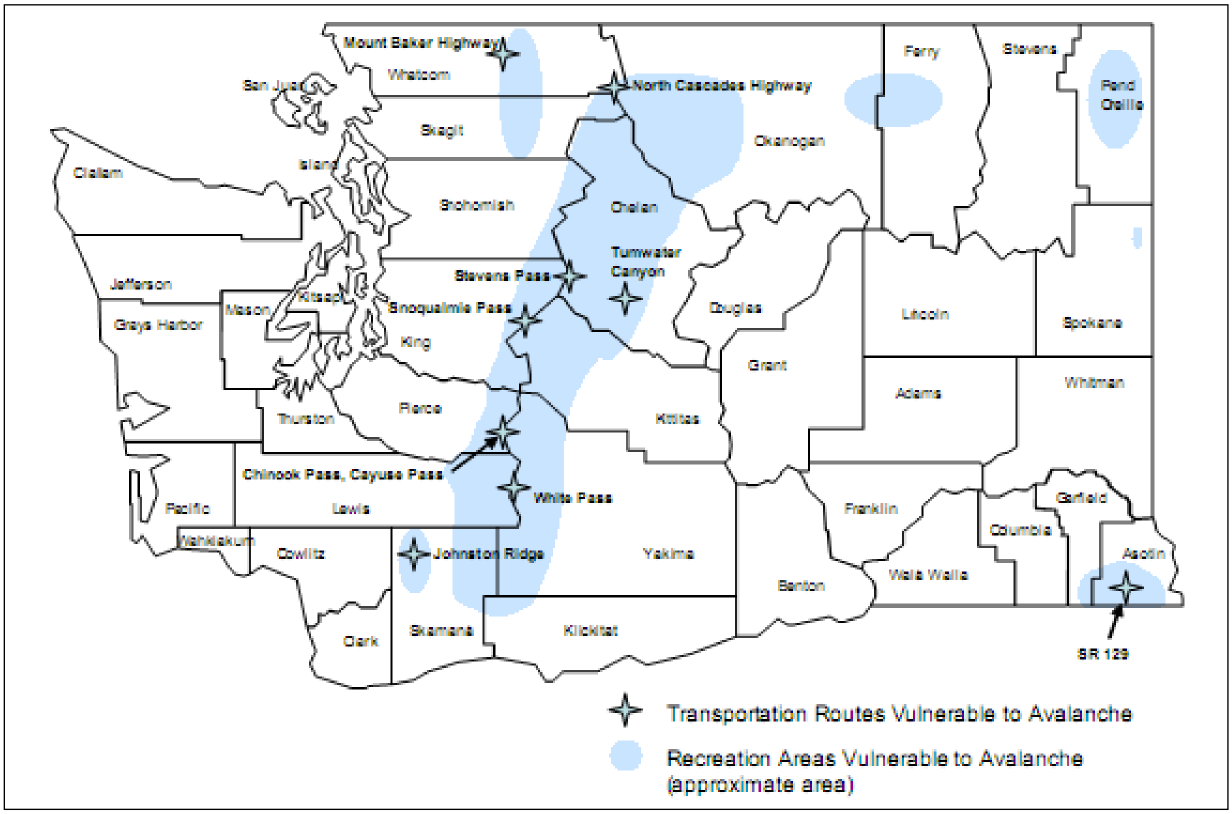


Figure 7-1. Areas Vulnerable to Avalanche

7.2.3 Frequency

Avalanches occur regularly every year in mountain areas. Many weather and terrain factors determine avalanche danger. At lower elevations of the Cascades, the avalanche season begins in November and continues until the last remnants of snow have melted in early summer. In the high alpine regions, the hazard continues year-round. Hundreds of thousands of avalanches are thought to occur each year in the Cascades. While the probability of avalanches occurring each year is very high (100%), there is a very low impact on the planning area due to the remote locations of events and mitigation efforts along developed areas. Avalanches along two key mountain highway passes are limited due to ongoing mitigation to control slides during winter months.

7.2.4 Severity

A number of weather and terrain factors determine avalanche severity and danger:

- Weather:
  - 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.
  - Wind is the most common cause of avalanches. Wind can deposit snow 10 times faster than snow falling from storms. Wind erodes snow from the upwind side of obstacles and deposits snow on the downwind (lee) side. This is called "wind loading".
- Terrain:
  - Ground cover – Large rocks, trees and heavy shrubs help anchor snow, but also create stress concentrations between anchored and unanchored snow.
  - Slope profile – Dangerous slab avalanches are more likely to occur on convex slopes that produce stress concentrations within surface snow due to varying creep rates.
  - Slope aspect – Leeward slopes are dangerous because windblown snow adds depth and creates dense slabs. South facing slopes are more dangerous in the springtime due to increasing solar effects.
  - Slope steepness—Snow avalanches are most common on slopes of 30 to 45 degrees.
- Snowpack:
  - Snow texture—the feel, appearance, or consistency of the snow determined by the shape, size and attachment of snow grains that comprise the particular snow layer. A layer of small grained moist snow has a distinctly different texture—much more cohesive and able to make snowballs—than well faceted snow that falls apart in one's hands and exhibits very little internal cohesion.
  - Snow layering – The snowpack is composed of ground-parallel layers that accumulate over the winter. Each layer contains ice grains that are representative of the distinct meteorological conditions during which the snow formed and was deposited. Once deposited, a snow layer continues to evolve under the influence of the meteorological conditions that prevail after deposition.
  - Snow bonding—in the absence of strong temperature gradients within a dry snowpack, this is the normally stabilizing or "rounding" process whereby individual snow grains or layers come into contact and gradually strengthen the ice skeleton or snow layer(s) through sintering or the formation of ice "necks" between the grains. The associated redistribution of water vapor results in inter-granular attachments or bonds between grains through an expanding ice matrix, and typically results in gradual strengthening of the surrounding snowpack structure. In observations and tests, the hardness of a faceting snow layer decreases with time and it becomes easier to penetrate and pull individual faceted grains out of a snow pit wall.

The common factors contributing to the avalanche hazard are old snow depth, old snow surface, new snow depth, new snow type, density, snowfall intensity, precipitation intensity, settlement, wind direction and speed, temperature, and subsurface snow crystal structure.

7.2.5 Warning Time

The time of an avalanche release depends on the condition of the snow pack; which can change rapidly during a day and particularly during rainfall. Research done at Snoqualmie Pass showed that most natural avalanches occurred less than 1 hour after the onset of rain; in these cases the snow pack was initially weak (Washington Emergency Management Division, 1996). In cases where the snow pack was stronger, avalanche activity was delayed or did not occur. Nonetheless an avalanche can occur with little or no warning time, which makes them particularly deadly.

During the avalanche season, the Northwest Avalanche Center issues twice daily mountain weather forecasts and daily avalanche forecasts as well as special statements and avalanche warnings during times of significantly increased avalanche danger. Additionally, the NWAC maintains and manages a comprehensive network of 25 remote mountain weather stations that provide hourly weather data to users and cooperators alike.

7.3. SECONDARY HAZARDS

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

7.4. CLIMATE CHANGE IMPACTS

Snow avalanches are mainly ruled by temperature fluctuations, heavy precipitation and wind regimes. With rising temperatures and higher intensity storm events, climate change is likely to increase the frequency and magnitude of both ordinary and extreme avalanche events. Melting of the permafrost layer has an additional impact on the increase in avalanches. However, these possible changes are not taken into account in current engineering practice: reference scenarios and return periods for avalanche hazard management are always computed under the assumption of a stationary process. Unlike other phenomena such as tropical storms, snow avalanches are rarely used as indicators of climate change.

7.5. EXPOSURE

There is minimal development in the high Cascade Range, which makes Kittitas County’s exposure to an avalanche small. Most mountainous areas in the county are part of the Mount Baker-Snoqualmie National Forest and other protected forests.

7.5.1 Population

There are no major populations exposed to avalanches in the county. Most of the avalanche hazard area is uninhabited or has minimal development. Ski resorts are not considered to be exposed to avalanches due to their ski slope maintenance protocols; however, skiers who ski out of bounds in these areas are exposed to avalanches. People working in the mountains, such as miners and loggers, are exposed, as are recreational users, such as hikers and cross-country skiers.

7.5.2 Property

There is little property that is exposed to avalanches. Property and buildings exposed include National Forest huts and temporary structures belonging to mining and forestry operations.

7.5.3 Critical Facilities and Infrastructure

Interstate 90 could be blocked by avalanches, but the Washington State Department of Transportation (WSDOT) conducts active winter avalanche control or mitigation on Interstate 90. This means avalanches are triggered intentionally on slopes above the roadways in a controlled environment to minimize traffic disruption and promote public safety. WSDOT also conducts passive avalanche control by building elevated roadways so avalanches can pass under highways, snow sheds so that avalanching snow flows over highways, catchment basins to stop avalanche flow, and diversion dams and berms to keep snow off highways.

Avalanche control is important along Snoqualmie Pass. I-90 is a heavily traveled corridors that connects major Puget Sound communities to Eastern Washington through the Cascade Mountains. Snoqualmie Pass is the state's only Interstate highway link through the Cascades. It averages nearly 450 inches of snow each winter and has a daily traffic volume of 32,000 vehicles (including 8,000 trucks). A two-hour closure of the pass costs the state's economy more than $1 million. WSDOT also identifies Blewett Pass on US 97 as being at risk to avalanche.

7.5.4 Environment

Avalanches are a natural event, but they can negatively affect the environment. This includes trees located on steep slopes. A large avalanche can knock down many trees and kill the wildlife that lives in them. In spring, this loss of vegetation on the mountains may weaken the soil, causing landslides and mudflows.

7.6. VULNERABILITY

In general, everything that is exposed to an avalanche event is vulnerable. More and more people are working and building in or using the high mountain areas of the Cascades in potential avalanche areas. These individuals often have little experience with, caution regarding, or preparation for, avalanche conditions. The increasing development of recreational sites in the mountains brings added exposure to the people using these sites and the access routes to them. The risk to human life is especially great at times of the year when rapid warming follows heavy, wet snowfall.

7.7. FUTURE TRENDS IN DEVELOPMENT

Future trends in development cannot be determined until the avalanche hazard areas are accurately mapped. From review of the buildable lands analysis, which projects the location and density of development based on current land use regulations, there is no significant housing or employment capacity that has the potential to be developed in these areas.

7.8. SCENARIO

In a worst-case scenario, an avalanche would occur in the Cascade Mountains after a series of storms. Storms starting with low temperatures and dry snow, followed by rising temperatures and wetter snow, are most likely to cause avalanches. Avalanches occurring in the Snoqualmie Pass vicinity, causing prolonged closure of Interstate 90, would have significant economic impact not only on Kittitas county, but also on all counties along the I-90 corridor.

7.9. ISSUES

The only issue of concern in the event of an avalanche is the threat to recreational users and property. The U.S. Forest Service, National Park Service, National Weather Service and Washington Department of Transportation currently have programs to monitor avalanche zones and forecast avalanche danger. However, there is no effective way to keep the public out of avalanche-prone areas, even during times of highest risk. A coordinated effort is needed among state, county and local law enforcement, fire, emergency management, public works agencies and media to provide winter snow pack and avalanche risk information to the public.

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. Figure 7-2 shows key elements of the danger scale.

This information, updated daily, is available during avalanche season from the joint NOAA/U.S. Forest Service Northwest Weather and Avalanche Center and can be obtained from Internet, NOAA weather wire, and Department of Transportation sources. Avalanche danger scale information should be explained to the public and made available through appropriate county and local agencies and the media.

Measures that have been used in other jurisdictions to reduce avalanche threat include monitoring timber harvest practices in slide-prone areas to ensure that snow cover is stabilized as well as possible, and encouraging reforestation in areas near highways, buildings, power lines and other improvements. The development of a standard avalanche report form, and the maintenance of a database of potential avalanche hazards likely to affect proposed developments in mountain wilderness areas, would be of significant value to permitting agencies.

Avalanche Safety Basics

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

UNITED STATES AVALANCHE DANGER DESCRIPTORS

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

Figure 7-2. United States Avalanche Danger Scale

CHAPTER 8.
DAM FAILURE

8.1. GENERAL BACKGROUND

8.1.1 Causes of Dam Failure

Dam failures in the United States typically occur in one of four ways (see Figure 8-1):

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

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

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

DEFINITIONS

Dam—Any artificial barrier and/or any controlling works, together with appurtenant works, that can or does impound or divert water. (Washington Administrative Code, Title 173, Chapter 175.)

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)

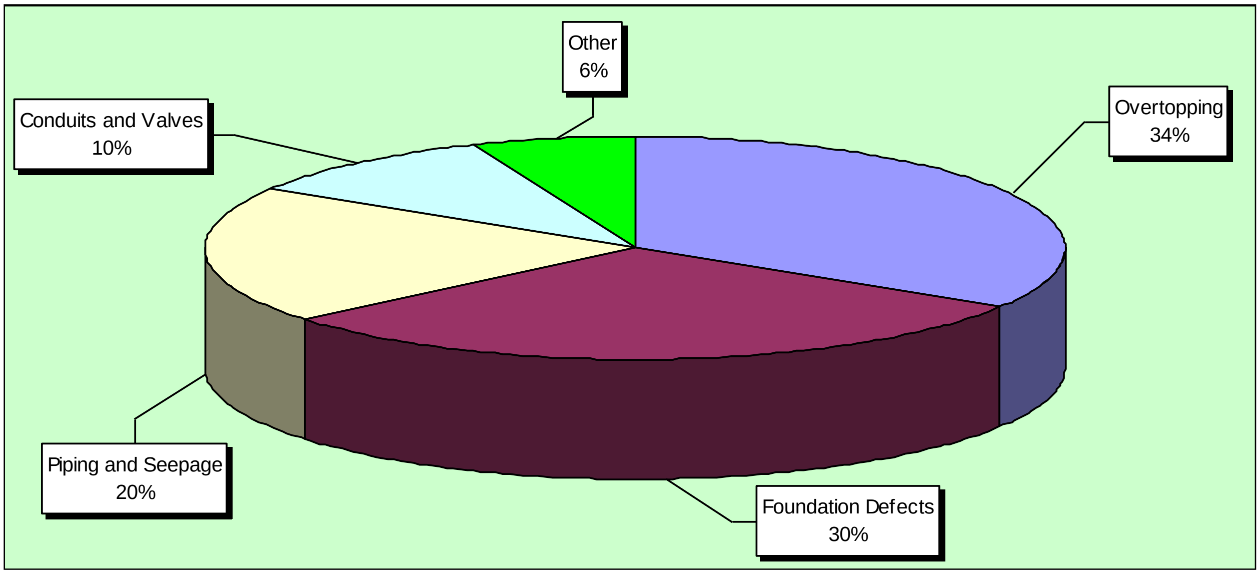


Figure 8-1. Historical Causes of Dam Failure

8.1.2 Regulatory Oversight

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

Washington Department of Ecology Dam Safety Program

The Dam Safety Office (DSO) of the Washington Department of Ecology regulates 1,073 dams of the 1,215 total dams in the state that impound at least 10 acre-feet of water. The DSO has developed dam safety guidelines to provide dam owners, operators, and design engineers with information on activities, procedures, and requirements involved in the planning, design, construction, operation and maintenance of dams in Washington. The authority to regulate dams in Washington and to provide for public safety is contained in the following laws:

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

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

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

U.S. Army Corps of Engineers Dam Safety Program

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

Federal Energy Regulatory Commission Dam Safety Program

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

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

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

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

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

8.2. HAZARD PROFILE

8.2.1 Past Events

- According to DSO records, 19 notable dam failure events occurred in Washington between 1918 and 2018. None of these occurred within or impacted Kittitas County and to date, Kittitas County has not had a presidentially declared disaster caused by dam failure.

8.2.2 Location

The DSO oversees 20 dams in Kittitas County, as listed in Table 8-1.. Six are operated by federal agencies, and the remainder are under the jurisdiction of the state. Five of the dams are listed as high hazard, which means there are seven or more lives at risk downstream of the dam. The remainder of the dams are ranked as low risk, with no lives at risk downstream of the dam.

Table 8-1. Dams in Kittitas County

Name	National ID #	Water Course	Owner	Year Built	Dam Type[a]	Crest Length (feet)	Height (feet)	Surface Area (acres)	Drainage area (sq. mi.)	Hazard Class[b]
Brown Boys Effluent Pond	WA01836	Off-Stream-Yakima River	Brown Boy Feed, INC.	2000	RE	800	10	2.0	0.01	3
Childress-Winegar	WA01011	Tr-Morrison Creek	David and Roberta Israel	1964	RE	200	9	5.0	0.00	3
Cle Elum	WA00274	Cle Elum River	U.S. Bureau of Reclamation (BOR)	1933	RE	750	165	4,812	206	1A
Easton Diversion	WA00276	Yakima River	BOR	1929	CN, PG	248	66	275	185	1B
Kachess	WA00260	Kachess River	BOR	1912	RE	1,400	115	4,600	63.60	1A
Keechelus	WA00265	Yakima River	BOR	1917	RE	6,550	128	3,160	54.70	1A
Knudson	WA01015	Tr-Yakima River	WDFW	1966	RE	12	10	7	0.00	3
Lower Sunlight Lake	WA01805	Yakima River	Sunlight Waters Country Club	1967	RE	360	12	2.8	4.39	3
Milk Pond	WA00392	Tr-Milk Creek	Snoqualmie National Forrest	1983	RE	140	18	9.4	2.53	3
Nelson Siding Community Club Dam	WA01996	Unnamed Tr – Yakima River	Nelson Siding Community	1970	RE	1000	7	25	0.00	3
Porky Pig Farm	WA01618	Tr-Yakima River Off-Stream	Larry M. Howard	1970	RE	1340	16	25	0.01	3
Quilomene Creek	WA01030	Quilomene Creek	WDFW Real Estate Division	1964	RE	478	19	7	0.00	3
Reecer Creek Ranch	WA01617	Currier Creek	Van De Graaf	1977	RE	860	6	25	0.00	3
Reimer Pond	WA01083	Tr-Yakima River Off-Stream	James Etux P Roan	1951	RE	1000	19	3.7	0.01	3
Roslyn Wastewater Lagoon	WA01652	Crystal Creek-Off-Stream	City of Roslyn	1973	RE	2000	10	5.3	10	3

Name	National ID #	Water Course	Owner	Year Built	Dam Type[a]	Crest Length (feet)	Height (feet)	Surface Area (acres)	Drainage area (sq. mi.)	Hazard Class[b]
Roza Diversion	WA00275	Yakima River	BOR	1939	CN, PG	486	67	100	1,650	3
Snoqualmie Pass PUD-Sewer Lagoon #1	WA00472	Tr-Lake Keechelus-Off-Stream	Wenatchee National Forrest	1982	RE	1110	23	8.4	0.01	3
Tjossem Pond	WA01228	Wilson Creek-Off-Stream	Morris P. Sorenson	1890	RE	154	12	7.8	0.01	3
Twardoski Dam	WA01991	Unnamed Tr – Yakima River	Brian Twardoski	1980	RE	280	13	3	1.35	3
Upper Sunlight Lake	WA00666	Yakima River	Sunlight Waters Country Club	1967	RE	325	25	5	7.8	1C

a. RE = Earth Fill Dam; CN, PG = Concrete Gravity Dam
b. See Section 8.2.4 for definition of hazard classes

The DSO has prepared dam failure inundation mapping for the Hazard Class 1A and 1B dams. Individual mapping was created for the Class 1A Cle Elum Dam (Figure 8-2) and Class 1B Easton Diversion Dam (Figure 8-3). The DSO prepared a single inundation-area map for failure of the Class 1A Kachess and Keechelus Dams (Figure 8-4). These inundation maps are used in the assessment of exposure and vulnerability for the dam failure hazard.

The inundation areas for the Cle Elum Dam and the Kachees and Keechelus Dams would impact the jurisdictions of Cle Elum, Ellensburg, and South Cle Elum. The Easton Diversion Dam inundation area would also impact Cle Elum and South Cle Elum. All inundation areas impact areas of Unincorporated Kittitas County. The Kachees and Keechelus Dam is estimated to have the largest impact on the planning area. For more information on loss estimates, see Section 8.6.2.

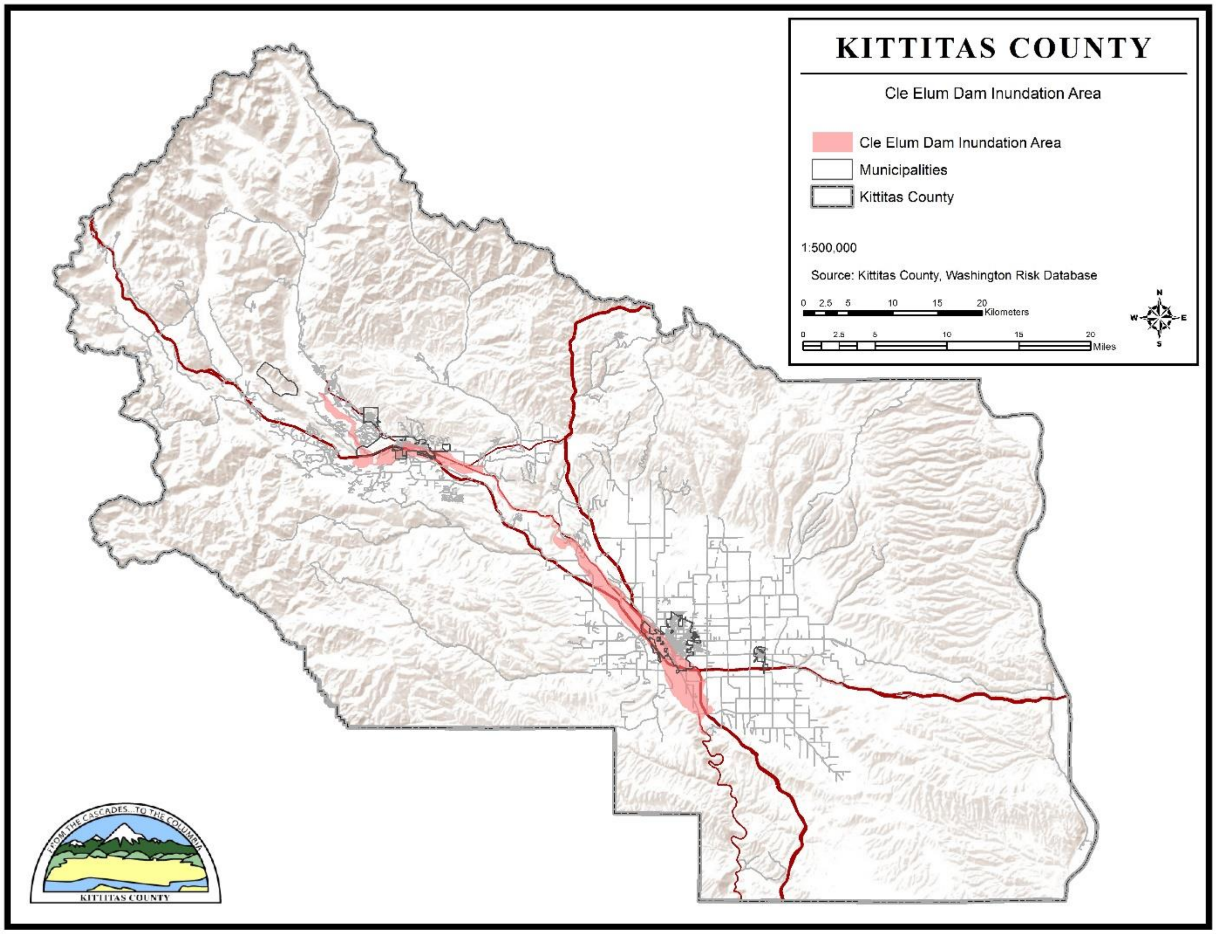


Figure 8-2. Cle Elum Dam Inundation Area

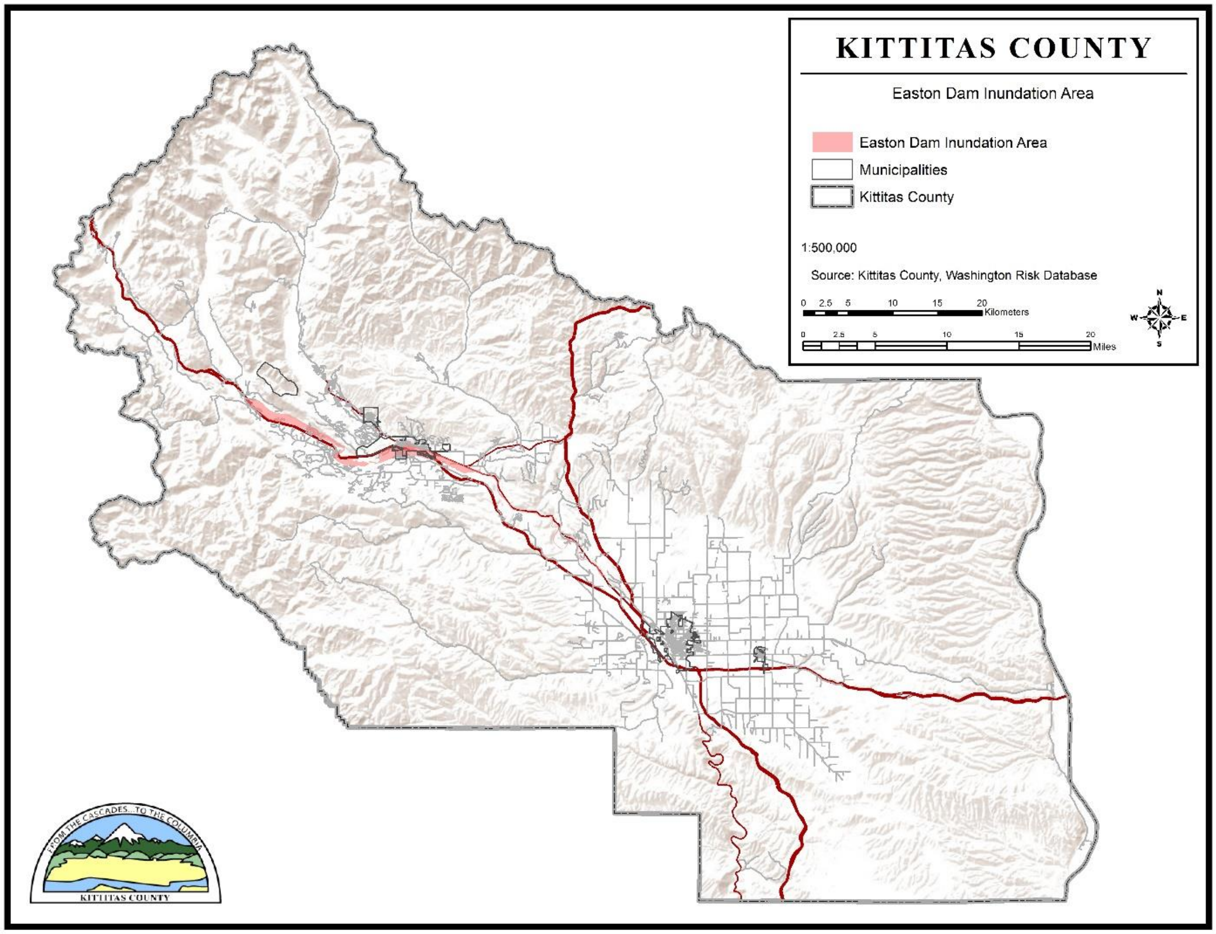


Figure 8-3. Easton Dam Inundation Area

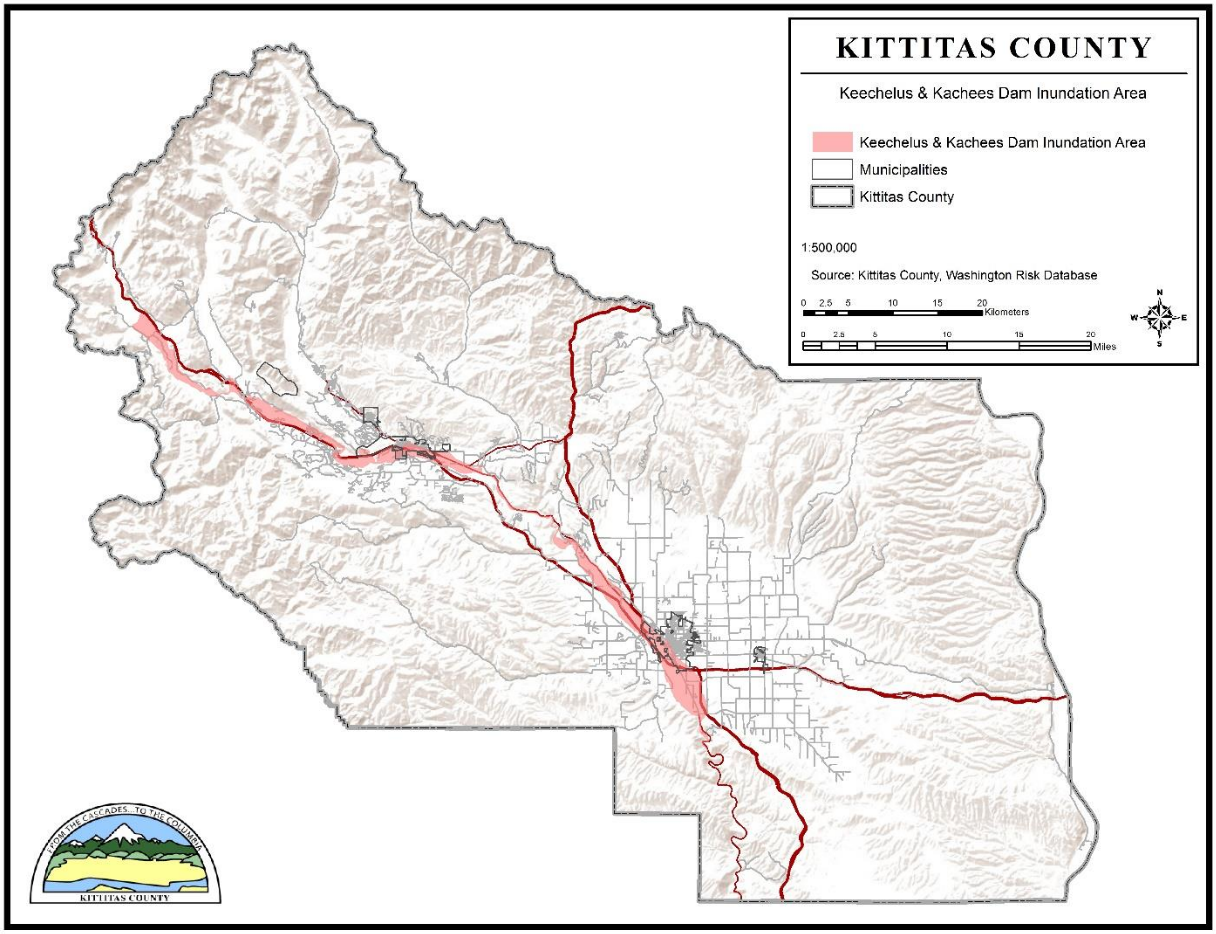


Figure 8-4. Keechelus and Kachess Dam Inundation Area

8.2.3 Frequency

Dam failures are infrequent and usually coincide with events that cause them, such as earthquakes or excessive rainfall. The probability of any type of dam failure is low in today's regulatory environment. There is a "residual risk" associated with dams that remains after safeguards have been implemented. The residual risk is associated with events beyond those that the facility was designed to withstand.

8.2.4 Severity

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

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

The Corps of Engineers developed the hazard classification system for dam failures shown in Table 8-2. The Washington and Corps of Engineers hazard rating systems are both based only on the potential consequences of a dam failure; neither system takes into account the probability of such failures.

8.2.5 Warning Time

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

Kittitas County and its planning partners have established protocols for flood warning and response to imminent dam failure in the flood warning portion of adopted emergency operations plans. These protocols are tied to emergency action plans (EAPs) created by the dam owners. Not all dams have EAPs; only those rated as high hazard are mandated to do so by state and federal regulations.

8.3. SECONDARY HAZARDS

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

Table 8-2. US Army Corps of Engineers Hazard Potential Classification (1995)

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

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

8.4. CLIMATE CHANGE IMPACTS

Potential changes to the hydrographs used to design dams due to the impacts of climate change are a growing concern for the safety of our nation's dams. Dams are designed partly based on assumptions about a river's flow behavior, expressed as hydrographs. As this is based on historical data, dams are not designed to be forward looking. Climate change is expected to create more variable temperatures and precipitation events, and dams are not prepared to handle the expected fluctuations in the water supply.

Changes in weather patterns can have significant effects on the hydrograph used for the design of a dam. If the hygrograph changes, it is conceivable that the dam can lose some or all of its designed margin of safety, also known as freeboard. If freeboard is reduced, dam operators may be forced to release increased volumes earlier in a storm cycle in order to maintain the required margins of safety. Such early releases of increased volumes can increase flood potential downstream. Throughout the west, communities downstream of dams are already experiencing 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.

8.5. EXPOSURE

An exposure analysis for dam failure was performed using dam inundation maps provided by Kittitas County, and building data from the Kittitas County Assessor. Structures and their respective total values (building and contents) are identified as at-risk if they are exposed to at least one of the inundation areas. Structures may be exposed to more than one dam failure inundation area but are not identified as part of this assessment. Data utilized for this assessment included the following datasets:

– Cle Elum Dam Failure Inundation Area;
– Easton Dam Failure Inundation Area;
– Kachees Dam Failure Inundation Area; and
– Keechelus Dam Failure Inundation Area.

8.5.1 Population

All populations in a dam failure inundation zone are exposed to the risk of a dam failure. Using GIS, residential structures that intersect the combined dam inundation area were identified, and an estimate of population was calculated by multiplying the number of residential structures by the Kittitas County average of 2.32 persons per household. Using this approach, the estimated population living in the mapped inundation areas is 4,417, or 12 percent of the county's population. Table 8-3 summarizes the at-risk population in the planning area by city.

Table 8-3. Population At Risk From Dam Failure

Jurisdiction	Affected Population	% of City Population
Cle Elum	1,111	62.2%
Ellensburg	722	7.7%
Kittitas	0	0%
Roslyn	0	0%
South Cle Elum	522	94.5%

Jurisdiction	Affected Population	% of City Population
Unincorporated Kittitas County	2,062	9.6%
Total[a]	**4,417**	**12.4%**

a. Represents the total population in the combined inundation areas all dams.

8.5.2 Property

Property exposure numbers were based on an aggregated value for all mapped dam inundation areas. Based on assessor building data, the exposure analysis estimated that there are 1,904 structures within the mapped dam failure inundation areas in the planning area. The value of exposed buildings in the planning area is summarized in Table 8-4. Structures exposed to dam failure inundation areas compose a considerably large portion of the population in some communities. With 12.4 percent of structures exposed, $327 million of building and content value is at risk, representing 7 percent of the total assessed value of the planning area. Except for 13 locations, nearly all structures within South Cle Elum (97.7 percent) are exposed to a dam failure inundation area which suggests that South Cle Elum may be a primary target for mitigation outreach. The cities of Cle Elum and Ellensburg as well as Kittitas County also have several hundred structures exposed to dam failure inundation areas. Losses for these communities are near $50 million in Cle Elum and Ellensburg with Kittitas County approaching $216 million.

Table 8-4. Value of Property Exposed to Dam Failure

Jurisdiction	Number of Buildings Exposed	Exposed Building Value	% of Total Assessed Value
Cle Elum	479	$56,666,641	62%
Ellensburg	311	$48,097,160	5%
Kittitas	0	0	0%
Roslyn	0	0	0%
South Cle Elum	225	$8,549,880	98%
Unincorporated Kittitas County	889	$215,781,250	6%
Total	**1,904**	**$327,094,900**	**7%**

8.5.3 Critical Facilities

Exposure analysis determined that 15 of the planning area's critical facilities (27 percent) are in the mapped inundation areas, as summarized in Table 8-5.

Table 8-5. Essential Facilities in Dam Failure Inundation Areas

Jurisdiction	Fire Station	Hospital	Emergency Facility	School	Total
Cle Elum	2	0	0	0	**2**
Ellensburg	1	0	2	0	**3**
Kittitas	0	0	0	0	**0**
Roslyn	0	0	0	0	**0**
South Cle Elum	1	0	0	0	**1**
Unincorporated Kittitas County	5	0	0	4	**9**
Total	**9**	**0**	**2**	**4**	**15**

8.5.4 Environment

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

The environment would be exposed to a number of risks in the event of dam failure. The inundation could introduce many foreign elements into local waterways. This could result in destruction of downstream habitat and could have detrimental effects on many species of animals, especially endangered species such as salmon.

8.6. VULNERABILITY

8.6.1 Population

Vulnerable populations are all populations downstream from dam failures that are incapable of escaping the area within the allowable time frame. This population includes the elderly and young who may be unable to get themselves out of the inundation area. The vulnerable population also includes those who would not have adequate warning from a television or radio emergency warning system. The potential for loss of life is also affected by the capacity and number of evacuation routes available to populations living in areas of potential inundation.

8.6.2 Property

Vulnerable properties are those closest to the dam within the inundation area. These properties would experience the largest, most destructive surge of water. Low-lying areas are also vulnerable since they are where the dam waters would collect. Transportation routes are vulnerable to dam inundation and have the potential to be wiped out, creating isolation issues. This includes all roads, railroads and bridges in the path of the dam inundation. Those that are most vulnerable are those that are already in poor condition and would not be able to withstand a large water surge. Utilities such as overhead power, cable, and phone lines could also be vulnerable. Loss of these utilities could create additional isolation issues for the inundation areas.

Vulnerability numbers are provided for each mapped dam inundation area, as summarized in Table 8-6 through Table 8-8:

- The estimated loss from the Cle Elum dam failure scenario is $234 million. This represents five percent of the total assessed value of Cle Elum.
- The estimated loss from the Easton Diversion dam failure scenario is $82 million. This represents two percent of the total assessed value of the planning area.
- The estimated loss from the Keechelus and Kachess dam failure scenario is $276 million. This represents six percent of the total assessed value of the planning area.

Table 8-6. Loss Estimates for Cle Elum Dam Failure

Jurisdiction	Number of Buildings Exposed	Exposed Building Value	% of Total Assessed Value
Cle Elum	474	$54,106,855	61%
Ellensburg	311	$48,097,160	5%
Kittitas	0	$0	0%
Roslyn	0	$0	0%
South Cle Elum	224	$8,549,880	98%

Jurisdiction	Number of Buildings Exposed	Exposed Building Value	% of Total Assessed Value
Unincorporated Kittitas County	449	$123,540,830	4%
Total	**1458**	**$234,294,725**	**5%**

Table 8-7. Loss Estimates for Easton Diversion Dam Failure

Jurisdiction	Number of Buildings Exposed	Exposed Building Value	% of Total Assessed Value
Cle Elum	140	$13,997,545	16%
Ellensburg	0	$0	0%
Kittitas	0	$0	0%
Roslyn	0	$0	0%
South Cle Elum	139	$3,942,105	45%
Unincorporated Kittitas County	324	$63,634,760	2%
Total	**603**	**$81,574,410**	**2%**

Table 8-8. Loss Estimates for Keechelus and Kachess Dam Failure

Jurisdiction	Number of Buildings Exposed	Exposed Building Value	% of Total Assessed Value
Cle Elum	424	$48,629,680	55%
Ellensburg	201	$29,026,470	3%
Kittitas	0	$0	0%
Roslyn	0	$0	0%
South Cle Elum	225	$8,549,880	98%
Unincorporated Kittitas County	812	$190,033,615	6%
Total	**1662**	**$276,239,645**	**6%**

8.6.3 Critical Facilities

On average, critical facilities would receive 5 percent damage to the structure and 20 percent damage to the contents during a dam failure event.

8.6.4 Environment

The environment would be vulnerable to a number of risks in the event of dam failure. The inundation could introduce foreign elements into local waterways, resulting in destruction of downstream habitat and detrimental effects on many species of animals, especially endangered species such as coho salmon. The extent of the vulnerability of the environment is the same as the exposure of the environment.

8.7. FUTURE TRENDS IN DEVELOPMENT

Land use in the planning area will be directed by comprehensive plans adopted under Washington’s GMA. These comprehensive plans, in conjunction with “critical areas” regulations adopted by municipal planning partners, provide the regulatory and planning capability to address the risks associated with dam failures. Dam failure is currently not addressed as a standalone hazard under these programs, but flooding is. Municipal planning partners have established comprehensive policies regarding sound land use in identified flood hazard areas. Most of the areas vulnerable to severe impacts from dam failure intersect the mapped flood hazard areas. Flood-related policies in the comprehensive plans will help reduce the risk associated with the dam failure hazard for all future development in the planning area.

8.8. SCENARIO

An earthquake in the region could lead to liquefaction of soils around a dam. This could occur without warning during any time of the day. A human-caused failure such as a terrorist attack also could trigger a catastrophic failure of a dam that impacts the planning area. While the probability of dam failure is very low, the probability of flooding associated with changes to dam operational parameters in response to climate change is higher. Dam designs and operations are developed based on hydrographs 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 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.

8.9. ISSUES

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

- Federally regulated dams have an adequate level of oversight and sophistication in the development of 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.
- Dam failure could result in loss of homes, businesses, and infrastructure such as transportation corridors and irrigation facilities, thus lowering the overall tax base for the affected area. Businesses could take long periods of time to recover, and the economy could be significantly impacted.

CHAPTER 9.
DROUGHT

DEFINITIONS

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

Hydrological Drought—Deficiencies in surface and subsurface water supplies.

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

9.1. GENERAL BACKGROUND

Drought is a normal phase in the climatic cycle of most geographical regions. According to the National Drought Mitigation Center, drought originates from a deficiency of precipitation over an extended period of time, usually a season or more. This results in a water shortage for some activity, group or environmental sector. Drought is the result of a significant decrease in water supply relative to what is "normal" in a given location. There are four generally accepted "operational" definitions of drought (National Drought Mitigation Center, 2006):

- **Meteorological drought** is an expression of precipitation's departure from normal over some period of time. Meteorological measurements are the first indicators of drought. Definitions are usually region-specific, and based on an understanding of regional climatology. A definition of drought developed in one part of the world may not apply to another, given the wide range of meteorological definitions.
- **Agricultural drought** occurs when there isn't enough soil moisture to meet the needs of a particular crop at a particular time. Agricultural drought happens after meteorological drought but before hydrological drought. Agriculture is usually the first economic sector to be affected by drought.
- **Hydrological drought** refers to deficiencies in surface and subsurface water supplies. It is measured as stream flow and as lake, reservoir, and groundwater levels. There is a time lag between lack of rain and less water in streams, rivers, lakes and reservoirs, so hydrological measurements are not the earliest indicators of drought. After precipitation has been reduced or deficient over an extended period of time, this shortage is reflected in declining surface and subsurface water levels.
- **Socioeconomic drought** occurs when a physical water shortage starts to affect people, individually and collectively. Most socioeconomic definitions of drought associate it with the supply and demand of an economic good.

It should be noted that water supply is controlled not only by precipitation, but also by other factors, including evaporation (which is increased by higher than normal heat and winds), transpiration (the use of water by plants), and human use.

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

– Agricultural—Drought threatens crops that rely on natural precipitation.

- Water supply—Drought threatens supplies of water for irrigated crops and for communities.
- Fire hazard—Drought increases the threat of wildfires from dry conditions in forest and rangelands.

In Washington, where hydroelectric power plants generate nearly three-quarters of the electricity produced, drought also threatens the supply of electricity. When supplies of locally generated hydropower shrink because of drought, utilities seek other sources of electricity, which can drive up prices even as supply is reduced.

Unlike most disasters, droughts normally occur slowly but last a long time. Drought conditions occur every few years in Washington. The droughts of 1977 and 2001, the worst and second worst in state history, provide good examples of how drought can affect the state. On average, the nationwide annual impacts of drought are greater than the impacts of any other natural hazard. They are estimated to be between $6 billion and $8 billion annually in the United States and occur primarily in the agriculture, transportation, recreation and tourism, forestry, and energy sectors. Social and environmental impacts are also significant, although it is difficult to put a precise cost on these impacts.

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

A drought directly or indirectly impacts all people in affected areas. A drought can result in farmers not being able to plant crops or the failure of planted crops. This results in loss of work for farm workers and those in related food processing jobs. Other water- or electricity-dependent industries are commonly forced to shut down all or a portion of their facilities, resulting in further layoffs. A drought can harm recreational companies that use water (e.g., swimming pools, water parks, and river rafting companies) as well as landscape and nursery businesses because people will not invest in new plants if water is not available to sustain them. With much of Washington's energy coming from hydroelectric plants, a drought means less inexpensive electricity coming from dams and probably higher electric bills. All people could pay more for water if utilities increase their rates.

9.2. HAZARD PROFILE

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

9.2.1 Past Events

Droughts recur every few years. Unlike floods and earthquakes, droughts not easily defined as "events." Over the last 30 years there have been at least three defined major droughts affecting the state and Kittitas County: in 1977, 2001 and 2005. According to the 2016 Washington State Enhanced Hazard Mitigation

Plan, Kittitas County has experienced serious or extreme drought conditions 10 to 15 percent of the time from 1895 to 1995, and meets the criteria to be categorized as one of nine counties that are the most at-risk for drought. The total social and economic impacts of these events on the Kittitas County planning area are not known at this time.

9.2.2 Location

The National Oceanic and Atmospheric Administration (NOAA) has developed several indices to measure drought impacts and severity and to map their extent and locations:

- **Palmer Z Index**: measures short-term drought on a monthly scale. *Figure 9-1* shows this index for July 2018.
- **Palmer Drought Severity Index (PDSI)**: attempts to measure the duration and intensity of the long-term drought-inducing circulation patterns. Long-term drought is cumulative, so the intensity of drought during the current month is dependent on the current weather patterns plus the cumulative patterns of previous months. Since weather patterns can change almost literally overnight from a long-term drought pattern to a long-term wet pattern, the PDSI can respond fairly rapidly. Figure 9-2 shows this index for July 2018.
- **Palmer Modified Drought Index**: Operational version of the Palmer Drought Severity Index. Figure 9-3 shows this index for July 2018.
- **Palmer Hydrological Drought Index**: measures hydrological impacts of drought (e.g., reservoir levels, groundwater levels, etc.) which take longer to develop and longer to recover from. This long-term drought index was developed to quantify these hydrological effects, and it responds more slowly to changing conditions than the PDSI. Figure 9-4 shows this index for July 2018.

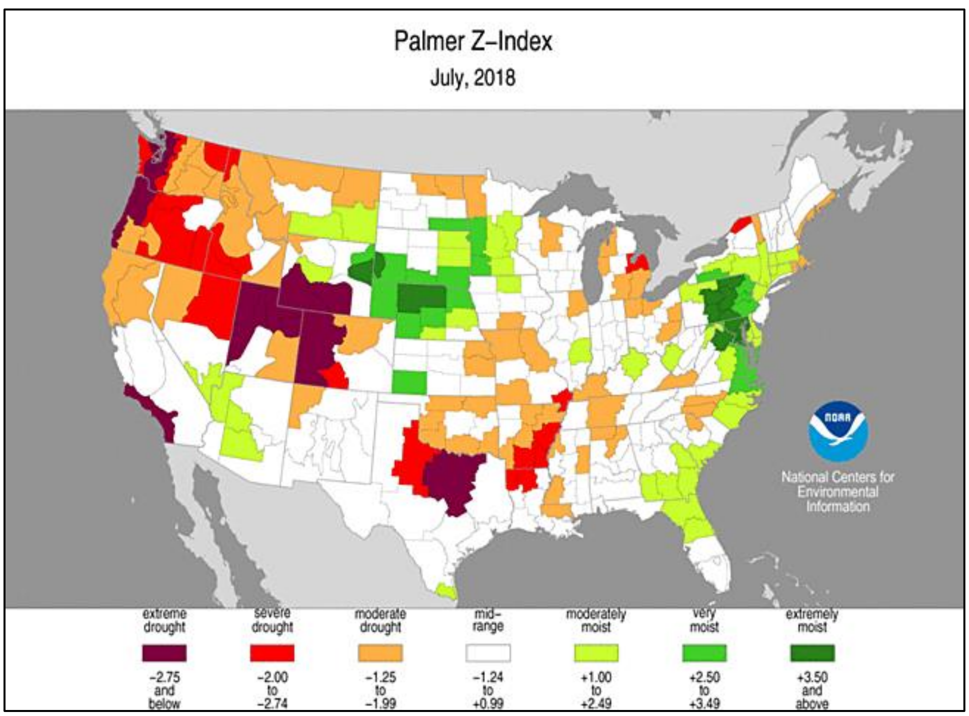


Figure 9-1. Palmer Z-Index for July 2018

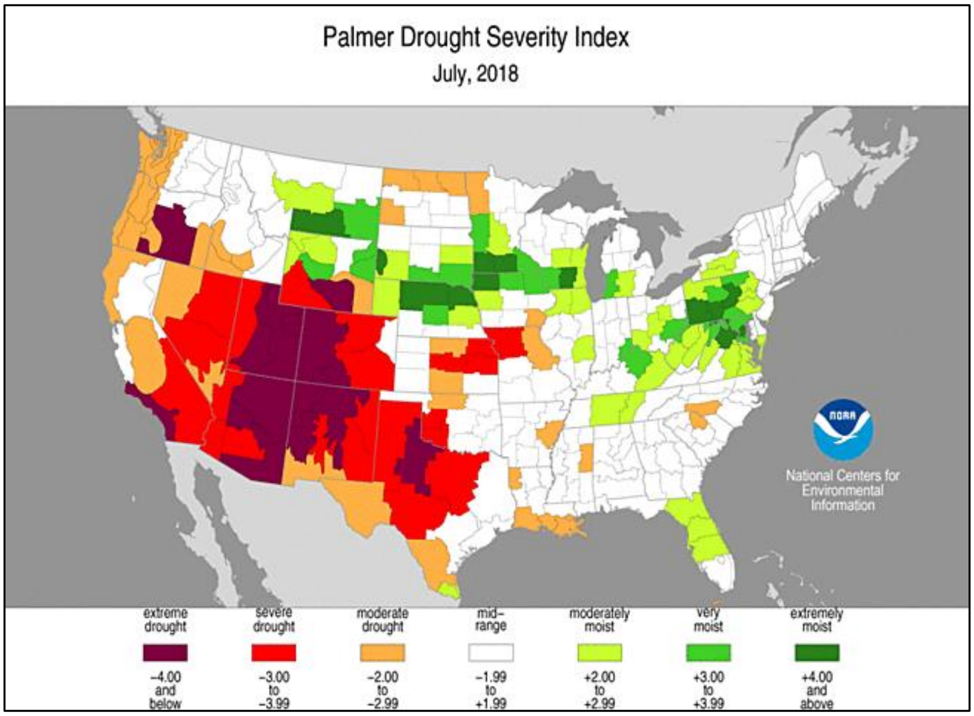


Figure 9-2. Palmer Drought Severity Index for July 2018

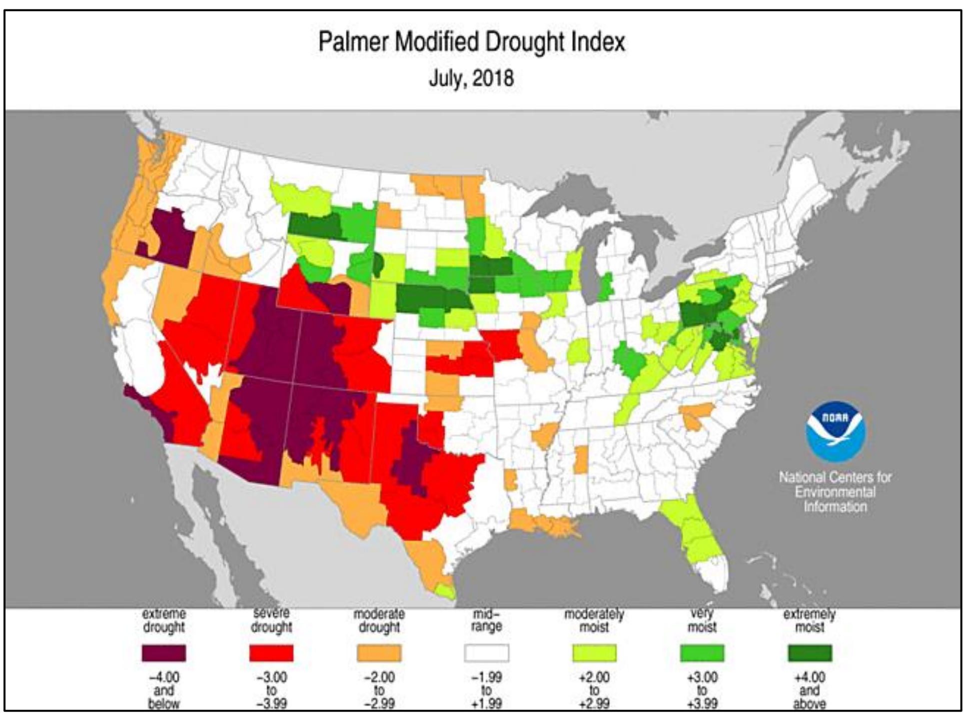


Figure 9-3. Palmer Modified Drought Index for July 2018

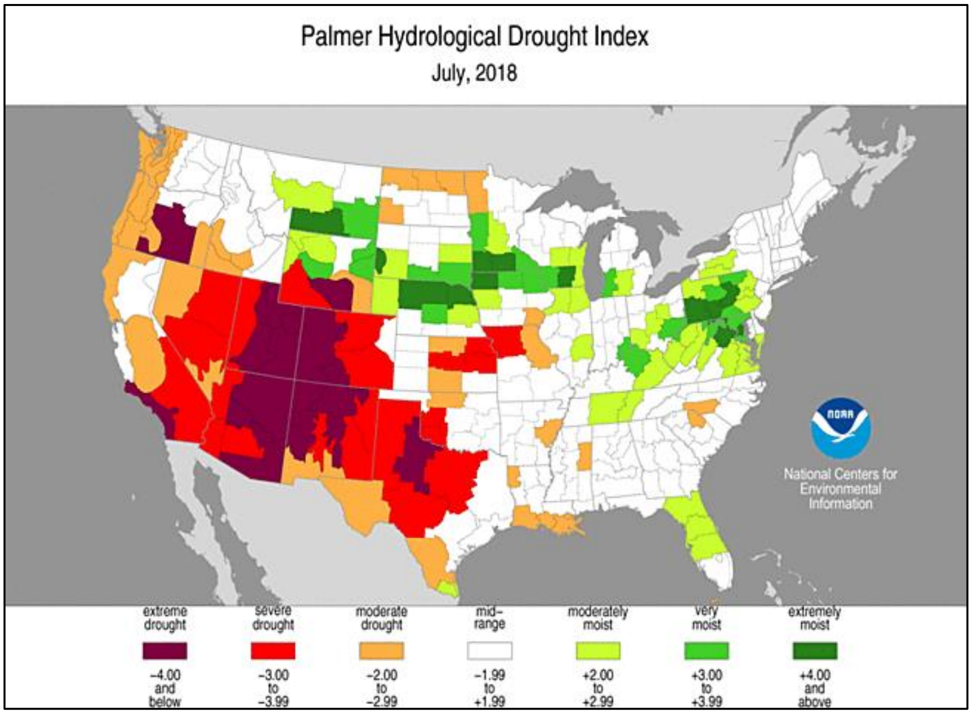


Figure 9-4. Palmer Hydrological Drought Index for July 2018

9.2.3 Frequency

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

Based on Washington’s history with drought from 1895 to 1995, the state as a whole can expect severe or extreme drought at least 5 percent of the time. All of Eastern Washington, except for the Cascade Mountain’s eastern foothills, can expect severe or extreme drought 10 to 15 percent of the time. The east slopes of the Cascades can expect severe or extreme drought from 5 to 10 percent of the time.

The Washington State Hazard Mitigation Plan determined that from 1895 to 1995, Kittitas County experienced serious or extreme drought at least 10 to 15 percent of the time. Thus it can be predicted that Kittitas County may experience the effects of drought at least once every decade. This may be changing, however. For the period from 1985 to 1995, Kittitas County experienced the effects of drought at least 30 percent of the time, and during the 1977 drought, the county experienced its effect 30 to 40 percent of the time. There are no data available regarding of how much effect the 2001 drought had on the county.

9.2.4 Severity

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

9.2.5 Warning Time

Droughts are climatic patterns that occur over long periods of time. Only generalized warning can take place due to the numerous variables that scientists have not pieced together well enough to make accurate and precise predictions.

9.3. SECONDARY HAZARDS

The secondary hazard most commonly associated with drought is wildfire. A prolonged lack of precipitation dries out vegetation, which becomes increasingly susceptible to ignition as the duration of the drought extends.

9.4. CLIMATE CHANGE IMPACTS

Research conducted by the Climate Impacts Group at the University of Washington indicates that the temperature of Eastern Washington is increasing. As temperatures increase there will be less water stored as ice and snow. This reduction may not result in a net change in annual precipitation, but it will result in lower late spring and summer river flows. Accordingly there will be increased competition between power, sport fishing and environmentalists, and farmers dependent on irritation.

Global water resources are already experiencing the following stresses without climate change:

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

With a warmer climate, droughts could become more frequent, more severe, and longer-lasting. From 1987 to 1989, losses from drought in the U.S. totaled $39 billion (OTA, 1993). More frequent extreme events such as droughts could end up being more cause for concern than the long-term change in temperature and precipitation averages.

Dalton et. al. found that reduced water supply combined with increased water demands in the summer could lead to water shortages, reducing the proportion of irrigable cropland and the value of agricultural production. A case study in the Yakima River Basin projects the more frequent occurrence of conditions in which senior water right holders experience shortage. Water shortages could impact the proportion of cropland able to be irrigated during the growing season and lead to substantially reduced value of agricultural production; however, certain producer strategies may mitigate the shortage. Some evidence also suggests that increased atmospheric CO2 concentrations may benefit water use efficiency in plants, possibly mitigating potential effects of drought.

The best advice to water resource managers regarding climate change is to start addressing current stresses on water supplies and build flexibility and robustness into any system. Flexibility helps to ensure a quick response to changing conditions, and robustness helps people prepare for and survive the worst conditions. With this approach to planning, water system managers will be better able to adapt to the impacts of climate change.

9.5. EXPOSURE

All people, property and environments in the Kittitas County planning area would be exposed to some degree to the impacts of moderate to extreme drought conditions.

9.6. VULNERABILITY

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

The Washington State Hazard Mitigation plan defines counties as being vulnerable to drought if they meet at least five of the following criteria:

- History of severe or extreme drought conditions:
  1. The county must have been in serious or extreme drought at least 10-15 percent of the time from 1895 to 1995.
- Demand on water resources based on:
  2. Acreage of irrigated cropland. The acreage of the county's irrigated cropland must be in top 20 in the state.
  3. Percentage of harvested cropland that is irrigated. The percentage of the county's harvested cropland that is irrigated must be in top 20 in the state.
  4. Value of agricultural products. The value of the county's crops must be in the top 20 in the state.
  5. Population growth greater than the state average. The county's population growth from 2000 to 2006 must be greater than state average of 8.17 percent.
- A County's inability to endure the economic conditions of a drought, based on:
  6. The county's median household income being less than 75 percent of the state median income of $51,749 in 2005.
  7. The county being classified as economically distressed in 2005 because its unemployment rate was 20 percent greater than the state average from January 2002 through December 2004.

As summarized in Table 9-1, Kittitas County is among nine counties in the state that meet at least five of the criteria and are considered to be vulnerable to drought.

Table 9-1. Kittitas County Vulnerability to Drought

Criterion	Value for Kittitas County	Meets Drought Vulnerability Criterion?
Percent of Time in Serious or Extreme Drought, 1895 – 1995	10 – 15	Yes
Irrigated Cropland (acres)	91,944	
Statewide Ranking for Irrigated Cropland Area	7	Yes
Percent of Harvested Cropland That Is Irrigated	137.8%	
Statewide Ranking for Irrigated Cropland Percentage	1	Yes
Market Value of Crops	$38,432,000	
Statewide Ranking for Market Value of Crops	18	Yes
Population Growth, 2000 – 2006	12.1%	Yes
Median Household Income	$34,669	Yes
Unemployment Rate 20% Greater Than State Average	No	No

9.6.1 Population

The planning partnership has the ability to minimize any impacts on residents and water consumers in the county should several consecutive dry years occur. No significant life or health impacts are anticipated as a result of drought within the planning area.

9.6.2 Property

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

9.6.3 Critical Facilities

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

9.6.4 Environment

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

9.6.5 Economic Impact

Economic impact will be largely associated with industries that use water or depend on water for their business. For example, landscaping businesses were affected in the droughts of the past as the demand for service significantly declined because landscaping was not watered. Agricultural industries will be impacted if water usage is restricted for irrigation.

9.7. FUTURE TRENDS IN DEVELOPMENT

Each municipal planning partner in this effort has an established comprehensive plan that includes policies directing land use and dealing with issues of water supply and the protection of water resources. These plans provide the capability at the local municipal level to protect future development from the impacts of drought. All planning partners reviewed their general plans under the capability assessments performed for this effort. Deficiencies identified by these reviews can be identified as mitigation actions to increase the capability to deal with future trends in development.

9.8. SCENARIO

An extreme multiyear drought more intense than the 1977 drought could impact the region with little warning. Combinations of low precipitation and unusually high temperatures could occur over several consecutive years. Intensified by such conditions, extreme wildfires could break out throughout Kittitas County, increasing the need for water. Surrounding communities, also in drought conditions, could increase their demand for water supplies relied upon by the planning partnership, causing social and political conflicts. If such conditions persisted for several years, the economy of Kittitas County could experience setbacks, especially in water dependent industries.

9.9. ISSUES

The planning team has identified the following drought-related issues:

- Identification and development of alternative water supplies
- Utilization of groundwater recharge techniques to stabilize the groundwater supply
- The probability of increased drought frequencies and durations due to climate change
- The promotion of active water conservation even during non-drought periods

CHAPTER 10.
EARTHQUAKE

10.1. GENERAL BACKGROUND

10.1.1 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.

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 in Figure 10-1. 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.

DEFINITIONS

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

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

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

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

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

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

Seiche—A standing wave in an enclosed or partly enclosed body of water and normally caused by earthquake activity and can affect harbors, bays, lakes, rivers and canals. These events usually don't occur in proximity to the epicenter of a quake, but possibly hundreds of miles away due to the fact that the shock waves a distance away is of a lower frequency

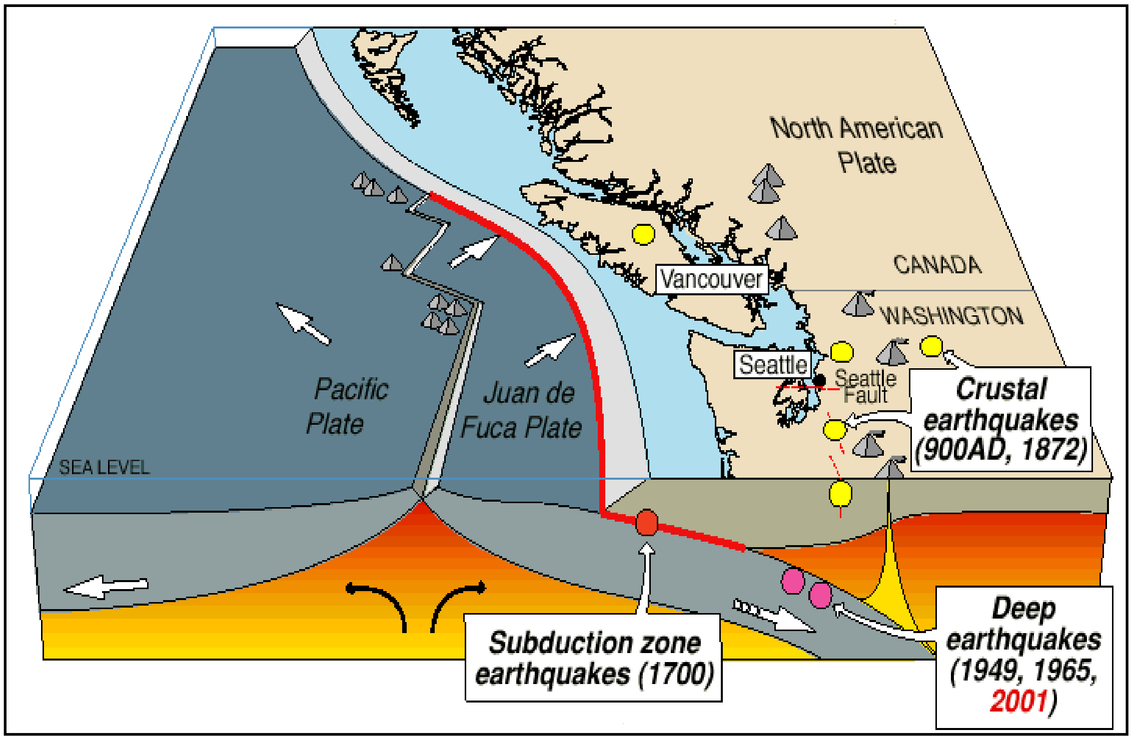


Figure 10-1. Earthquake Types in the Pacific Northwest

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.

10.1.2 Earthquake Classifications

Earthquakes are typically classified in one of two ways: by the amount of energy released, measured as **magnitude**, or by the impact on people and structures, measured as **intensity**.

Magnitude

Currently the most commonly used magnitude scale is the moment magnitude (M_W) scale, with the follow classifications of magnitude:

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

- Micro—$M_W < 3$

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

Intensity

Currently the most commonly used intensity scale is the modified Mercalli intensity scale, with ratings defined as follows (USGS, 1989):

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

10.1.3 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 10-1 lists damage potential and perceived shaking by PGA factors, compared to the Mercalli scale.

Table 10-1. Mercalli Scale and Peak Ground Acceleration Comparison (USGS 2008, 2010)

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

a. PGA measured in percent of g, where g is the acceleration of gravity

10.1.4 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 10-2 summarizes NEHRP soil classifications. NEHRP Soils B and C typically can sustain ground shaking without much effect, dependent on the earthquake magnitude. The areas that are commonly most affected by ground shaking have NEHRP Soils D, E and F. In general, these areas are also most susceptible to liquefaction.

Table 10-2. National Earthquake Hazard Reduction Program (NEHRP) Soil Classification System

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

10.2. 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.

10.2.1 Past Events

According to Washington State Department of Natural Resources, over 1,000 earthquakes occur annually in the State. This is an average of approximately 3 per day though most go unfelt and do not cause damage. Larger magnitude earthquakes, which result in damage, occur less frequently in the state. Table 10-3 lists past seismic events that have impacted the planning area with a magnitude of 3.0 or greater since 1971, according to the Pacific Northwest Seismic Network.

Table 10-3. Historical Earthquakes Impacting Kittitas County

Date	Latitude	Longitude	Depth (km)	Magnitude
08/18/1971	47.6488	-120.1457	13.23	3.20
06/15/1976	47.6247	-120.3268	0.75	3.0
07/13/1977	47.0902	-120.9840	3.26	3.90
06/27/1978	46.8767	-120.9717	12.38	3.60

Date	Latitude	Longitude	Depth (km)	Magnitude
04/07/1979	46.9785	-120.4512	16.89	3.00
02/18/1981	47.1973	-120.8925	3.37	4.20
09/26/1982	46.8673	-121.0477	3.25	3.40
12/05/1983	46.9148	-120.7130	7.76	3.80
04/11/1984	47.5350	-120.1855	8.02	4.30
08/24/1984	47.6495	-120.9548	0.75	3.00
01/05/1985	47.0638	-120.0942	0.34	3.30
01/31/1985	47.0595	-120.0838	0.29	3.30
04/19/1985	46.8972	-120.2837	5.35	3.20
06/17/1985	47.0580	-120.0770	0.28	3.00
10/01/1985	46.7963	-120.0478	1.09	3.0
10/01/1985	46.7887	-120.0473	1.71	3.00
06/11/1987	46.7775	-120.6940	17.23	3.00
07/30/1988	47.6497	-120.0742	0.02	3.20
12/15/1990	46.8022	-119.9925	3.14	3.10
12/22/1990	46.7990	-119.9923	3.31	3.40
02/01/1991	46.8133	-120.5578	6.55	3.40
02/22/1991	46.8708	-120.6518	13.26	3.20
07/06/1991	46.9367	-120.3385	4.08	3.40
07/07/1991	46.9300	-120.3380	3.84	3.30
11/24/1991	47.6042	-120.2410	7.18	3.20
10/26/1992	46.8402	-120.7118	0.04	3.50
06/18/1994	47.6212	-121.2697	0.04	4.30
03/09/1995	47.1907	-1209552	1.61	3.00

Date	Latitude	Longitude	Depth (km)	Magnitude
06/30/1995	47.1065	-120.5275	11.23	3.00
12/17/1995	47.5950	-120.2192	12.42	3.10
01/01/1997	46.7768	120.4545	19.03	3.70
12/25/1999	47.6333	-120.2015	6.91	3.00
07/25/2006	47.638	-120.2070	6.71	3.10
03/29/2010	47.0033	-120.9583	1.3	3.7
02/18/2015	47.2492	-120.7527	3.6	4.0
10/10/2016	46.9172	-120.4357	7.8	3.1
02/26/2017	47.0757	-120.9967	4.0	3.2
04/29/2018	47.2467	-120.7440	-0.9	3.3

10.2.2 Location

Identifying the extent and location of an earthquake is not as simple as it is for other hazards such as flood, landslide or wild fire. 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 that shows the impacts of these components was used to assess the risk of earthquakes within the planning area. While the impacts from each of these components can build upon each other during an earthquake event, the mapping looks at each component individually. The mapping used in this assessment is described below.

Shake Maps

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

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

- A probabilistic seismic hazard map shows the hazard from earthquakes that geologists and seismologists agree could occur. The maps are expressed in terms of probability of exceeding a certain PGA, such as the 10-percent probability of exceedance in 50 years. This level of ground shaking has been used for designing buildings in high seismic areas.
- Earthquake scenario maps describe the expected ground motions and effects of hypothetical large earthquakes for a region. Five scenarios were chosen for this plan:
- Cle Elum Fault Scenario—A Magnitude 6.8 event with a shallow depth and epicenter located 13 miles southwest of Ellensburg (see Figure 10-2)
- Horse Heavens Scenario—A Magnitude 7.1 event with an epicenter southwest of Yakima, WA (see Figure 10-3)
- Mill Creek Scenario—A Magnitude 7.1 event with an epicenter southwest of Kennewick, WA (see Figure 10-4)
- Rattlesnake Wallula Scenario—A Magnitude 7.4 event with an epicenter east of I-82, near Kennewick, WA (see Figure 10-5)
- Saddle Mountain Fault Scenario—A Magnitude 7.3 event with an epicenter 23 miles southeast of Ellensburg (see Figure 10-6)

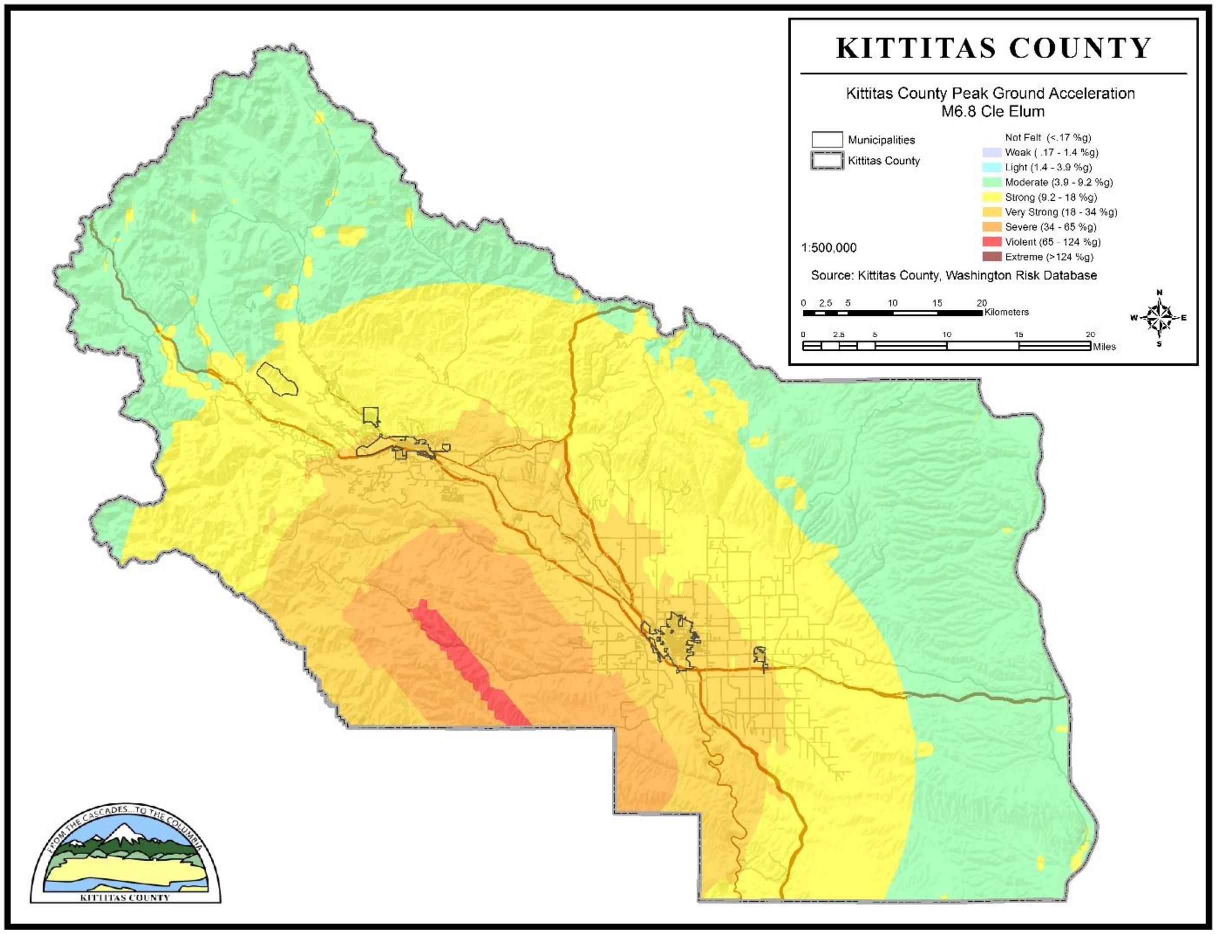


Figure 10-2. Peak Ground Acceleration, Cle Elum Earthquake Scenario

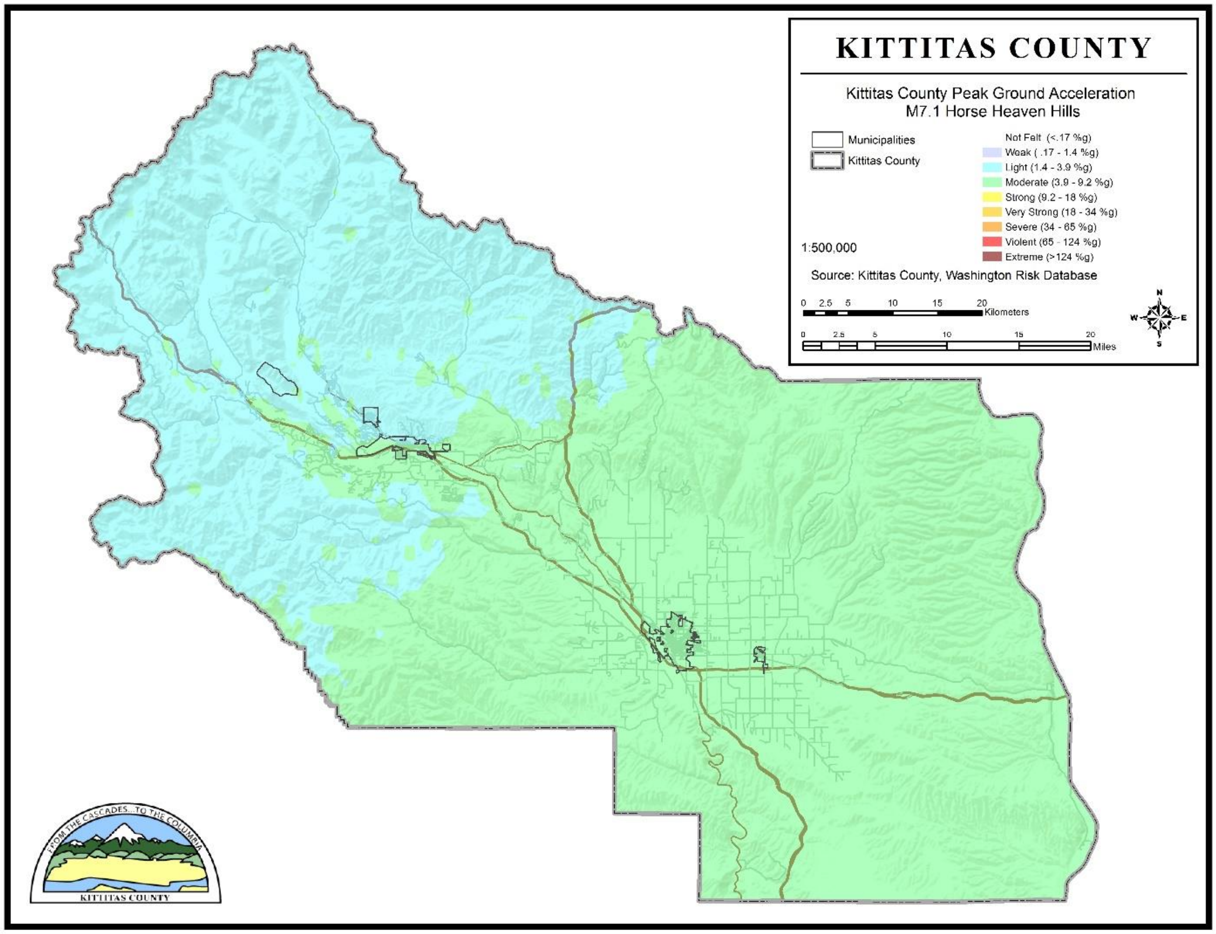


Figure 10-3. Peak Ground Acceleration, Horse Heaven Hills Earthquake Scenario

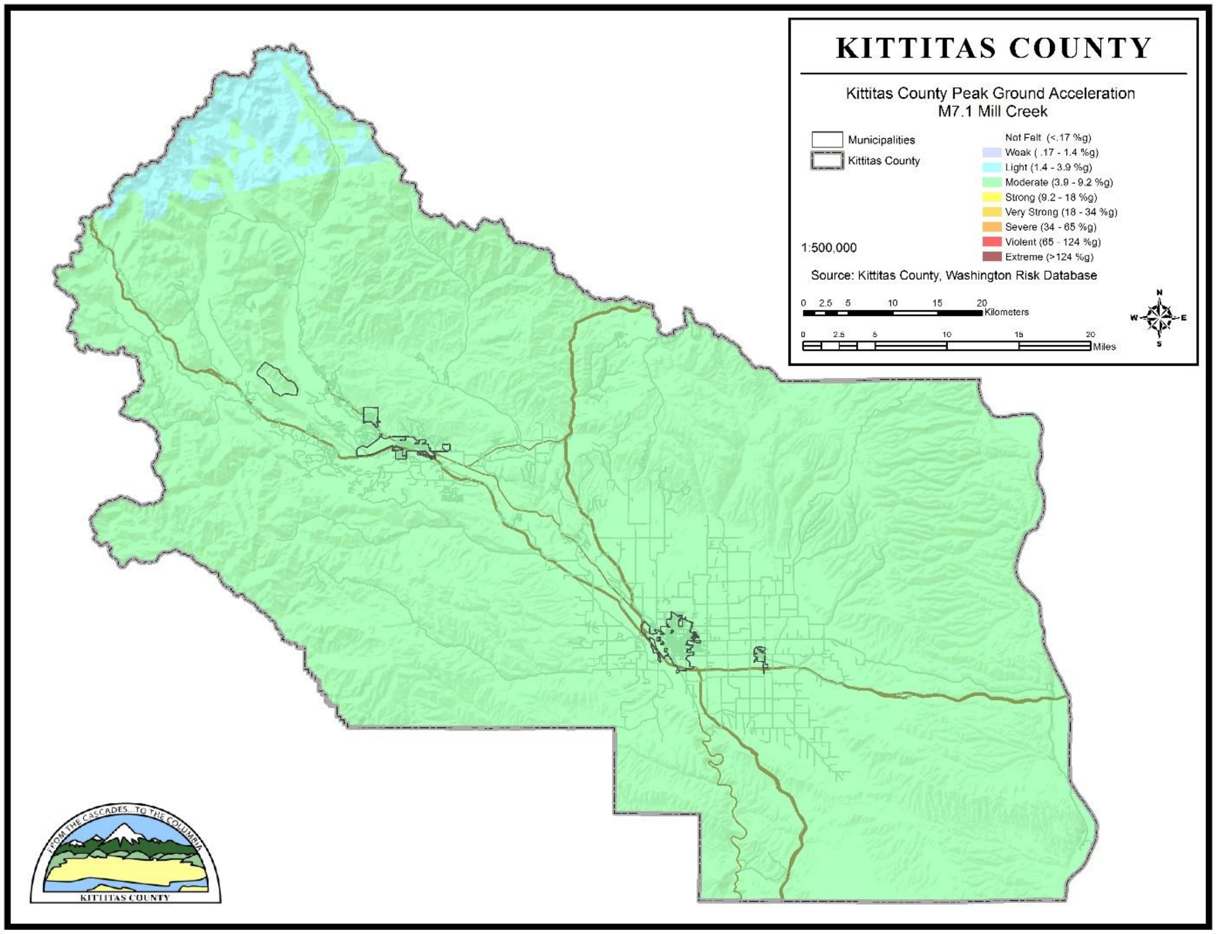


Figure 10-4. Peak Ground Acceleration, Mill Creek Earthquake Scenario

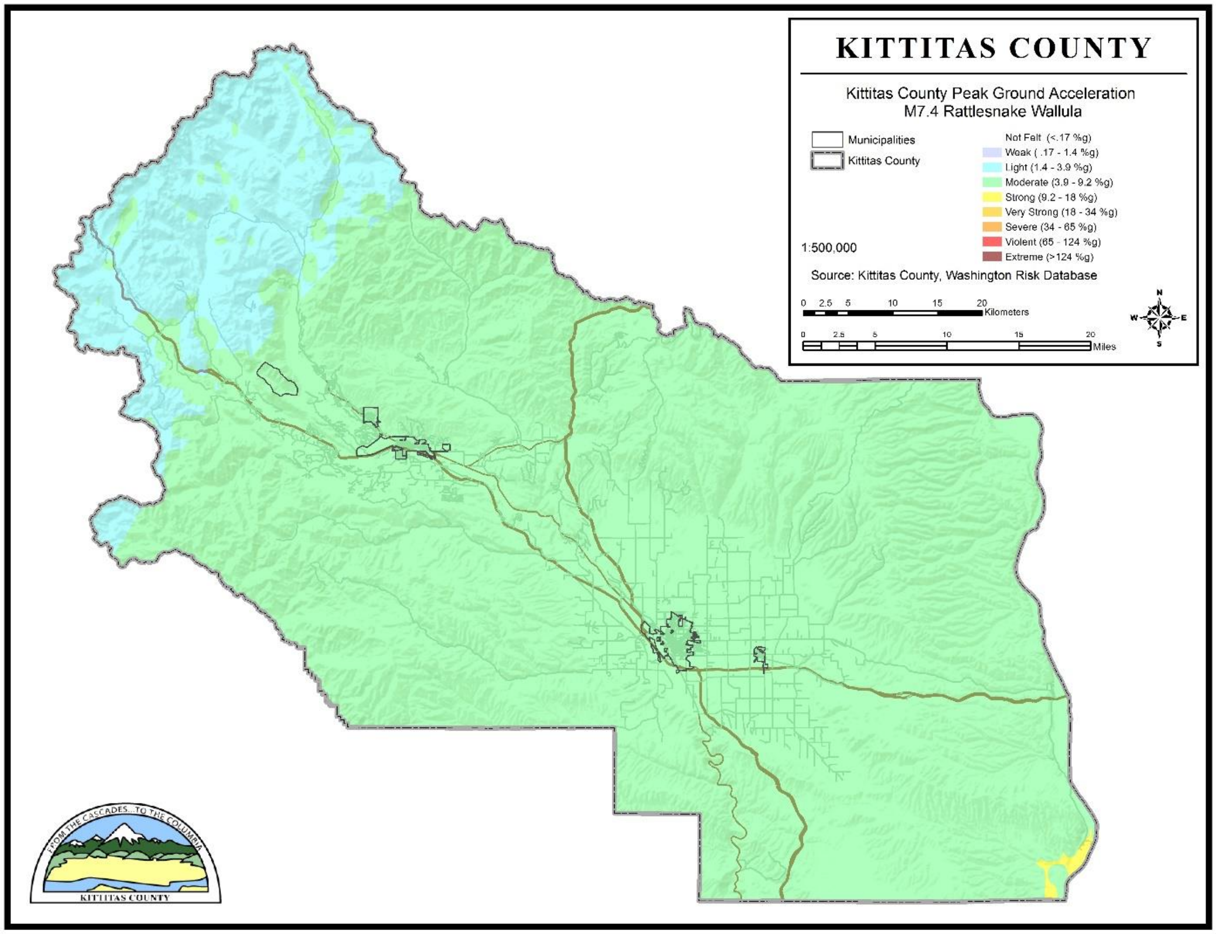


Figure 10-5. Peak Ground Acceleration, Rattlesnake Wallula Earthquake Scenario

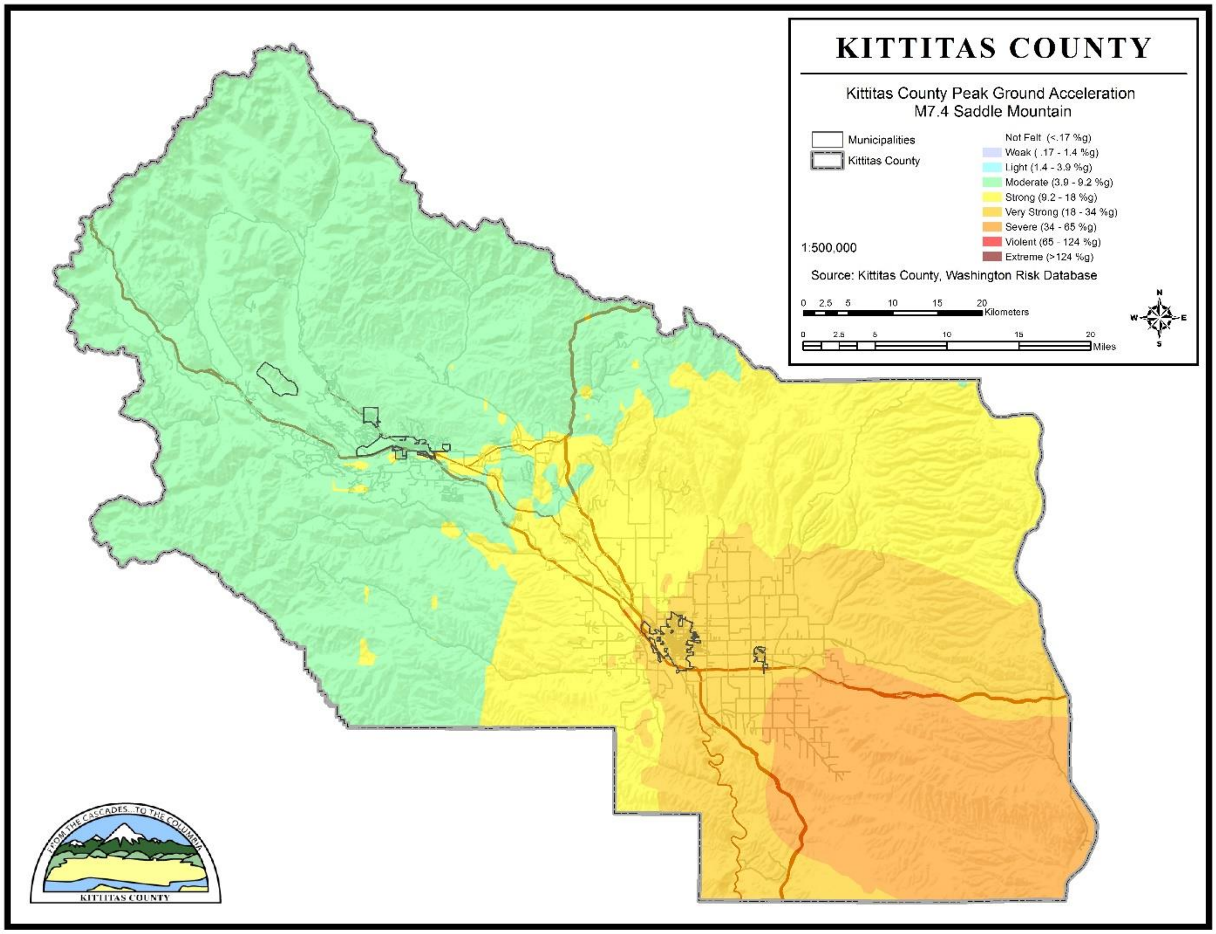


Figure 10-6. Peak Ground Acceleration, Saddle Mountain Earthquake Scenario

NEHRP Soil Maps

NEHRP soil types define the locations that will be significantly impacted by an earthquake. NEHRP Soils B and C typically can sustain low-magnitude ground shaking without much effect. The areas that are most commonly affected by ground shaking have NEHRP Soils D, E and F. Figure 10-7 shows NEHRP soil classifications in the county.

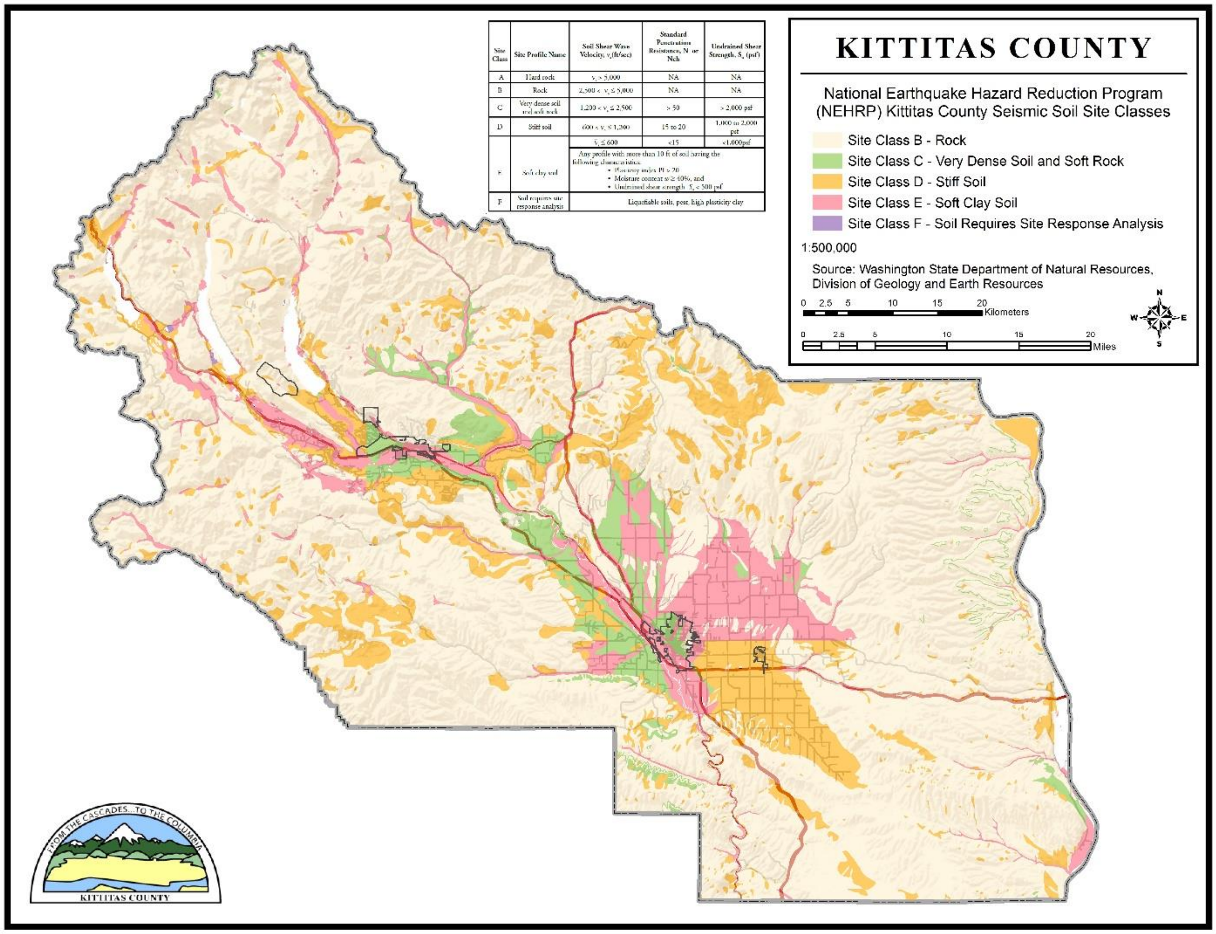


Figure 10-7. NEHRP Seismic Soil Site Classes for Kittitas County

Liquefaction Maps

Soil liquefaction maps are useful tools to assess potential damage from earthquakes. When the ground liquefies, sandy or silty materials saturated with water behave like a liquid, causing pipes to leak, roads and airport runways to buckle, and building foundations to be damaged. In general, areas with NEHRP Soils D, E and F are also susceptible to liquefaction. If there is a dry soil crust, excess water will sometimes come to the surface through cracks in the confining layer, bringing liquefied sand with it, creating sand boils. Figure 10-8 shows the liquefaction susceptibility in Kittitas County.

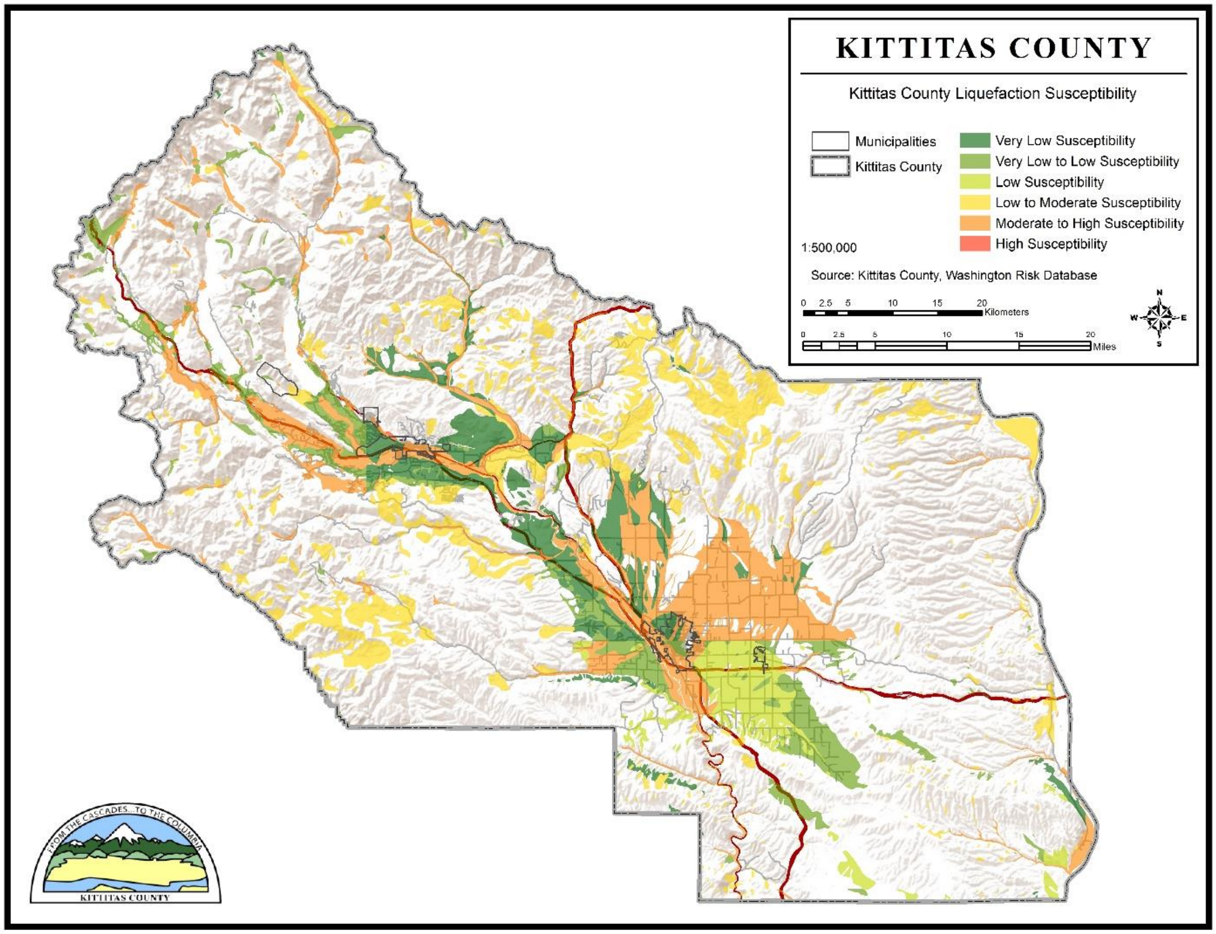


Figure 10-8. Liquefaction Susceptibility for Kittitas County

10.2.3 Frequency

Because of its location at the boundary of two major tectonic plates, Washington State is particularly vulnerable to earthquakes. FEMA has determined that Washington State ranks second (behind only California) among states most susceptible to damaging earthquakes. According to the Washington State Enhanced Hazard Mitigation Plan, the probability of future occurrence for earthquakes similar to the 1965 Magnitude 6.5 Seattle-Tacoma event and the 2001 Magnitude 6.8 Nisqually event is about once every 35 years. The USGS has estimated that there is an 84-percent chance of a Magnitude 6.5 or greater deep earthquake over the next 50 years.

The USGS Unified Hazard Tool shows that there is a 2 percent chance annually of a level IV earthquake (on the Modified Mercalli Scale) occurring within 50 kilometers of Kittitas within the next 50 years. The largest earthquake within 100 miles of Kittitas was a Magnitude 5.5 event in 1996. Annual earthquake probabilities for different peak ground accelerations within 50 kilometers of the planning area over the next 50 years are shown in Table 10-4.

Table 10-4. Earthquake Annual Probabilities within 50 Years

Peak Ground Acceleration (%g)	Annual Probability of Occurrence within 50 Km of Kittitas (Annual Frequency of Exceedance)
0.269	2.0957 %
.053	0.788 %
.0738	0.449 %
.103	0.243 %
.145	0.121 %
.203	0.0582 %
.284	0.0263 %
.397	0.0111 %
.556	0.00428 %
.778	0.00147 %
1.09	0.000433 %

a. PGA measured in percent of g, where g is the acceleration of gravity

10.2.4 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. 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. 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?

The severity of a seismic event is directly correlated to the stability of the ground close to the event's epicenter. The difference in severity between intensity ranges can be immense. A poorly built structure on a stable site is far more likely to survive a large earthquake than a well-built structure on an unstable site. Thorough geotechnical site evaluations should be the rule of thumb for new construction in the planning area until creditable soils mapping becomes available.

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. Figure 10-9 shows the PGAs with a 10-percent exceedance chance in 50 years in Washington. South-central Washington is a medium- to high-risk area.

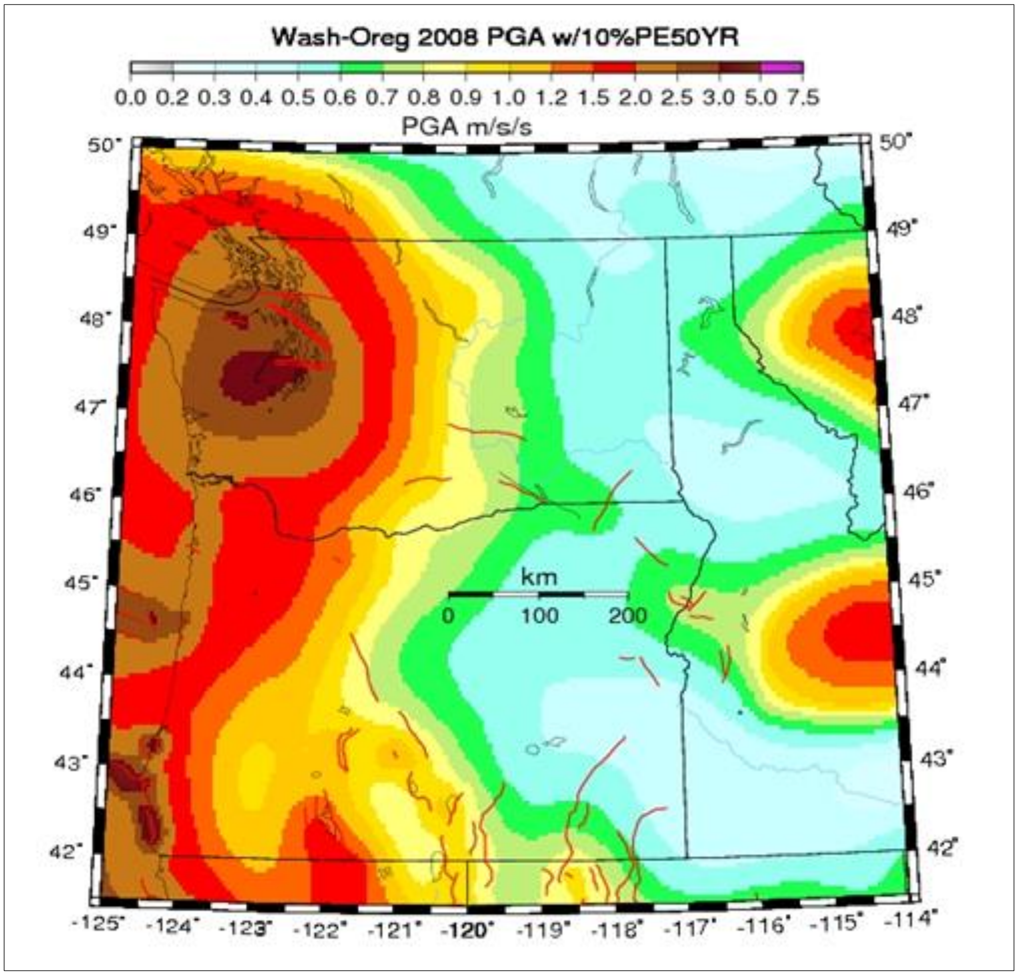


Figure 10-9. PGA with 2-Percent Probability of Exceedance in 50 Years, Northwest Region

10.2.5 Warning Time

There is currently no reliable way to predict the day or month that an earthquake will occur at any given location. Research is being done with warning systems that use the low energy waves that precede major earthquakes. These potential warning systems give approximately 40 seconds notice that a major earthquake is about to occur. The warning time is very short but it could allow for someone to get under a desk, step away from a hazardous material they are working with, or shut down a computer system.

10.3. SECONDARY HAZARDS

Earthquakes can cause large and sometimes disastrous landslides and mudslides. River valleys are vulnerable to slope failure, often as a result of loss of cohesion in clay-rich soils. Soil liquefaction occurs when water-saturated sands, silts or gravelly soils are shaken so violently that the individual grains lose contact with one another and float freely in the water, turning the ground into a pudding-like liquid. Building and road foundations lose load-bearing strength and may sink 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.

10.3.1 Seiche

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

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

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

With three large reservoirs and a risk of seismic events, there is potential for seiches to occur in Kittitas County. The degree of vulnerability to this secondary hazard is difficult to gage without hazard mapping that illustrates extent, location and potential severity of probabilistic events.

10.4. 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). Other research indicates that geologic events such as earthquakes are sensitive to changes on the earth’s surface, such as shifts in water or atmospheric pressure. Other scientists have expressed doubts that earthquakes are significantly impacted by climate change.

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.

10.5. EXPOSURE

10.5.1 Population

The entire population of Kittitas County is potentially exposed 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 type their homes are constructed on, their proximity to fault location, etc. Whether directly impacted or indirectly impact, 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.

10.5.2 Property

The Kittitas County Assessor estimates that there are 15,364 buildings in Kittitas County, with a total assessed value of $4.54 billion. Since all structures in the planning area are susceptible to earthquake impacts to varying degrees, this total represents the countywide property exposure to seismic events.

10.5.3 Critical Facilities

All critical facilities in Kittitas County are exposed to the earthquake hazard. Chapter 4.5 of this plan lists the number of each type of facility by jurisdiction. 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.

10.5.4 Environment

Secondary hazards associated with earthquakes will likely have some of the most damaging effects on the environment. Earthquake-induced landslides can significantly impact surrounding habitat. It is also possible for streams to be rerouted after an earthquake. This can change the water quality, possibly damaging habitat and feeding areas. There is a possibility of streams fed by groundwater drying up because of changes in underlying geology.

10.6. VULNERABILITY

Earthquake vulnerability data was generated using a Level 2 Hazus analysis. 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.

10.6.1 Population

A geographic analysis of demographics, using the Hazus model and data from the U.S. Census Bureau, identified populations vulnerable to earthquake hazards. The information was pulled from Census Blocks that intersected the floodplain as follows:

- **Economically Disadvantaged Populations**— Approximately 1,700 households in the planning area census blocks that intersect NEHRP D and E soils are listed as being economically disadvantaged, defined as having household incomes of $10,000 or less. This is about 12 percent of all households in these census blocks, and about 10 percent of the overall number of households. These households 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 Below Poverty Level**— Approximately 4,800 households in the planning area census blocks that intersect NEHRP D and E soils are listed as being below the poverty level ($30,00 a year or less). This is about 35 percent of all households in these census blocks, and

about 29 percent of the overall number of households. 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**— Approximately 4,400 residents in the planning area census blocks that intersect NEHRP D and E soils are over 65 years old. This is about 13 percent of all residents in these census blocks, and about 11 percent of the overall population. 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.
- **Population under 16 Years Old**— Approximately 6,200 residents in the planning area census blocks that intersect NEHRP D and E soils are under 16 years old. This is about 18 percent of all residents in these census blocks, and about 15 percent of the overall population. This population group is vulnerable because they are less likely to be able to take care of themselves, especially as they are not old enough to carry a driver's license. They are dependent on their primary caregivers, and require extra attention by those caregivers during earthquake events that could become a distraction.

10.6.2 Property

Building Age

Table 10-5 identifies significant milestones in building and seismic code requirements that directly affect the structural integrity of development. The planning team used Hazus to identify the number of structures within the county by date of construction and group them according to these time periods.

Table 10-5. Age of Structures in Kittitas County

Time Period	Number of Current County Structures Built in Period	Significance of Time Frame
Pre-1933	3,416	Before 1933, there were no explicit earthquake requirements in building codes.
1933-1940	632	In 1940, the first strong motion recording was made.
1941-1960	1,376	In 1960, the Structural Engineers Association of California published guidelines for earthquake provisions.
1961-1975	2,294	In 1975, significant improvements were made to lateral force requirements.
1976-1994	4,161	In 1994, the Uniform Building Code was amended to include provisions for seismic safety.
1994—present	6,694	Seismic code is currently enforced.
Total	**18,573**	

The number of structures does not reflect the number of total housing units, as many multi-family units and attached housing units are reported as one structure. Approximately 36 percent of the planning area's structures were constructed after the Uniform Building Code was amended in 1994 to include seismic safety provisions. Approximately 18.4 percent were built before 1933 when there were no building permits, inspections, or seismic standards.

Loss Estimates

Vulnerability numbers are provided for each earthquake scenario, as summarized in Table 10-6 through Table 10-10:

- The estimated loss from the Cle Elum earthquake scenario (M6.8) is $131 million. This represents almost three percent of the total assessed value for Cle Elum.
- The estimated loss from the Horse Heaven Hills earthquake scenario (M7.1) is $400,217. This represents less than one percent of the total assessed value of the planning area.
- The estimated loss from the Mill Creek earthquake scenario (M7.1) is $2 million. This represents less than one percent of the total assessed value of the planning area.
- The estimated loss from the Rattlesnake Wallula earthquake scenario (M7.1) is $1 million. This represents less than one percent of the total assessed value of the planning area.
- The estimated loss from the Saddle Mountain earthquake scenario is $103 million. This represents over two percent of the total assessed value of the planning area.

Table 10-6. Loss Estimates for Buildings Exposed to Cle Elum Earthquake Scenario (M6.8)

Jurisdiction	Loss Value (Building and Contents)	Loss Ratio (Building and Contents)
Cle Elum	$7,346,700	8.3%
Ellensburg	$24,882,964	2.8%
Kittitas	$915,307	1.4%
Roslyn	$878,410	1.3%
South Cle Elum	$832,932	9.5%
Unincorporated Kittitas County	$96,662,466	2.8%
Total	**$131,518,779**	**2.9%**

Table 10-7. Loss Estimates for Buildings Exposed to Horse Heaven Hills Earthquake Scenario (M7.1)

Jurisdiction	Loss Value (Building and Contents)	Loss Ratio (Building and Contents)
Cle Elum	$1,199	0.0%
Ellensburg	$109,344	0.0%
Kittitas	$277,090	0.0%
Roslyn	$10,357	0.0%
South Cle Elum	$115	0.0%
Unincorporated Kittitas County	$2,112	0.0%
Total	**$400,217**	**<0.1%**

Table 10-8. Loss Estimates for Buildings Exposed to the Mill Creek Earthquake Scenario (M7.1)

Jurisdiction	Loss Value (Building and Contents)	Loss Ratio (Building and Contents)
Cle Elum	$7,108	0.0%

Jurisdiction	Loss Value (Building and Contents)	Loss Ratio (Building and Contents)
Ellensburg	$630,638	0.1%
Kittitas	$59,504	0.1%
Roslyn	$2,426	0.0%
South Cle Elum	$7,624	0.1%
Unincorporated Kittitas County	$1,355,955	0.0%
Total	**$2,063,256**	**<0.1%**

Table 10-9. Loss Estimates for Buildings Exposed to Rattlesnake Wallula Earthquake Scenario (M7.4)

Jurisdiction	Loss Value (Building and Contents)	Loss Ratio (Building and Contents)
Cle Elum	$4,490	0.0%
Ellensburg	$375,650	0.0%
Kittitas	$59,069	0.1%
Roslyn	$670	0.0%
South Cle Elum	$5,767	0.1%
Unincorporated Kittitas County	$1,017,438	0.0%
Total	**$1,463,084**	**<0.1%**

Table 10-10. Loss Estimates for the Saddle Mountain Earthquake Scenario (M7.4)

Jurisdiction	Loss Value (Building and Contents)	Loss Ratio (Building and Contents)
Cle Elum	$146,229	0.2%
Ellensburg	$27,574,644	3.1%
Kittitas	$3,084,095	4.7%
Roslyn	$54,797	0.1%
South Cle Elum	$129,011	1.5%
Unincorporated Kittitas County	$72,415,514	2.1%
Total	**$103,404,291**	**2.3%**

10.6.3 Critical Facilities

Level of Damage

The Mercalli scale lists damage potential and perceived shaking for a given area. Based on this scale, the level of vulnerability from peak ground acceleration was determined for critical facilities, for each of the five earthquake scenarios. Table 10-11 to Table 10-15 summarize the results.

Table 10-11. Critical Facility Vulnerability to M6.8 Cle Elum Event

Category	Not Felt to Weak	Light to Moderate	Strong to Very Strong	Severe to Violent	Extreme
Fire Station	0	3	28	0	0
Hospital	0	0	4	0	0
Emergency Facility	0	0	4	0	0
School	0	0	17	0	0
Total	**0**	**3**	**53**	**0**	**0**

Table 10-12. Critical Facility Vulnerability to M7.1 Horse Heaven Hills Event

Category	Not Felt to Weak	Light to Moderate	Strong to Very Strong	Severe to Violent	Extreme
Fire Station	0	31	0	0	0
Hospital	0	4	0	0	0
Emergency Facility	0	4	0	0	0
School	0	17	0	0	0
Total	**0**	**56**	**0**	**0**	**0**

Table 10-13. Critical Facility Vulnerability to M7.1 Mill Creek Event

Category	Not Felt to Weak	Light to Moderate	Strong to Very Strong	Severe to Violent	Extreme
Fire Station	0	31	0	0	0
Hospital	0	4	0	0	0
Emergency Facility	0	4	0	0	0
School	0	17	0	0	0
Total	**0**	**56**	**0**	**0**	**0**

Table 10-14. Critical Facility Vulnerability to M7.4 Rattlesnake Wallula Event

Category	Not Felt to Weak	Light to Moderate	Strong to Very Strong	Severe to Violent	Extreme
Fire Station	0	31	0	0	0
Hospital	0	4	0	0	0
Emergency Facility	0	4	0	0	0
School	0	17	0	0	0
Total	**0**	**56**	**0**	**0**	**0**

Table 10-15. Critical Facility Vulnerability to M7.4 Saddle Mountain Event

Category	Not Felt to Weak	Light to Moderate	Strong to Very Strong	Severe to Violent	Extreme
Fire Station	0	14	16	1	0
Hospital	0	2	2	0	0
Emergency Facility	0	0	4	0	0
School	0	4	13	0	0

Category	Not Felt to Weak	Light to Moderate	Strong to Very Strong	Severe to Violent	Extreme
Total	**0**	**20**	**35**	**1**	**0**

10.6.4 Environment

The environment vulnerable to earthquake hazard is the same as the environment exposed to the hazard.

10.7. FUTURE TRENDS IN DEVELOPMENT

The land use elements of the comprehensive plans adopted by the municipal planning partners provide a long-range guide to the physical development of the planning area and its urban growth area. As one of the faster growing counties in Washington, Kittitas County and its planning partners will need to manage growth in a way that accounts for impacts from potential earthquakes. With tools such as the Washington State Building Code and local critical areas ordinances that define seismic hazard areas, the planning partners are prepared to deal with future growth.

10.8. SCENARIO

Any seismic activity of Magnitude 6.0 or greater on faults within the planning area would have significant impacts. The seismic event likely to have the largest impact is a Magnitude 6.8 or greater event on the Cle Elum fault. Potential warning systems could give 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 significant structural failure of property on unstable soils. With the abundance of floodplain within the planning area, liquefaction impacts in these areas could be widespread. Un-engineered canal embankments would likely fail, representing a loss of critical infrastructure. The structural integrity of the numerous earthen dams within the planning area could be jeopardized as well. These events could cause secondary hazards, including landslides and mudslides. 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.

10.9. ISSUES

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

- Approximately 42 percent of the planning area's building stock was built prior to 1975, when seismic provisions became uniformly applied through building codes.
- Critical facility owners should be encouraged to create or enhance continuity of operations plans using the information on risk and vulnerability contained in this plan.
- Geotechnical standards should be established that take into account the probable impacts from earthquakes in the design and construction of new or enhanced facilities.
- Major infrastructure crossing vulnerable soils, such as roads, bridges and railroads, is at risk.
- Landslides could have a widespread effect on the city and its surrounding areas.
- The county has over 330 miles of canals that were not constructed to engineering standards. The structural integrity of these facilities as it pertains to seismic impacts is not known.
- Until additional data on the impacts of events typical for this region are developed, non-structural retrofitting techniques should be considered and promoted by the partnership.

- More information is needed on the known and unknown faults in Eastern Washington. A systematic assessment of earthquake hazards in Eastern Washington started in 2008. The findings of ongoing research on surface faults may lead to an assessment of greater earthquake risk in parts of Eastern Washington.

CHAPTER 11.
FLOOD

11.1. GENERAL BACKGROUND

A floodplain is the area adjacent to a river, creek or lake that becomes inundated during a flood. Floodplains may be broad, as when a river crosses an extensive flat landscape, or narrow, as when a river is confined in a canyon.

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.

DEFINITIONS

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

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

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

Return Period—The average number of years between occurrences of a hazard (equal to the inverse of the annual likelihood of occurrence).

Riparian Zone—The area along the banks of a natural watercourse.

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

11.1.1 Measuring Floods and Floodplains

The frequency and severity of flooding are measured using a discharge probability, which is a statistical tool used to define the probability that a certain river discharge (flow) level will be equaled or exceeded within a given year. Flood studies use historical records to determine the probability of occurrence for the different discharge levels. The flood frequency equals 100 divided by the discharge probability. For example, the 100-year discharge has a 1-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 1-percent annual probability of occurrence (the base flood or 100-year flood) is used as the regulatory boundary by many agencies. Also referred to as the special flood hazard area (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.

11.1.2 Floodplain Ecosystems

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

- Biology: conserve biological resources and support highly productive ecosystems
- Hydraulics and Hydrology: conserve the quantity, quality, and flow of water in the floodplain
- Geomorphology: Conserve channel and coastal stability
- Historic and Cultural Resources: Avoid or minimize adverse effects to sites possessing historic and cultural significance, including archaeological resources
- Cultivated Resources: protect stream banks and vegetative buffers to reduce runoff from entering water sources
- Natural Hazard Protection: protect human life, health, welfare, and property from flood hazards

The 2016 Kittitas County Shoreline Master Program update outlines policies and management practices consistent with the protection of these natural floodplain functions. The plan also classifies floodplain areas by environmental designation. These classifications and corresponding maps were reviewed to identify the areas of Kittitas County most critical to protecting natural floodplain functions. The vast majority of these areas are the floodplains surrounding streams, rivers, and lakes in unpopulated areas of the county. A smaller number of floodplain areas are located in smaller neighborhoods along rivers or in the incorporated communities of Cle Elum, South Cle Elum, and Ellensburg.

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

11.1.4 Federal Flood Programs

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 (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 principle tool for identifying the extent and location of the flood hazard. FIRMs are the most detailed and consistent data source available, and for many communities they represent the minimum area of oversight under their floodplain management program.

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 salmonid species.

Kittitas County entered the NFIP on May 5, 1981. Structures permitted or built in the county before then are called “pre-FIRM” structures, and structures built afterwards are called “post-FIRM.” The insurance rate is different for the two types of structures. The current Kittitas County FIRMs became effective on October 15, 1981. Preliminary FIRMs for Kittitas County were generated in early 2018, and while these were not effective at the time of this plan update, these preliminary FIRMs were used to map the extent and location of flood hazards in this risk assessment. The preliminary FIRMs represent a significant improvement in flood mapping from the 1981 effective FIRMs.

All incorporated cities in Kittitas County also participate in the NFIP. The county and cities are currently in good standing with the provisions of the NFIP. Compliance is monitored by FEMA regional staff and by the Department of Ecology under a contract with FEMA. 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.

The 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 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.

Figure 11-1 shows the nationwide number of CRS communities by class as of May 1, 2018, when there were 1,660 communities receiving flood insurance premium discounts under the CRS program.

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. Although CRS communities represent only 5 percent of the over 22,000 communities that participate in the NFIP, more than 69 percent of all flood insurance policies are written in CRS 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.

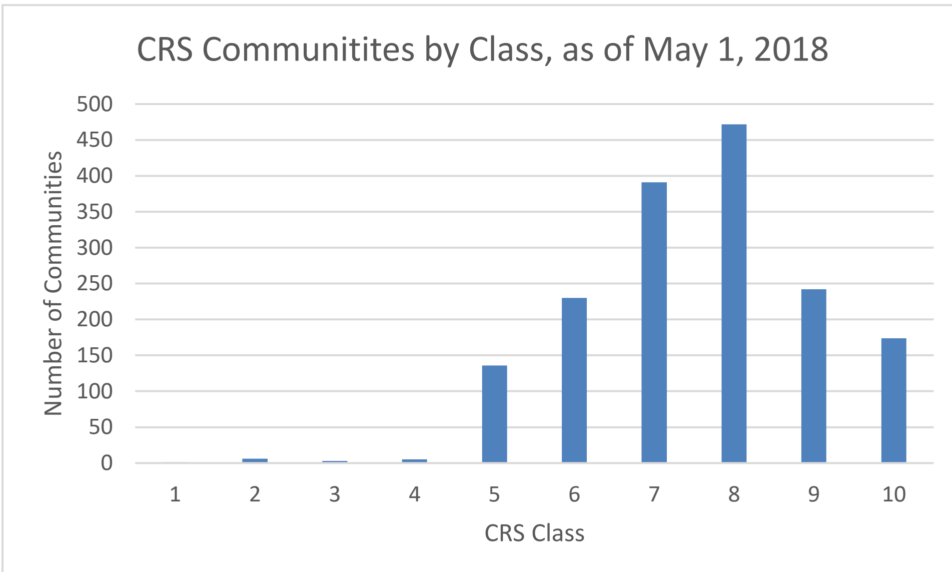


Figure 11-1. CRS Communities by Class Nationwide as of May 1, 2018

Kittitas County joined the CRS program in 2014, and currently is a Class 6 community, providing flood insurance premium discounts of 20% to residents. The most recent verification report was conducted on June 17, 2014, and documented a total of 2,033 credits earned.

11.2. HAZARD PROFILE

In Kittitas County, the Yakima River is the principle hydraulic feature. Its basin covers 1,594 square miles of the county. The major Yakima River tributaries include the Cle Elum and Teanaway Rivers (all forks) and many creeks including, but not limited to, Cabin, Cole, Gold, Silver, Manastash, Taneum, Naneum, Wilson, Reecer, Mercer, Big, and Little. Understanding the hydrology of the basin helps planners to estimate the likely frequency and magnitude of flooding and to locate sites where erosion may be a hazard. Hydrology of an area is largely affected by climate, topography, geology and glacial history.

Temperatures and precipitation shape the flood hazard potential in Kittitas County. The amount of snowfall and snowmelt runoff rates are critical in determining flood potentials. Most flooding in the Yakima and Teanaway River basins follows periods in which large amounts of wet snow accumulate and is associated with rain-on-snow events during which runoff cannot percolate into the soil because the soil has been saturated or because the ground is frozen.

11.2.1 Geomorphology

Geomorphology refers to the relationship between the shape and other physical characteristics of a river and the rocks and sediments of the valley in which it flows. The river creates its channel, which reflects the force of the flowing water and the material of which the bed and banks are made. Changes in watershed conditions can affect the amount of runoff and the amount and size of sediment that enters the river. Changes in runoff and sediment loading affect the river's behavior, including flood characteristics.

The Yakima River's character changes in response to local geology as it flows downstream. Much of the river is braided, with interlaced channels and gravel bars and an active channel area; however, there are areas where basalt geology constricts the lateral movement of the river. All forks of the Teanaway River generally are constrained in their upper reaches. Moving downstream to the Teanaway River valley, the river is fairly channelized, but has free lateral movement.

11.2.2 Stream Flow

During ordinary years, much of the precipitation in Kittitas County remains as snowpack for several months after it falls, providing for higher flows during the spring thaw; however, much of the runoff is stored in one of the three reservoirs for irrigation purposes later in the year. In high precipitation years, rain-on-snow events decrease the snowpack and increase stream flow to the point of flood events. This was most apparent during the 1990, 1995, and 1995 flood events.

Cool spring temperatures increase peak stream flows, as snow remains in the mountains throughout the early spring, then melts and runs off more quickly when temperatures increase in later spring or early summer. When large amounts of water runoff at one time, high flows occur. Higher peak flows increase the possibility of flooding.

Exchanges between surface water and groundwater also drive stream flow in the Yakima River basin, but the relationships between the two are complex. Permeable glacial sediments are thought to provide for a high degree of hydraulic continuity between surface water and groundwater in most parts of the basin. Where surface water and groundwater are in continuity, the condition of the river corridor will have strong impact on groundwater resources as well as on flooding. Riparian vegetation both slows flows and helps water percolate to the zone from which it can recharge the aquifer. Similarly, changes in land use that affect groundwater quantity and quality and aquifer recharge potential will be reflected in the river.

11.2.3 Principal Flooding Sources

Riverine Flooding

There are many flood problem areas in Kittitas County. Large-scale developments with urban densities adjacent to the Yakima and Teanaway Rivers—specifically, Elk Meadows, Elk Meadows Park, Pine Glen, Sun Island, Sun Country, Teanaway Acres, and the Teanaway Wagon Wheel—have experienced substantial flood damage. The county also has numerous streams with large and unpredictable floodplains and flood capacities. These include, but are not limited to, Cabin, Cole, Big, Little, Silver, Gold, Manastash, Taneum, Wilson and Reecer Creeks.

Floods on the Yakima, Teanaway and Cle Elum Rivers occur as the result of snowmelt in spring and early summer and occur after heavy rains in November and December. Ice and debris can have an impact on flood stages when culverts and bridges are obstructed. The spring/summer snowmelt floods are characterized by slow rise and long duration of high flow; river stages may be increased by ice and debris jams. The fall/winter flood crests are reduced because flood storage is available after the irrigation season in Kachess, Keechelus, and Cle Elum Lakes. However, these reservoirs control only a small part of the runoff, and storage may not be available if two winter flood events occur in short succession. The three reservoirs have a combined storage capacity of 833,700 acre-feet (157,800 acre-feet in Keechelus Lake; 239,000 acre-feet in Kachess Lake; and 436,900 acre-feet in Cle Elum Lake). These reservoirs were constructed for irrigation purposes, but are also operated for flood control on the basis of runoff forecasts.

Irrigation Facilities

Ellensburg and Kittitas are surrounded by a complex irrigation system consisting of the North Branch, Town and Cascade canals; the Whipple Wasteway; and the Reecer, Currier, Whiskey, Mercer, Wilson, Cooke and Caribou Creeks. Covering over 330 miles, this system distributes water for irrigation and was designed to provide some flood control. However, the system has a decreasing capacity downstream and can become overtaxed when used to route floodwaters. Significant floods have occurred in the past when this system diverted floodwaters from one basin to another.

Urban Flooding

Kittitas County has experienced rapid change due to urban development in once rural areas. Drainage facilities in recently urbanized areas are many series of pipes, roadside ditches and channels. Urban flooding occurs when these conveyance systems lack the capacity to convey rainfall runoff to nearby creeks, streams and rivers. As drainage facilities are overwhelmed, roads and transportation corridors become conveyance facilities. The key factors that contribute to urban flooding are rainfall intensity and duration. Topography, soil conditions, urbanization and groundcover also play an important role.

Urban floods can be a great disturbance of daily life in urban areas. Roads can be blocked and people may be unable to go to work or school. Economic damage can be high, but casualties are usually limited because of the nature of the flooding. On flat terrain, the flow speed is low and people can still drive through it. The water rises relatively slowly and usually does not reach life endangering depths.

11.2.4 Past Events

Since 1862, approximately 38 major floods with streamflow over 10,000 cubic feet per second (cfs) have occurred on the Yakima River and its tributaries. Five of the highest peak discharges were measured at USGS Station 12484500 on the Yakima River at Umtanum, 10 miles south of Ellensburg, on the following dates.

- November 1906 (41,000 cubic feet per second (cfs))
- November 1909 (22,900 cfs)
- December 1933 (32,200 cfs)
- May 1948 (27,700 cfs)
- February 1996 (27,200 cfs)

Additionally, the National Weather Service Advanced Hydrologic Prediction Service records the heights of historic crests. The Yakima River at Cle Elum gauge recorded the following historic crests:

- 8.68 ft on 02/09/1996
- 8.69 ft on 11/29/1995
- 9.70 ft on 11/25/1990
- 8.45 ft on 05/31/1983
- 9.84 ft on 12/02/1977
- 11.27 ft on 11/23/1959
- 11.68 ft on 05/29/1948
- 11.27 ft on 12/22/1933
- 12.07 ft on 12/13/1921
- 12.12 ft on 12/30/1917

- 10.81 ft on 06/03/1913
- 11.87 ft on 11/24/1909
- 14.58 ft on 11/14/1906

Examining damages from past flooding events provides an understanding of the potential damages that can be caused by flooding. The most recent floods on the Yakima River were in May 2017, December 2015, January 2015, and May 2014. During many historical floods developments adjacent to the Yakima and Teanaway Rivers had to be evacuated. In November 1995, the estimated water level of the Yakima River was at 34 feet. This flood threatened the SR 970 and Lambert Road bridges over the Teanaway River and broke through dikes on both rivers, damaging both private and public property. During the February 1996 flood, private property and county roads and bridges were damaged throughout the valley, including, but not limited to, the Manastash, Swauk, Taneum, and lower Badger Pocket areas. A total of 22 bridges sustained damage in the county, in addition to approximately 120 road damage sites. Figure 11-2 shows a home in West Ellensburg after the 2011 flood events. Table 11-1 summarizes flood events in the planning area since 1955. Since 1964, ten presidential-declared flood events in the county have caused in excess of $20 million in property damage.

Table 11-1. Kittitas County Flood Events

Date	Declaration #	Type of event	Estimated Damage[a]
12/29/1964	DR-185	Heavy Rains & Flooding	$130,000
06/10/1972	--	Flooding – Hail – Severe Storm/Thunder Storm [a]	$10,000
12/13/1975	DR-492	Severe Storms, Flooding	N/A
12/10/1977	DR-545	Severe storms, Mudslides, Flooding	N/A
07/25/1987	--	Flooding – Lightning [a]	$5,000
08/21/1990	--	Flooding [a]	$11,500
11/26/1990	DR-883	Flooding, Severe Storms	N/A
01/03/1996	DR-1079	Storms/High Winds/Floods	Over $23 million statewide
02/09/1996	DR-1100	Severe Storms/Flooding	Over $33 million statewide
01/17/1997	DR-1159	Severe Winter Storms/Flooding	N/A
05/04/2004	--	Flash flooding [a]	$90,000
01/30/2009	DR-1817	Severe Winter Storm, Landslides, Mudslides, and Flooding	$10,000,000
03/25/2011	DR-1963	Severe Winter Storm, Flooding, Landslides, and Mudslides (see Figure 11-2)	$4,000,000
01/15/2016	DR-4249	Severe Storms, Straight-line Winds, Flooding, Landslides, and Mudslides	N/A

a. Data obtained from Spatial Hazard Events and Losses Database for the United States (SHELDUS)
N/A = Information is not available

Figure 11-2. **Home in West Ellensburg Surrounded by Floodwaters, January 18, 2011**

11.2.5 Location

The major floods in Kittitas County have resulted from intense weather rainstorms between November and March. The flooding that has occurred in portions of the county has been extensively documented by gage records, high water marks, damage surveys and personal accounts. The current Kittitas County Flood Insurance Rate Maps (FIRMs) became effective on October 15, 1981. Preliminary FIRMs for Kittitas County were generated in early 2018, and these were used to map the extent and location of updated flood hazards in this risk assessment, as shown in Figure 11-3. All jurisdictions in Kittitas County have buildings exposed to the flood hazard area.

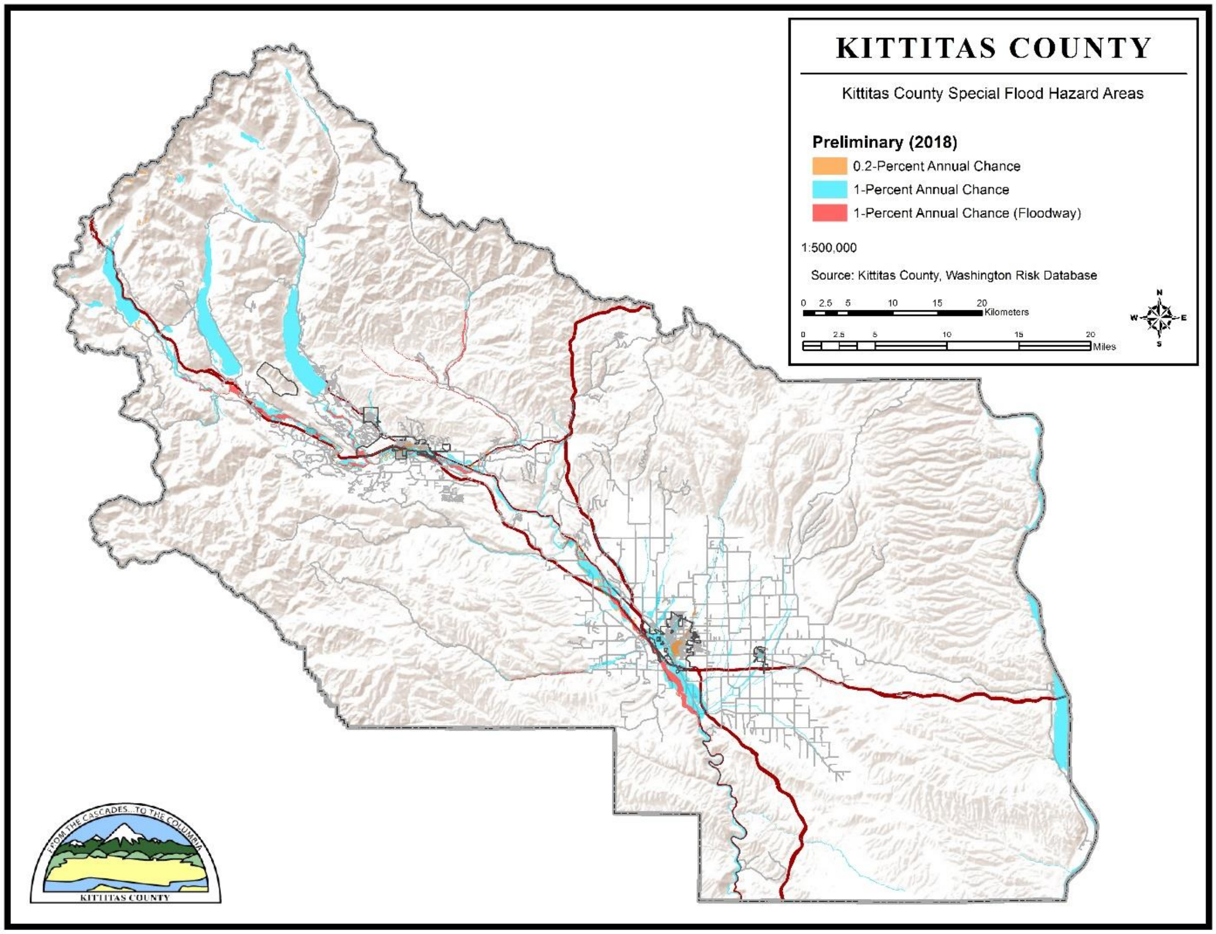


Figure 11-3. Kittitas County Special Flood Hazard Areas

11.2.6 Frequency

Kittitas County experiences episodes of river flooding almost every winter. Large floods that can cause property damage typically occur every 3 to 7 years. Urban portions of the county annually experience nuisance flooding related to drainage issues.

11.2.7 Severity

The principal factors affecting flood damage are flood depth and velocity. The deeper and faster flood flows become, the more damage they can cause. Shallow flooding with high velocities can cause as much damage as deep flooding with slow velocity. This is especially true when a channel migrates over a broad floodplain, redirecting high velocity flows and transporting debris and sediment. Flood severity is often evaluated by examining peak discharges; Table 11-2 lists peak flows used by FEMA to map the floodplains of Kittitas County.

Table 11-2. Summary of Peak Discharges within Kittitas County

Source/Location	Discharge (cubic feet/second)			
	10-Year	50-Year	100-Year	500-Year
Yakima River				

Source/Location	Discharge (cubic feet/second)			
	10-Year	50-Year	100-Year	500-Year
At downstream study limit	20,000	29,300	33,900	45,400
Upstream of Wilson Creek	19,000	28,000	32,300	46,600
At confluence with Manastash Creek	18,900	27,700	32,000	43,200
At confluence with Dry Creek	18,500	27,100	31,400	42,400
At confluence with Teanaway River	17,100	25,100	29,100	39,600
Upstream of confluence with Teanaway River	14,700	21,700	25,200	34,300
Upstream of confluence with Crystal Creek	14,500	21,400	24,700	33,800
At confluence with the Cle Elum River	14,200	21,000	24,300	33,200
Upstream of confluence with Big Creek	7,220	10,600	12,200	16,600
At Easton	6,580	9,660	11,200	15,200
Upstream of confluence with Kachess River	4,900	7,180	8,290	11,300
Upstream of confluence with Cabin Creek	3,740	5,480	6,300	8,600
Kachess River at mouth[a]	**2,300**	**3,360**	**3,860**	**5,180**
Silver Creek at mouth	**260**	**370**	**425**	**560**
Cle Elum River				
At mouth	8,020	11,800	13,600	18,600
At upstream study limit	7,540	11,100	12,800	17,400
Manastash Creek				
At apex of alluvial fan	1,400	2,030	2,310	3,030
At confluence with N. Fork Manastash Creek	1,240	1,780	2,040	2,670
At upstream study limit	967	1,400	1,590	2,100
Crystal Creek at mouth	**150**	**220**	**250**	**320**
Naneum Creek at mouth	**920**	**1,310**	**1,480**	**1,890**
Wilson Creek				
At mouth[b]	3,100	4,250	4,750	5,900
Upstream of confluence with Cherry Creek	2,050	2,750	3,000	3,700
Upstream of confluence with Naneum Creek[b]	1,550	2,170	2,360	2,950
Upstream study limit	475	680	770	986
Right Channel Wilson Creek[b]	**1,260**	**1,610**	**1,725**	**2,045**
Reecer Creek at downstream limit	**280**	**400**	**450**	**560**
Currier Creek				
At downstream limit	280	400	450	560
At Dry Creek connection road	180	255	290	360
Whiskey Creek				
At 5th street	75	105	175[c]	275[c]
At upstream limit	75	105	118	147
Mercer Creek				
At mouth	110	150	220 [c]	310 [c]
At Railroad Ave	110	150	170	210
Caribou Creek at downstream study limit	**294**	**417**	**471**	**595**
Teanaway River				
At Mouth	5,300	6,700	7,350	8,700
Upstream of confluence with N. Fork Teanaway River	2,400	3,000	3,300	3,900
N. Fork Teanaway River at mouth	**2,900**	**3,700**	**4,000**	**4,750**

Source/Location	Discharge (cubic feet/second)			
	10-Year	50-Year	100-Year	500-Year
Middle Fork Teanaway River at mouth	**1,250**	**1,570**	**1,700**	**2,020**
West Fork Teanaway River at Mouth	**1,300**	**1,640**	**1,780**	**2,080**

a. Discharges reflect regulated conditions
b. Includes overflow from Yakima River, Reecer, and Currier Creeks
c. Includes overflow from Reecer Creek

11.2.8 Warning Time

Floods are the number one natural disaster in the United States in terms of loss of life and property. Floods are generally characterized as either slow-rise or flash floods. Slow-rise may be preceded by a warning time from several hours, to days, to possibly weeks. Evacuation and sandbagging for a slow-rise flood may lessen flood damage. Flash floods are the most difficult to prepare for, due to the extremely short warning time, if any is given at all. Flash flood warnings usually require evacuation within an hour.

Each watershed has unique qualities that affect its response to rainfall. A hydrograph, which is a graph or chart illustrating stream flow in relation to time (see Figure 11-4), is a useful tool for examining a stream's response to rainfall. Once rainfall starts falling over a watershed, runoff begins and the stream begins to rise. Water depth in the stream channel (stage of flow) will continue to rise in response to runoff even after rainfall ends. Eventually, the runoff will reach a peak and the stage of flow will crest. It is at this point that the stream stage will remain the most stable, exhibiting little change over time until it begins to fall and eventually subside to a level below flooding stage.

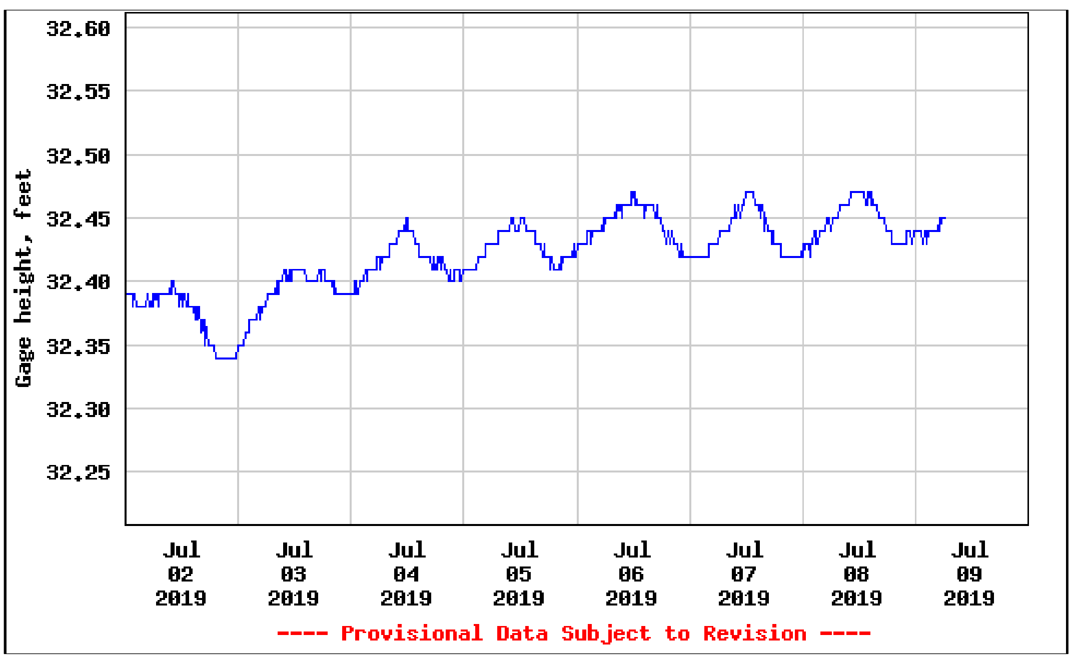


Figure 11-4. Yakima River Hydrograph at Umtanum (USGS Station 12484500)

The potential warning time a community has to respond to a flooding threat is a function of the time between the first measurable rainfall and the first occurrence of flooding. The time it takes to recognize a flooding threat reduces the potential warning time to the time that a community has to take actions to protect lives and property. Another element that characterizes a community's flood threat is the length of time floodwaters remain above flood stage.

The Kittitas County flood threat system consists of a network of precipitation gages throughout the watershed and stream gages at strategic locations on the Yakima River that constantly monitor and report stream levels. This information is fed into a USGS forecasting program, which assesses the flood threat based on the amount of flow in the stream (measured in cubic feet per second). In addition to this program, data and flood warning information is provided by the National Weather Service. All of this information is analyzed to evaluate the flood threat and possible evacuation needs.

Due to the sequential pattern of meteorological conditions needed to cause serious flooding, it is unusual for a flood to occur without warning. Warning times for slow-rise floods can be between 24 and 48 hours. Flash flooding can be less predictable, but potential hazard areas can be warned in advanced of potential flash flooding danger.

11.3. 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, moving the edge of the floodplain closer to buildings or causing them to fall in. Flooding is also responsible for hazards such as landslides when high flows over-saturate soils on steep slopes, causing them to fail. Hazardous materials spills are also a secondary hazard of flooding if storage tanks rupture and spill into streams, rivers or storm sewers.

There are various public health concerns that arise as a result of exposure to flooded areas, including drowning, infectious diseases from contaminated floodwaters, exposure to chemical hazards, electrical hazards from downed power lines, and injury from objects carried by flood waters (CDC, 2017). Mold growth is a common occurrence in flood-damaged homes and damp environments. Mold can also spread if it is disturbed during the clean-up process, as it is transferred from one surface to another. Infants, children, immune-compromised patients, pregnant women, individuals with existing respiratory conditions (allergies, multiple chemical sensitivity, and asthma) and the elderly appear to be at higher risks for adverse health effects from mold. Symptoms include nose and throat irritation, wheezing, coughing, asthma attacks in individuals who have asthma, and lower respiratory tract infections (in children). People with pre-existing respiratory conditions also may be susceptible to more serious lung infections (FEMA 2010).

11.4. 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. Going forward, model calibration or statistical relation development must happen more frequently, new forecast-based tools must be developed, and a standard of practice that explicitly considers climate change must be adopted. Climate change is already impacting water resources, and resource managers have observed the following:

- Historical hydrologic patterns can no longer be solely relied upon to forecast the water future.
- Precipitation and runoff patterns are changing, increasing the uncertainty for water supply and quality, flood management and ecosystem functions.

- Extreme climatic events will become more frequent, necessitating improvement in flood protection, drought preparedness and emergency response.

The amount of snow is critical for water supply and environmental needs, but so is the timing of snowmelt runoff into rivers and streams. Rising snowlines caused by climate change will allow more mountain area to contribute to peak storm runoff. High frequency flood event s (e.g. 10 -year floods) in particular will likely increase with a changing climate. Reduced snowpack and shifts in streamflow seasonality due to climate change pose an additional challenge to reservoir system managers as they strive both to minimize flood risk and to satisfy warm season water demands.

Along with reductions in the amount of the snowpack and accelerated snowmelt, scientists project greater storm intensity, resulting in more direct runoff and flooding. Changes in watershed vegetation and soil moisture conditions will likewise change runoff and recharge patterns. As stream flows and velocities change, erosion patterns will also change, altering channel shapes and depths, possibly increasing sedimentation behind dams, and affecting habitat and water quality. Floodplain and municipal water supply infrastructure are also vulnerable to projected increases in extreme precipitation and flood risk. With potential increases in the frequency and intensity of wildfires due to climate change, there is potential for more floods following fire, which increase sediment loads and water quality impacts.

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

11.5. EXPOSURE

The Level 2 Hazus protocol was used to assess the risk and vulnerability to flooding in the planning area. GIS building and assessor data (replacement cost values and detailed structure information) were loaded into Hazus. An updated inventory was used in place of the Hazus defaults for essential facilities. Preliminary Kittitas County Flood Insurance Rate Maps (FIRMs) were used to delineate flood hazard areas and estimate potential losses from the 0.2-, 1-, 2-, 4-, and 10-percent annual change flood events (where flood depth grids were available). Where available, flood depth grids were integrated into the model and vulnerability numbers were generated in Hazus. Where flood depth grids were unavailable, an exposure analysis was performed to identify structures exposed to flood risk. All data sources have a level of accuracy acceptable for planning purposes

11.5.1 Population

Population counts of those living in the floodplain were generated by analyzing County assessor and parcel data that intersect with the 100-year floodplain identified on FIRMs. Using GIS, residential structures that intersected the floodplain were identified, and an estimate of population was calculated by multiplying the residential structures by the average Kittitas County household size of 2.32 persons per household. Using this approach, it was estimated that the exposed population for the entire county is 2,225 within the 100-year floodplain (5.2 percent of the total county population).

11.5.2 Property

Structures in the Floodplain

Table 11-3 and Table 11-4 summarize the total area and number of structures in the floodplain by municipality. Using GIS, it was determined that there are 959 structures within the 100-year floodplain and 1,869 structures within the 500-year floodplain. In the 100-year floodplain, about 71 percent of these structures are in unincorporated areas. Ninety-three percent are residential, and 7 percent are commercial, industrial or agricultural.

Table 11-3. Area and Structures Within the 100-Year Floodplain

Jurisdiction	Area in Floodplain (Acres)	Number of Structures in Floodplain							
		Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Cle Elum	524	43	0	0	0	0	0	0	43
Ellensburg	1,105	160	0	0	0	0	0	0	160
Kittitas	60	55	0	0	0	0	0	0	55
Roslyn	69	16	0	0	0	0	0	0	16
South Cle Elum	21	4	0	0	0	0	0	0	4
Unincorporated Kittitas County	45,677	616	6	0	58	0	1	0	681
Total	**47,456**	**894**	**6**	**0**	**58**	**0**	**1**	**0**	**959**

Table 11-4. Area and Structures Within the 500-Year Floodplain

Jurisdiction	Area in Floodplain (Acres)	Number of Structures in Floodplain							
		Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Cle Elum	675	173	1	0	0	0	0	0	174
Ellensburg	1,512	787	4	0	0	0	0	0	791
Kittitas	60	55	0	0	0	0	0	0	55
Roslyn	69	16	0	0	0	0	0	0	16
South Cle Elum	37	61	0	0	0	0	0	0	61
Unincorporated Kittitas County	47,309	698	6	0	67	0	1	0	772
Total	**49,662**	**1,790**	**11**	**0**	**67**	**0**	**1**	**0**	**1,869**

Exposed Value

Table 11-5 and Table 11-6 summarize the estimated value of exposed buildings in the planning area. This methodology estimates over $205 million worth of building-and-contents exposure to the 100-year flood, representing 4.5 percent of the total assessed value of the planning area, and $368 million worth of building-and-contents exposure to the 500-year flood, representing 8 percent of the total.

Table 11-5. Value of Exposed Buildings Within the 100-Year Floodplain

Jurisdiction	Value of Exposed Buildings	% of Total Assessed Value
Cle Elum	$2,753,280	3.1%
Ellensburg	$31,934,790	3.6%

Jurisdiction	Value of Exposed Buildings	% of Total Assessed Value
Kittitas	$8,135,265	12.3%
Roslyn	$1,886,730	2.8%
South Cle Elum	$40,545	0.5%
Unincorporated Kittitas County	$160,992,545	4.7%
Total	**$205,743,155**	**4.5%**

Table 11-6. Value of Exposed Buildings Within the 500-Year Floodplain

Jurisdiction	Value of Exposed Buildings	% of Total Assessed Value
Cle Elum	$16,576,060	18.8%
Ellensburg	$155,422,385	17.4%
Kittitas	$8,135,265	12.3%
Roslyn	$1,886,730	2.8%
South Cle Elum	$2,152,680	24.6%
Unincorporated Kittitas County	$184,797,285	5.4%
Total	**$368,970,405**	**8.1%**

Zoning in the 100-Year Floodplain

Some land uses are more vulnerable to flooding, such as residential, while others are less vulnerable, such as agricultural land or parks. Table 11-7 shows the general zoning of parcels in the 100-year and 500-year floodplain. About 6 percent of the parcels in the 100-year floodplain are zoned for agricultural uses, with 10% zoned as forest and range. These are favorable, lower-risk uses for the floodplain. The amount of the floodplain that contains vacant, developable land is not known. This would be valuable information for gauging the future development potential of the floodplain.

Table 11-7. General Zoning within the Floodplain (100- and 500-Year) of Kittitas County

Zoning	100-Year Floodplain		500-Year Floodplain	
	Area (acres)	% of total	Area (acres)	% of total
Agriculture	8,066	6%	449	<1%
Commercial	9,669	8%	552	<1%
Forest & Range	12,120	10%	349	<1%
Incorporated City	1,265	1%	445	<1%
Industrial	536	<1%	10	<1%
Master Planned Resort	779	1%	41	<1%
Planned Unit Development	130	<1%	16	<1%
Residential	3,019	2%	240	<1%
Urban Growth Area	3,225	3%	682	1%
Total	**38,807**	**31%**	**2,785**	**2%**

11.5.3 Critical Facilities

Table 11-8 and Table 11-9 summarize the critical facilities in the 100-year and 500-year floodplains of Kittitas County. Details are provided in the following sections.

Table 11-8 Critical Facilities in the 100-Year Floodplain

Jurisdiction	Fire Station	Hospital	Emergency Facility	School	Total
Cle Elum	0	0	0	0	0
Ellensburg	1	0	1	0	2
Kittitas	0	0	0	0	0
Roslyn	0	0	0	0	0
South Cle Elum	0	0	0	0	0
Unincorporated Kittitas County	2	0	0	2	4
Total	**3**	**0**	**1**	**2**	**6**

Table 11-9 Critical Facilities in the 500-Year Floodplain

Jurisdiction	Fire Station	Hospital	Emergency Facility	School	Total
Cle Elum	2	0	0	0	2
Ellensburg	1	0	1	1	3
Kittitas	0	0	0	0	0
Roslyn	0	0	0	0	0
South Cle Elum	0	0	0	0	0
Unincorporated Kittitas County	2	0	0	3	5
Total	**5**	**0**	**1**	**4**	**10**

Tier II Facilities

Tier II facilities are those that use or store materials that can harm the environment if damaged by a flood. During a flood event, containers holding these materials can rupture and leak into the surrounding area, having a disastrous effect on the environment as well as residents.

Utilities and Infrastructure

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. Water and sewer systems can be flooded or backed up, causing health problems. Underground utilities can be damaged. Dikes can fail or be overtopped, inundating the land that they protect. The following sections describe specific types of critical infrastructure.

Roads

The following major roads in Kittitas County pass through the 100-year floodplain and thus are exposed to flooding:

- Interstate 82
- State Route 821

- Interstate 90
- State Route 10
- State Route 970
- U.S. Route 97

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.

Water and Sewer Infrastructure

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

Levees

Levees have historically been used to control flooding in potions of Kittitas County. According to County GIS records, there are approximately 17 miles of earthen levees in the county. There are also levees on many smaller rivers, streams and creeks that protect small areas of land. Many of the levees are older and were built under earlier flood management goals. Many of these older levees are exposed to scouring and failure due to old age and construction methods.

11.5.4 Environment

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

11.6. VULNERABILITY

Many of the areas exposed to flooding may not experience serious flooding or flood damage. This section describes vulnerabilities in terms of population, property, infrastructure and environment.

11.6.1 Population

A geographic analysis of demographics, using the Hazus model and data from the U.S. Census Bureau, identified populations vulnerable to the flood hazards. The information was pulled from census blocks that intersected the floodplain as follows:

- **Economically Disadvantaged Populations**—Approximately 6 percent of the people within the 100-year or 500-year floodplain are economically disadvantaged, defined as having household incomes of $10,000 or less.
- **Population Below Poverty Level**— Approximately 17 percent of the people within the 100-year or 500-year floodplain live below the poverty line, defined as having household incomes of $30,000 or less.

- **Population over 65 Years Old**— Approximately 6 percent of the population in the census blocks that intersect the 100-year or 500-year floodplain are over 65 years old.
- **Population under 16 Years Old**— Approximately 9 percent of the population within census blocks located in or near the 100-year or 500-year floodplain are under 16 years of age.

11.6.2 Property

Hazus calculates losses to structures from flooding 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. For this analysis, local data on structures was used instead of the default inventory data provided with Hazus. The analysis is summarized in Table 11-10 and Table 11-11 for the 100-year and 500-year flood events, respectively.

Table 11-10. Estimated Flood Loss for the 100-Year Flood Event (Hazus-Generated)

Jurisdiction	Value of Exposed Buildings	% of Total Assessed Value in Jurisdiction
Cle Elum	$75,821	0.1%
Ellensburg	$0	0.0%
Kittitas	$0	0.0%
Roslyn	$0	0.0%
South Cle Elum	$2,018	0.0%
Unincorporated Kittitas County	$5,956,810	0.2%
Total	$6,034,649	**0.1%**

Table 11-11. Estimated Flood Loss for the 500-Year Flood Event (Hazus-Generated)

Jurisdiction	Value of Exposed Buildings	% of Total Assessed Value in Jurisdiction
Cle Elum	$126,001	0.1%
Ellensburg	$0	0
Kittitas	$0	0
Roslyn	$0	0
South Cle Elum	$4,536	0.1%
Unincorporated Kittitas County	$13,929,380	0.4%
Total	$14,059,917	0.3%

It is estimated that there would be up to $6 million of flood loss from a 100-year flood event in the planning area. This represents 18 percent of the total exposure to the 100-year flood and 0.1 percent of the total assessed value for the county. It is estimated that there would be $14 million of flood loss from a 500-year flood event, representing 28 percent of the total exposure to a 500-year flood event and 0.3 percent of the total assessed value.

National Flood Insurance Program

Table 11-12 lists flood insurance statistics that help identify vulnerability in Kittitas County. Six communities in the planning area participate in the NFIP, with 433 flood insurance policies providing

$106 million in coverage, as of September 29, 2018. According to FEMA statistics, 197 flood insurance claims were paid between 1978 and 2018, for a total of $2.3 million, an average of $11,531 per claim.

Properties constructed after a FIRM has been adopted are eligible for reduced flood insurance rates. Such structures are less vulnerable to flooding since they were constructed after regulations and codes were adopted to decrease vulnerability. Properties built before a FIRM is adopted are more vulnerable to flooding because they do not meet code or are located in hazardous areas. The first FIRMs in Kittitas County were available in 1981.

Table 11-12. Flood Insurance Statistics for Kittitas County

Jurisdiction	Date of Entry Initial FIRM Effective Date	# of Flood Insurance Policies in Force as of Sept 29, 2018	Total Coverage (Building and Contents)	Number of Claims, 1978 to 2018	Value of Claims paid, 1978 to 2018
Cle Elum	05/05/1981	12	$2,968,900	16	$147,440
Ellensburg	05/05/1981	61	$14,203,700	14	$114,545
Kittitas	04/15/1982	2	$556,000	5	$10,509
Roslyn	06/05/1985	1	$291,000	0	$0
South Cle Elum	05/05/1981	2	$500,000	0	$0
Unincorporated Kittitas County	05/05/1981	355	$87,827,500	162	$1,999,192
Total	**-**	**433**	**$106,347,100**	**197**	**$2,271,687**

The following information from flood insurance statistics is relevant to reducing flood risk:

- There are a total of 433 Active Insurance Policies in Kittitas County. 59 percent of the Active Policies are in a floodplain, and of those, 93 percent are in the 100-year floodplain.
- There are 1,790 residential structures in the floodplain, 75 percent of which are single family structures. 45 percent of all single family structure in the floodplain are in the 100-year floodplain. Only 9.6 percent of the total residential structures in the county are single family structures in a floodplain.
- The average claim paid in the planning area represents about 5 percent of the 2018 average assessed value of structures in the floodplain.

The percentage of policies and claims outside a mapped floodplain suggests that not all of the flood risk in the planning area is reflected in current mapping. One way to understand flood risk outside the mapped floodplains is to consider where active policies and historical claims are located. Based on information from the NFIP, 41 percent of active policies and 36 percent of historic claims are for structures outside an identified special flood hazard area. Of the total value of claims paid, 24 percent were for properties outside an identified 100- or 500-year floodplain. Figure 11-5 shows the location of historical flood insurance claims since 1978, aggregated by census block.

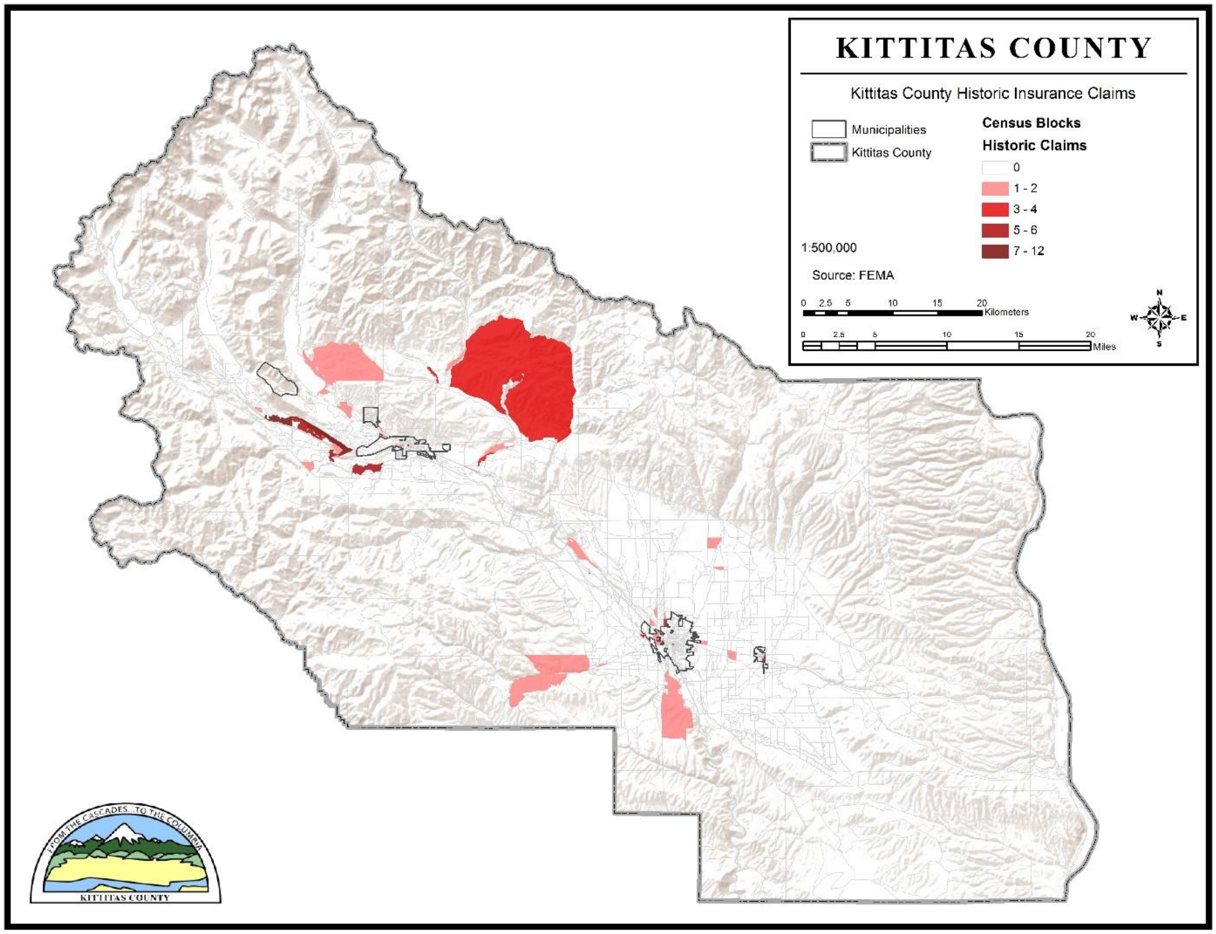


Figure 11-5. Historic Flood Insurance Claims by Census Block, 1978 to 2018

Repetitive Loss

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 20 percent of the nation's flood insurance claims. In 1998, FEMA reported that the NFIP's 75,000 repetitive loss structures have 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 recent report on repetitive losses by the National Wildlife Federation found that 20 percent of these properties are outside any mapped 100-year floodplain. The key identifiers for repetitive loss properties are the existence of flood insurance policies and claims paid by the policies.

FEMA-sponsored programs, such as the CRS, require participating communities to identify repetitive loss areas. A repetitive loss area is the portion of a floodplain holding structures that FEMA has identified as meeting the definition of repetitive loss. Identifying repetitive loss areas helps to identify structures that are at risk but are not on FEMA's list of repetitive loss structures because no flood insurance policy was in force at the time of loss. Figure 11-6 shows the repetitive loss areas in Kittitas County, represented by the number of repetitive loss properties within census blocks. FEMA's list of repetitive loss properties identifies 14 such properties in the Kittitas County planning area as of September 29, 2018. None of these properties have been identified as "severe repetitive loss" according to FEMA criteria. Information on the building type of each property was unavailable. The breakdown of the properties by jurisdiction is presented in Figure 11-6.

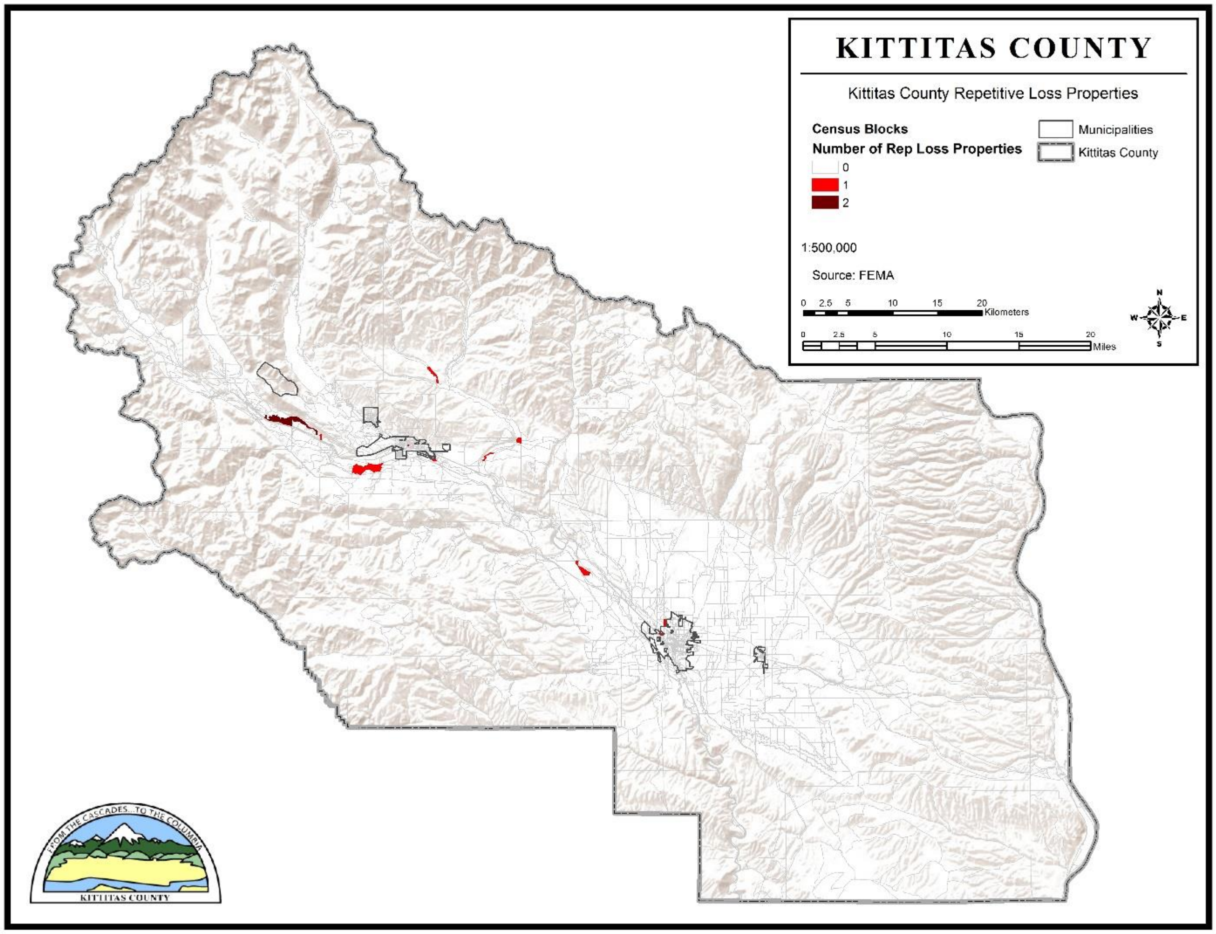


Figure 11-6. Repetitive Loss Properties in Kittitas County, Aggregated by Census Block

Five of the properties on the repetitive loss list are outside the County's special flood hazard area. As all of these properties are just outside the special flood hazard area, they were most likely damaged by flood events typical for the floodplain they are adjacent to. Therefore it can be concluded that the overall cause of repetitive flooding is the same as has been identified for the river basins in which each repetitive loss area is found. With the potential for flood events every three to seven years, the County and its planning partners consider all of the mapped floodplain areas as susceptible to repetitive flooding. Kittitas County sends an annual mailer to the owners of repetitive loss properties containing information on protecting properties from repetitive flooding.

Table 11-13. Repetitive Loss Properties in Kittitas County

Jurisdiction	Repetitive Loss Properties	Properties That Have Been Mitigated	Number of Corrections	Corrected Number of Repetitive Loss Properties
Cle Elum	9	0	0	9
Ellensburg	2	0	0	2
Kittitas	0	0	0	0
Roslyn	0	0	0	0
South Cle Elum	0	0	0	0
Unincorporated	3	0	0	3
Total	**14**	**0**	**0**	**14**

11.6.3 Critical Facilities

An exposure analysis was performed by intersecting structures with geographic flood hazard data to identify structures exposed to flood Table 11-14 below shows the number of critical facilities that intersect with the flood hazard are

Table 11-14. Critical Facilities in 100-Year Flood Hazard Area

Jurisdiction	Fire Station	Hospital	Emergency Facility	School	Total
Cle Elum	2	0	0	0	2
Ellensburg	1	0	1	1	3
Kittitas	0	0	0	0	0
Roslyn	0	0	0	0	0
South Cle Elum	0	0	0	0	0
Unincorporated Kittitas County	2	0	0	3	5
Total	**5**	**0**	**1**	**4**	**10**

11.6.4 Environment

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

11.7. FUTURE TRENDS

Kittitas County and its planning partner cities are subject to the provisions of the Washington GMA, which regulates identified critical areas. County critical areas regulations include frequently flooded areas, defined as the FEMA 100-year mapped floodplain. The GMA establishes programs to monitor the densities at which commercial, residential and industrial development occurs under local GMA comprehensive plans and development regulations.

As participants in the NFIP, Kittitas County and the partner cities have adopted flood damage prevention ordinances pursuant to the participation requirements. While these ordinances do not prohibit new development within the floodplain, they include new development provisions that account for the risk inherent to the floodplain.

The combination of the GMA provisions, critical areas regulations and NFIP flood damage prevention provisions equips the municipal planning partners with adequate tools to address new development in the floodplain. As pressures mount for growth into areas with flood risk, these tools could be enhanced with higher regulatory standards to increase the level of risk reduction on new development. Areas likely to flood are not expected to expand significantly based on development trends in the next five years. Additional information on future growth in the County is presented in Chapter 4 of this plan.

11.8. SCENARIO

The primary water courses in Kittitas 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 November and late March. 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.

Flooding events could have a significant impact on the Kittitas County economy. Businesses could be flooded, and be unable to reopen until necessary repairs are made. A FEMA Ready Business report found that 40% of small businesses don't reopen after a hazard event, and 25% more small businesses will close one year after the hazard event. Flooding frequently results in roads and bridges becoming impassable, making it difficult for residents to reach their place of work. With 26% of the population employed in local and state government, there could be major impacts on the basic functioning of the government. Other industries that will be particularly impacted will be Accommodation and Food Service with 18.1 percent of Kittitas County employees, Retail Trade with 12.1 percent, and Health Services with 8.7 percent

11.9. ISSUES

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

- The extent of flood-protection 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.
- The risk associated with the flood hazard overlaps the risk associated with other hazards such as earthquake and landslide losses. This provides an opportunity to seek mitigation alternatives with multiple objectives that can reduce risk for multiple hazards.
- There is no consistency of land-use practices within the planning area or the scope of regulatory floodplain management beyond the minimum requirements of the NFIP.
- Climate change could alter flood conditions in Kittitas 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.
- A buildable-lands analysis that looks at vacant lands and their designated land use would be a valuable tool in helping decision-makers make wise decisions about future development.
- The risk associated with flooding due to canal failure is unknown at this time. Data on this risk need to be gathered to better support communities’ preparedness and response efforts.

CHAPTER 12.
LANDSLIDE

12.1. 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.

DEFINITIONS

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

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

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

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.

12.2. 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 12-1 through Figure 12-4 show 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.

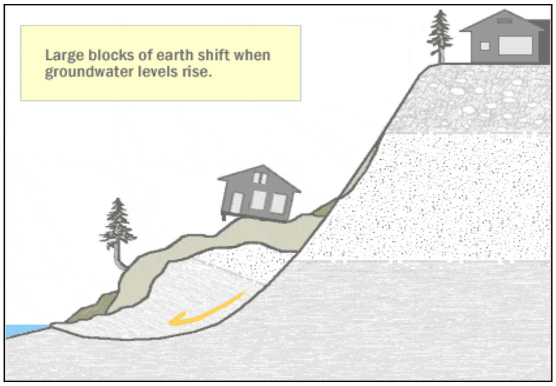


Figure 12-1. Deep Seated Slide

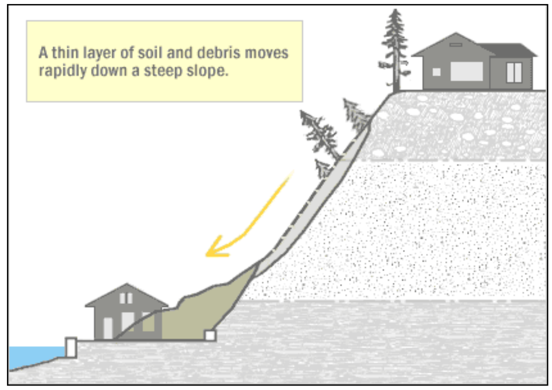


Figure 12-2. Shallow Colluvial Slide

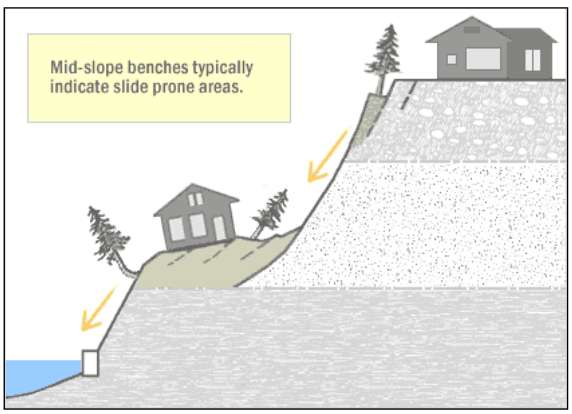


Figure 12-3. Bench Slide

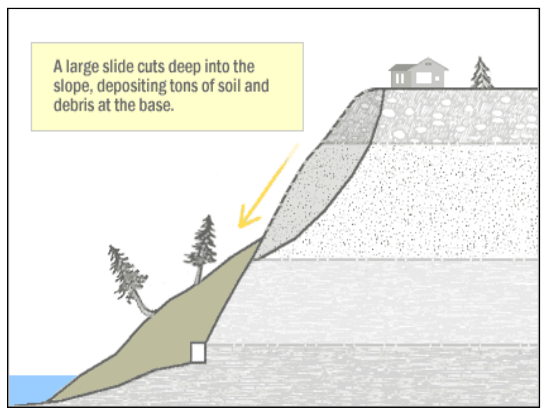


Figure 12-4. Large Slide

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.

12.2.1 Past Events

There is little recorded information regarding landslides in Kittitas County. According to the Spatial Hazard Events and Losses Database for the United States (SHELDUS), there have been four recorded landslide events in Kittitas County since 1960. These events occurred on January 26, 1965, December 18, 1972, and October 11, 2009. All of these events coincided with presidential disaster declarations for severe storms and flooding. The combined estimated damage for these events amounts to $15 million. In addition, while not recorded in the SHELDUS database, there were disaster declarations for Kittitas County that included landslide events on January 17, 1997, January 6, 2009, January 11, 2011, and November 12, 2015. There are no records in the county of fatalities attributed to mass movement. However, deaths have occurred across the west coast as a result of slides and slope collapses. The Oso Landslide of 2014 in Snohomish County, WA provides context for the worst case scenario. This event caused 43 fatalities, and destroyed 40 homes as well as nearly a mile of State Route 530. The landslide moved about 18 million tons of sand, till, and clay at an average speed of 40 mph.

Location

The best available predictor of where movement of slides and earth flows might occur is the location of past movements. Past landslides can be recognized by their distinctive topographic shapes, which can remain in place for thousands of years. Most landslides recognizable in this fashion range from a few acres to several square miles. Most show no evidence of recent movement and are not currently active. A small proportion of them may become active in any given year, with movements concentrated within all or part of the landslide masses or around their edges.

The recognition of ancient dormant mass movement sites is important in the identification of areas susceptible to flows and slides because they can be reactivated by earthquakes or by exceptionally wet weather. Also, because they consist of broken materials and frequently involve disruption of groundwater flow, these dormant sites are vulnerable to construction-triggered sliding.

The basis for the mapping for this risk assessment is the Landslide Hazard Zonation Project prepared by the Forest Practices Division of the Washington Department of Natural Resources. Identification of unstable slopes to aid in mitigation of landslide hazards is now an integral part of land management and regulation in Washington. Permanent rules adopted by the Washington Forest Practices Board in 2001 address landslide hazards from specific landforms across the state (WAC 222-16-050 (1)(d)). This methodology was developed to provide standardized methods for landslide inventories and for producing hazard maps to identify unstable slopes in support of forest practices rules. It also provides a framework for monitoring the success of new forest practices related to unstable slopes. The Landslide Hazard Areas for the planning area are shown in Figure 12-5. All buildings within the hazard areas are located in Unincorporated Kittitas County. For additional information on exposure, see Section 12.5.

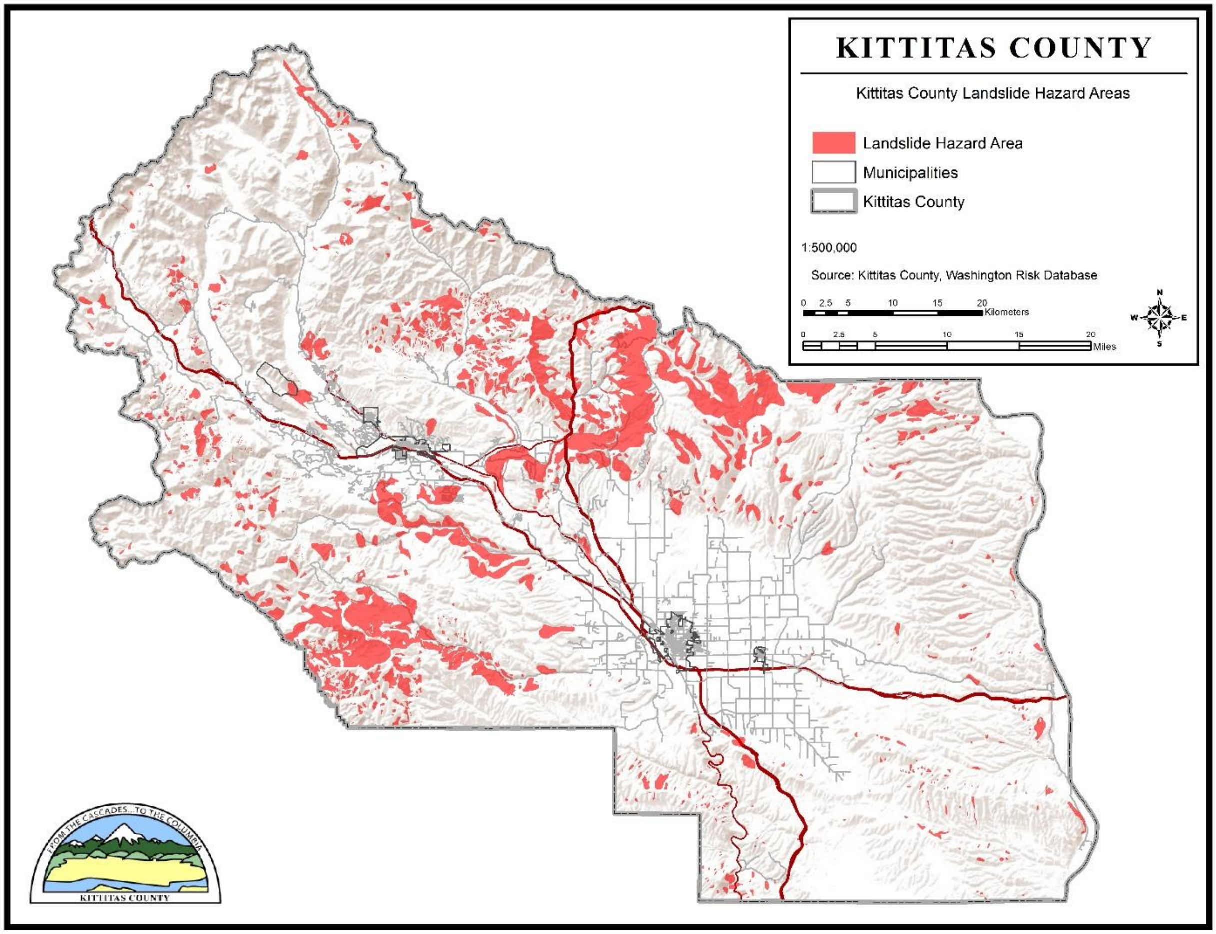


Figure 12-5. Kittitas County Landslide Hazard Areas

12.2.2 Frequency

Landslides are often triggered by other natural hazards such as earthquakes, heavy rain, floods or wildfires, so landslide frequency is often related to the frequency of these other hazards. In Kittitas County, landslides typically occur during and after major storms, so the potential for landslides largely coincides with the potential for sequential severe storms that saturate steep, vulnerable soils. Landslide events occurred during the winter storms of 2009 and 2011. According to SHELDUS records, the planning area has been impacted by severe storms at least once every other year since 1960. Until better data is generated specifically for landslide hazards, this severe storm frequency is appropriate for the purpose of ranking risk associated with the landslide hazard.

In general, landslides are most likely during periods of higher than average rainfall. The ground must be saturated prior to the onset of a major storm for significant landsliding to occur. Most local landslides occur in January after the water table has risen during the wet months of November and December. Water is involved in nearly all cases; and human influence has been identified in more than 80 percent of reported slides.

12.2.3 Severity

Landslides destroy property and infrastructure and can take the lives of people. Slope failures in the United States result in an average of 25 lives lost per year and an annual cost to society of about $1.5 billion. According to SHELDUS, the 1965, 1972, and 2009 storms caused $15 million in property damage due to landslides and other combined hazards.

12.2.4 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

12.3. 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.

12.4. CLIMATE CHANGE IMPACTS

As the occurrence of landslides is typically dependent on other hazards such as earthquakes, severe storms, or wildfires, climate change impacts on these hazards will also impact landslides. Climate change will increase the frequency and intensity of severe storms, and more intense storms are likely to trigger landslides more frequently. Increases in temperatures will reduce snowpack and spring snowmelt, which may reduce the likelihood of spring landslides due to snowmelt. Warming temperatures also could increase the occurrence and duration of droughts and the probability of wildfire, reducing the vegetation that helps to support steep slopes. Overall, the impacts of climate change on various hazards will result in an increased probability for landslide occurrences.

12.5. EXPOSURE

12.5.1 Population

Population could not be examined by landslide hazard area because census block group areas do not coincide with the hazard areas. A population estimate was made using the structure count of residential buildings within the landslide hazard area and applying the census value of 2.32 persons per household for Kittitas County. Using this approach, the estimated population living in the landslide hazard area is 847. This approach could understate the exposure by as much as a factor of two.

12.5.2 Property

Table 12-1 shows the number and assessed value of structures exposed to the landslide risk. There are 365 structures on parcels in the landslide risk areas, with an estimated value of $164 million. Predominant zoning in cities is for single-family, vacant and manufactured homes. Table 12-2 shows the general zoning of parcels exposed to landslides in Kittitas County. Lands zoned for commercial forest uses are most vulnerable. Of all commercial forest land, 15% is located within landslide risk areas.

Table 12-1. Kittitas County Buildings in Landslide Hazard Areas

Jurisdiction	Buildings Exposed	Value of Exposed Buildings	% of Assessed Value
Cle Elum	0	$0	0.0%
Ellensburg	0	$0	0.0%
Kittitas	0	$0	0.0%
Roslyn	0	$0	0.0%
South Cle Elum	0	$0	0.0%
Unincorporated	365	$164,279,000	4.8%
Total	**365**	**$164,279,000**	**3.6%**

Table 12-2. General Zoning in Landslide Risk Areas of Kittitas County

Zoning	Area within Landslide Risk Area (Acres)	% of Total
Agriculture	10,120	2%
Commercial Forest	117,313	15%
Forest & Range	15,470	7%

Zoning	Area within Landslide Risk Area (Acres)	% of Total
Master Planned Resort	154	2%
Planned Unit Development	299	16%
Residential	1,453	5%
Total	144,809	10%

12.5.3 Critical Facilities and Infrastructure

An exposure analysis was performed for critical facilities located in the landslide hazard area. There were no schools, emergency facilities, hospitals, or fire stations in Kittitas County located in the landslide hazard area. While these facilities are not at risk, a significant amount of infrastructure can be exposed to mass movements:

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

12.5.4 Environment

Environmental problems as a result of mass movements can be numerous. Landslides that fall into streams may significantly impact fish and wildlife habitat, as well as affecting water quality. Hillsides that provide wildlife habitat can be lost for prolong periods of time due to landslides.

12.6. VULNERABILITY

12.6.1 Population

Due to the nature of census block group data, it is difficult to determine demographics of populations vulnerable to mass movements. In general, all of the estimated 847 persons exposed to higher risk landslide areas are considered to be vulnerable. Increasing population and the fact that many homes are built on view property atop or below bluffs and on steep slopes subject to mass movement, increases the number of lives endangered by this hazard.

12.6.2 Property

Although complete historical documentation of the landslide threat in Kittitas County is lacking, the landslides of 2009, 2011, and 2015 suggest a significant vulnerability to such hazards. The millions of dollars in damage countywide attributable to mass movement during those storms affected private property and public infrastructure and facilities.

Loss estimations for the landslide hazard are not based on modeling utilizing damage functions, because no such damage functions have been generated. Instead, loss estimates were developed representing 10 percent, 30 percent and 50 percent of the assessed value of exposed structures. This allows emergency managers to select a range of economic impact based on an estimate of the percent of damage to the general building stock. Damage in excess of 50 percent is considered to be substantial by most building codes and typically requires total reconstruction of the structure. Table 12-3 shows the general building stock loss estimates for landslide risk areas.

Table 12-3. Estimated Losses in Landslide Risk Areas

Jurisdiction	Buildings Exposed to Hazard Area	Assessed Value of Buildings Exposed	10% Damage	30% Damage	50% Damage
Cle Elum	0	$0	$0	$0	$0
Ellensburg	0	$0	$0	$0	$0
Kittitas	0	$0	$0	$0	$0
Roslyn	0	$0	$0	$0	$0
South Cle Elum	0	$0	$0	$0	$0
Unincorporated	365	$164,279,000	$16,427,900	$49,283,700	$82,139,510
Total	**365**	**$164,279,000**	**$16,427,900**	**$49,283,700**	**$82,139,510**

12.6.3 Critical Facilities and Infrastructure

There were no critical facilities exposed to the landslide hazard area. Several types of infrastructure are exposed to mass movements, including transportation, water and sewer and power infrastructure. Highly susceptible areas of the county include mountain and coastal roads and transportation infrastructure. At this time all infrastructure and transportation corridors identified as exposed to the landslide hazard are considered vulnerable until more information becomes available.

12.6.4 Environment

The environment vulnerable to landslide hazard is the same as the environment exposed to the hazard.

12.7. FUTURE TRENDS IN DEVELOPMENT

Landslide hazard areas are included in “geologically hazardous areas,” one category of critical areas regulated under the state GMA for Kittitas County. “Landslide hazard areas” are defined as areas potentially subject to mass earth movement based on a combination of geologic, topographic, and hydrologic factors, with a vertical height of 10 feet or more. These include the following:

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

Kittitas County and its planning partners appear to be well equipped to deal with future growth and development within the planning area. The landslide hazard portions of the planning area are regulated by

County Code (Title 17A.06) as well as by the International Building Code. Development will occur in landslide hazards within the planning area, but it will be regulated such that the degree of risk will be reduced through building standards and performance measures.

12.8. SCENARIO

Major landslides in Kittitas 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 late winter when the water table is high. After heavy rains from November to December, 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.

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 bridges that pass over landslide prone ravines and knock out rail service through the county. Road obstructions caused by mass movements would create isolation problems for 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 Kittitas County.

12.9. ISSUES

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

- There are existing homes in landslide risk areas throughout the county. The degree of vulnerability of these structures depends on the codes and standards to which the structures were constructed. 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 13.
SEVERE WEATHER

13.1. 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; 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.

Five types of severe weather events typically impact Kittitas County: thunderstorms, damaging winds, hail storms, heavy snowfall associated with winter storms and flash flooding. Flooding issues associated with severe weather are discussed in Chapter 11. The other four types of severe weather common to Kittitas County are described in the following sections.

13.1.1 Thunderstorms

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

Three factors cause thunderstorms to form: moisture, rising unstable air (air that keeps rising when disturbed), and a lifting mechanism to provide the disturbance. The sun heats the surface of the earth, which warms the air above it. If this warm surface air is forced to rise (hills or mountains can cause rising motion, as can the interaction of warm air and cold air or wet air and dry air) it will continue to rise as long as it weighs less and stays warmer than the air around it. As the air rises, it transfers heat from the surface of the earth to the upper levels of the atmosphere (the process of convection). The water vapor it contains begins to cool and it condenses into a cloud. The cloud eventually grows upward into areas where the temperature is below freezing. Some of the water vapor turns to ice and some of it turns into water droplets. Both have

DEFINITIONS

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

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

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

Tornado—Funnel clouds that generate winds up to 500 miles per hour. They can affect an area up to three-quarters of a mile wide, with a path of varying length. Tornadoes can come from lines of cumulonimbus clouds or from a single storm cloud. They are measured using the Fujita Scale, ranging from F0 to F5.

Windstorm—A storm featuring violent winds. Southwesterly winds are associated with strong storms moving onto the coast from the Pacific Ocean. Southern winds parallel to the coastal mountains are the strongest and most destructive winds. Windstorms tend to damage ridgelines that face into the winds.

Winter Storm—A storm having significant snowfall, ice, and/or freezing rain; the quantity of precipitation varies by elevation.

electrical charges. Ice particles usually have positive charges, and rain droplets usually have negative charges. When the charges build up enough, they are discharged in a bolt of lightning, which causes the sound waves we hear as thunder. Thunderstorms have three stages (see Figure 13-1):

- The ***developing stage*** of a thunderstorm is marked by a cumulus cloud that is being pushed upward by a rising column of air (updraft). The cumulus cloud soon looks like a tower (called towering cumulus) as the updraft continues to develop. There is little to no rain during this stage but occasional lightning. The developing stage lasts about 10 minutes.
- The thunderstorm enters the ***mature stage*** when the updraft continues to feed the storm, but precipitation begins to fall out of the storm, and a downdraft begins (a column of air pushing downward). When the downdraft and rain-cooled air spread out along the ground, they form a gust front, or a line of gusty winds. The mature stage is the most likely time for hail, heavy rain, frequent lightning, strong winds, and tornadoes. The storm occasionally has a black or dark green appearance.
- Eventually, a large amount of precipitation is produced and the updraft is overcome by the downdraft beginning the ***dissipating stage***. At the ground, the gust front moves out a long distance from the storm and cuts off the warm moist air that was feeding the thunderstorm. Rainfall decreases in intensity, but lightning remains a danger.

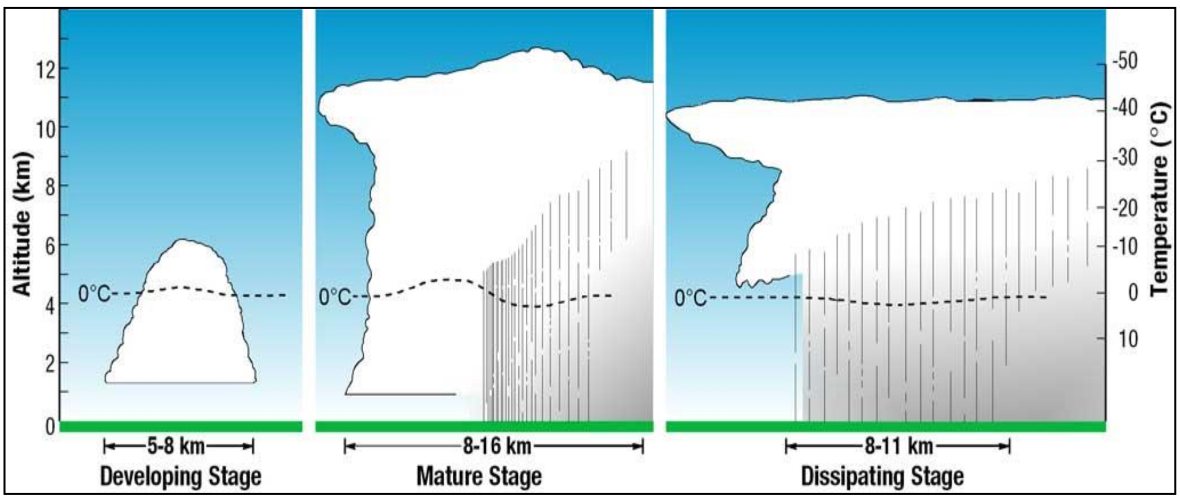


Figure 13-1. The Thunderstorm Life Cycle

There are four types of thunderstorms:

- **Single-Cell Thunderstorms—**Single-cell thunderstorms usually last 20 to 30 minutes. A true single-cell storm is rare, because the gust front of one cell often triggers the growth of another. Most single-cell storms are not usually severe, but a single-cell storm can produce a brief severe weather event. When this happens, it is called a pulse severe storm.
- **Multi-Cell Cluster Storm—**A multi-cell cluster is the most common type of thunderstorm. The multi-cell cluster consists of a group of cells, moving as one unit, with each cell in a different phase of the thunderstorm life cycle. Mature cells are usually found at the center of the cluster and dissipating cells at the downwind edge. Multi-cell cluster storms can produce moderate-size hail, flash floods and weak tornadoes. Each cell in a multi-cell cluster lasts only about 20 minutes; the multi-cell cluster itself may persist for several hours. This type of storm is usually more intense than a single cell storm.

- **Multi-Cell Squall Line—**A multi-cell line storm, or squall line, consists of a long line of storms with a continuous well-developed gust front at the leading edge. The line of storms can be solid, or there can be gaps and breaks in the line. Squall lines can produce hail up to golf-ball size, heavy rainfall, and weak tornadoes, but they are best known as the producers of strong downdrafts. Occasionally, a strong downburst will accelerate a portion of the squall line ahead of the rest of the line. This produces what is called a bow echo. Bow echoes can develop with isolated cells as well as squall lines. Bow echoes are easily detected on radar but are difficult to observe visually.
- **Super-Cell Storm—**A super-cell is a highly organized thunderstorm that poses a high threat to life and property. It is similar to a single-cell storm in that it has one main updraft, but the updraft is extremely strong, reaching speeds of 150 to 175 miles per hour. Super-cells are rare. The main characteristic that sets them apart from other thunderstorms is the presence of rotation. The rotating updraft of a super-cell (called a mesocyclone when visible on radar) helps the super-cell to produce extreme weather events, such as giant hail (more than 2 inches in diameter), strong downbursts of 80 miles an hour or more, and strong to violent tornadoes.

13.1.2 Damaging Winds

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

- **Straight-line winds—**Any thunderstorm wind that is not associated with rotation; this term is used mainly to differentiate from tornado winds. Most thunderstorms produce some straight-line winds as a result of outflow generated by the thunderstorm downdraft.
- **Downdrafts—**A small-scale column of air that rapidly sinks toward the ground.
- **Downbursts—**A strong downdraft with horizontal dimensions larger than 2.5 miles resulting in an outward burst or damaging winds on or near the ground. Downburst winds may begin as a microburst and spread out over a wider area, sometimes producing damage similar to a strong tornado. Although usually associated with thunderstorms, downbursts can occur with showers too weak to produce thunder.
- **Microbursts—**A small concentrated downburst that produces an outward burst of damaging winds at the surface. Microbursts are generally less than 2.5 miles across and short-lived, lasting only 5 to 10 minutes, with maximum wind speeds up to 168 mph. There are two kinds of microbursts: wet and dry. A wet microburst is accompanied by heavy precipitation at the surface. Dry microbursts, common in places like the high plains and the intermountain west, occur with little or no precipitation reaching the ground.
- **Gust front—**A gust front is the leading edge of rain-cooled air that clashes with warmer thunderstorm inflow. Gust fronts are characterized by a wind shift, temperature drop, and gusty winds out ahead of a thunderstorm. Sometimes the winds push up air above them, forming a shelf cloud or detached roll cloud.
- **Derecho—**A derecho is a widespread thunderstorm wind caused when new thunderstorms form along the leading edge of an outflow boundary (the boundary formed by horizontal spreading of thunderstorm-cooled air). The word “derecho” is of Spanish origin and means “straight ahead.” Thunderstorms feed on the boundary and continue to reproduce. Derechos typically occur in summer when complexes of thunderstorms form over plains, producing heavy rain and severe wind. The damaging winds can last a long time and cover a large area.

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

13.1.3 Hail Storms

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

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

Hailstones can have layers like an onion if they travel up and down in an updraft, or they can have few or no layers if they are “balanced” in an updraft. One can tell how many times a hailstone traveled to the top of the storm by counting its layers. Hailstones can begin to melt and then re-freeze together, forming large and very irregularly shaped hail.

13.1.4 Winter Storms/Heavy Snow

The National Weather Service defines a 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. There are three key ingredients to a severe winter storm:

- Cold Air—Below-freezing temperatures in the clouds and near the ground are necessary to make snow and/or ice.
- Moisture—Moisture is required in order to form clouds and precipitation. Air blowing across a body of water, such as a large lake or the ocean, is an excellent source of moisture.
- Lift—Lift is required in order to raise the moist air to form the clouds and cause precipitation. An example of lift is warm air colliding with cold air and being forced to rise over the cold dome. The boundary between the warm and cold air masses is called a front. Another example of lift is air flowing up a mountain side.

Strong storms crossing the North Pacific sometimes slam into the coast from California to Washington. The Pacific provides a virtually unlimited source of moisture for storms. If the air is cold enough, snow falls over Washington and Oregon and sometimes in California. As the moisture rises into the mountains, heavy snow closes the mountain passes and can cause avalanches. Cold air from the north has to filter through mountain canyons into the basins and valleys to the south. If the cold air is deep enough, it can spill over the mountain ridge. As the air funnels through canyons and over ridges, wind speeds can reach 100 mph, damaging roofs and taking down power and telephone lines. Combining these winds with snow results in a blizzard.

Heavy snow can immobilize a region and paralyze a city, stranding commuters, stopping the flow of supplies, and disrupting emergency and medical services. Accumulations of snow can collapse buildings and knock down trees and power lines. In rural areas, homes and farms may be isolated for days, and unprotected livestock may be lost. In the mountains, heavy snow can lead to avalanches. The cost of snow removal, repairing damages, and loss of business can have large economic impacts on cities and towns.

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.

13.2. HAZARD PROFILE

13.2.1 Past Events

Table 13-1 summarizes severe weather events in Kittitas County since 1970, as recorded by the National Centers for Environmental Information Storm Events Database. Within the database, severe weather events are classified as cold/wind chill, extreme cold/wind chill, hail, heavy rain, heavy snow, high wind, ice storm, lightning, strong wind, thunderstorm wind, winter storm, or winter weather. Collection of data on thunderstorm wind and hail events began in 1955, while data on all other hazard events began being collected in 1996.

Table 13-1. Severe Weather Events Impacting Planning Area Since 1970 (NCEI)

Date	Event Type	Event Location	Property Damages
5/12/1988	Thunderstorm Wind	Kittitas County	None Recorded
11/19/1996	Heavy Snow	Kittitas County	None Recorded
12/27/1996	Heavy Snow	Kittitas County	None Recorded
12/28/1996	Heavy Snow	Kittitas County	None Recorded
12/28/1996	Heavy Snow	Kittitas County	None Recorded
12/29/1996	Heavy Snow	Kittitas County	None Recorded
12/30/1996	Heavy Snow	Kittitas County	None Recorded
6/6/1998	Heavy Rain	Kittitas County, Cle Elum	None Recorded
12/1/1998	Heavy Snow	Kittitas County	None Recorded
12/5/1998	Heavy Snow	East Kittitas County	None Recorded
12/25/1998	Winter Storm	Kittitas County	None Recorded
12/27/1998	Heavy Snow	Kittitas County	None Recorded
1/22/1999	Heavy Snow	Kittitas County	None Recorded
2/2/1999	High Wind	Kittitas County	None Recorded
1/15/2000	Heavy Snow	East Kittitas County	None Recorded
11/29/2000	Heavy Snow	East Kittitas County	None Recorded
12/15/2000	High Wind	Kittitas County	None Recorded
12/23/2000	Heavy Snow	East Kittitas County	None Recorded

Date	Event Type	Event Location	Property Damages
5/19/2001	High Wind	Kittitas County	$20,000.00
10/16/2001	High Wind	East Kittitas County	None Recorded
11/28/2001	Heavy Snow	Kittitas County	None Recorded
10/30/2002	Extreme Cold/Wind Chill	Kittitas County	None Recorded
11/1/2002	Extreme Cold/Wind Chill	East Kittitas County	None Recorded
12/26/2002	Heavy Snow	East Kittitas County	None Recorded
1/22/2003	Heavy Snow	Kittitas County	None Recorded
3/7/2003	Heavy Snow	East Kittitas County	None Recorded
11/19/2003	High Wind	East Kittitas County	None Recorded
12/1/2003	Heavy Snow	East Kittitas County	None Recorded
12/13/2003	Heavy Snow	East Kittitas County	None Recorded
1/1/2004	Heavy Snow	East Kittitas County	None Recorded
1/4/2004	Cold/Wind Chill	Kittitas County	None Recorded
1/6/2004	Heavy Snow	East Kittitas County	None Recorded
1/8/2004	Ice Storm	East Kittitas County	None Recorded
1/28/2004	Winter Weather	East Kittitas County	None Recorded
2/25/2004	Heavy Snow	Kittitas County	None Recorded
4/27/2004	Strong Wind	East Kittitas County	$1,000.00
12/19/2004	High Wind	East Kittitas County	None Recorded
12/29/2004	Heavy Snow	East Kittitas County	None Recorded
1/1/2005	Winter Weather	Kittitas County	None Recorded
1/7/2005	Heavy Snow	Kittitas County	None Recorded
1/15/2005	Heavy Snow	East Kittitas County	None Recorded
1/17/2005	Ice Storm	East Kittitas County	None Recorded
6/21/2005	Strong Wind	East Kittitas County	$1,000.00
12/1/2005	Heavy Snow	Kittitas County	None Recorded
7/4/2006	Hail	Kittitas County, Cle Elum	None Recorded
7/5/2006	Hail	Kittitas County, Roslyn	None Recorded
7/5/2006	Hail	Kittitas County, Cle Elum	None Recorded
11/6/2006	Heavy Rain	Kittitas County, Easton	None Recorded
11/26/2006	Heavy Snow	Kittitas County	None Recorded
12/14/2006	Winter Storm	Kittitas County	None Recorded
12/23/2006	Heavy Snow	Kittitas County	None Recorded

Date	Event Type	Event Location	Property Damages
12/25/2006	Heavy Snow	Kittitas County	None Recorded
1/29/2007	High Wind	Kittitas County	$7,000.00
12/1/2007	Heavy Snow	Kittitas County	None Recorded
1/8/2008	Heavy Snow	Kittitas County	None Recorded
7/1/2008	Hail	Kittitas County, Ellensburg	None Recorded
12/17/2008	Heavy Snow	Kittitas County	None Recorded
12/20/2008	Heavy Snow	Kittitas County	None Recorded
1/6/2009	High Wind	Kittitas County	None Recorded
6/13/2009	Heavy Rain	Kittitas County, Cle Elum	None Recorded
6/13/2009	Heavy Rain	Kittitas County, Ellensburg	None Recorded
12/14/2009	Heavy Snow	Kittitas County	None Recorded
12/31/2009	Heavy Snow	Kittitas County	None Recorded
7/12/2010	High Wind	Kittitas County	None Recorded
9/19/2010	Lightning	Kittitas County, Ellensburg	$60,000.00
11/15/2010	High Wind	East Slopes of the Washington Cascades	$100,000.00
11/21/2010	Heavy Snow	Kittitas County	None Recorded
11/21/2010	Heavy Snow	East Slopes of the Washington Cascades	None Recorded
11/23/2010	Extreme Cold/Wind Chill	East Slopes of the Washington Cascades	None Recorded
11/23/2010	Extreme Cold/Wind Chill	Kittitas County	None Recorded
11/30/2010	Heavy Snow	East Slopes of the Washington Cascades	None Recorded
12/11/2010	Heavy Snow	East Slopes of the Washington Cascades	None Recorded
12/11/2010	Heavy Snow	Kittitas County	None Recorded
1/8/2011	Heavy Snow	East Slopes of the Washington Cascades	None Recorded
1/11/2011	Heavy Snow	Kittitas County	None Recorded
1/11/2011	Heavy Snow	East Slopes of the Washington Cascades	None Recorded
2/12/2011	Strong Wind	Kittitas County	$10,000.00
2/21/2011	Heavy Snow	East Slopes of the Washington Cascades	None Recorded
2/27/2011	Heavy Snow	East Slopes of the Washington Cascades	None Recorded
5/14/2011	Lightning	Kittitas County	$300,000.00
11/14/2011	High Wind	East Slopes of the Washington Cascades	$1,000.00
11/17/2011	Heavy Snow	East Slopes of the Washington Cascades	None Recorded
1/16/2012	Heavy Snow	East Slopes of the Washington Cascades	None Recorded
2/28/2012	Heavy Snow	East Slopes of the Washington Cascades	None Recorded

Date	Event Type	Event Location	Property Damages
3/20/2012	Heavy Snow	East Slopes of the Washington Cascades	None Recorded
7/17/2012	Heavy Rain	Kittitas County, Ellensburg	None Recorded
11/12/2012	Heavy Snow	East Slopes of the Washington Cascades	None Recorded
12/7/2012	Heavy Snow	East Slopes of the Washington Cascades	None Recorded
12/16/2012	Winter Storm	East Slopes of the Washington Cascades	None Recorded
12/16/2012	Winter Storm	Kittitas County	None Recorded
12/19/2012	Winter Storm	East Slopes of the Washington Cascades	None Recorded
12/25/2012	Heavy Snow	East Slopes of the Washington Cascades	None Recorded
12/25/2012	Heavy Snow	Kittitas County	None Recorded
1/7/2013	Heavy Snow	East Slopes of the Washington Cascades	None Recorded
4/14/2013	Heavy Snow	East Slopes of the Washington Cascades	None Recorded
6/29/2013	Hail	Kittitas County	None Recorded
8/10/2013	Hail	Kittitas County, Easton	None Recorded
1/10/2014	High Wind	East Slopes of the Washington Cascades	None Recorded
1/11/2014	High Wind	East Slopes of the Washington Cascades	None Recorded
1/13/2014	High Wind	East Slopes of the Washington Cascades	None Recorded
2/8/2014	Heavy Snow	East Slopes of the Washington Cascades	None Recorded
2/8/2014	Heavy Snow	Kittitas County	None Recorded
2/16/2014	Heavy Snow	East Slopes of the Washington Cascades	None Recorded
11/13/2014	Heavy Snow	East Slopes of the Washington Cascades	None Recorded
12/4/2014	Ice Storm	East Slopes of the Washington Cascades	None Recorded
1/4/2015	Heavy Snow	East Slopes of the Washington Cascades	None Recorded
5/29/2015	Hail	Kittitas County, Teanaway	None Recorded
11/17/2015	High Wind	East Slopes of the Washington Cascades	None Recorded
12/17/2015	Heavy Snow	East Slopes of the Washington Cascades	None Recorded
12/17/2015	Heavy Snow	Kittitas County	None Recorded
12/21/2015	Heavy Snow	East Slopes of the Washington Cascades	None Recorded
12/21/2015	Heavy Snow	Kittitas County	None Recorded
12/8/2016	Heavy Snow	East Slopes of the Washington Cascades	None Recorded
12/8/2016	Heavy Snow	East Slopes of the Washington Cascades	None Recorded
12/26/2016	Heavy Snow	East Slopes of the Washington Cascades	None Recorded
12/26/2016	Heavy Snow	East Slopes of the Washington Cascades	None Recorded
1/7/2017	Heavy Snow	East Slopes of the Washington Cascades	None Recorded

Date	Event Type	Event Location	Property Damages
1/7/2017	Heavy Snow	Kittitas County	None Recorded
1/17/2017	Ice Storm	East Slopes of the Washington Cascades	None Recorded
1/17/2017	Ice Storm	Kittitas County	None Recorded
2/2/2017	Heavy Snow	East Slopes of the Washington Cascades	None Recorded
2/5/2017	Heavy Snow	East Slopes of the Washington Cascades	None Recorded
2/5/2017	Heavy Snow	Kittitas County	None Recorded
2/8/2017	Winter Storm	East Slopes of the Washington Cascades	None Recorded
2/8/2017	Heavy Snow	Kittitas County	None Recorded
3/6/2017	Heavy Snow	East Slopes of the Washington Cascades	None Recorded
12/28/2017	Heavy Snow	East Slopes of the Washington Cascades	None Recorded
12/28/2017	Ice Storm	Kittitas County	None Recorded
1/10/2018	Heavy Snow	East Slopes of the Washington Cascades	None Recorded
1/23/2018	Heavy Snow	East Slopes of the Washington Cascades	None Recorded
1/25/2018	Heavy Snow	East Slopes of the Washington Cascades	None Recorded
4/27/2018	High Wind	Kittitas County	None Recorded

Historic events provide context for the most severe potential events. According to the National Weather Service Forecast Office in Pendleton, Oregon, the largest daily snowfall from 1999 to present in Ellensburg was 9.0 inches on December 6th, 2001. The overall Ellensburg record is 19 inches of snowfall, which occurred on February 2, 1916. Tuesday, February 12, 2019 saw the largest snowfall in a 24-hour period on Snoqualmie Pass. Crews recorded 31.5 inches of snow near Hyak Sno-Park according to the Washing State Department of Transportation. The lowest temperature on record in Ellensburg was -31 degrees Fahrenheit, and occurred on December 12th, 1919. According to the Western Regional Climate Center, Ellensburg had the highest annual average wind speed in the state from 1998 to 2006. The Wild Horse Wind and Solar Facility in Ellensburg has recorded wind speeds up to 117 mph. Historical records for tornados and hail is unavailable.

13.2.2 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 most damaging to areas that are heavily wooded. Figure 13-2, Figure 13-3, Figure 13-4, and Figure 13-5 show the distribution of average weather conditions over Kittitas County.

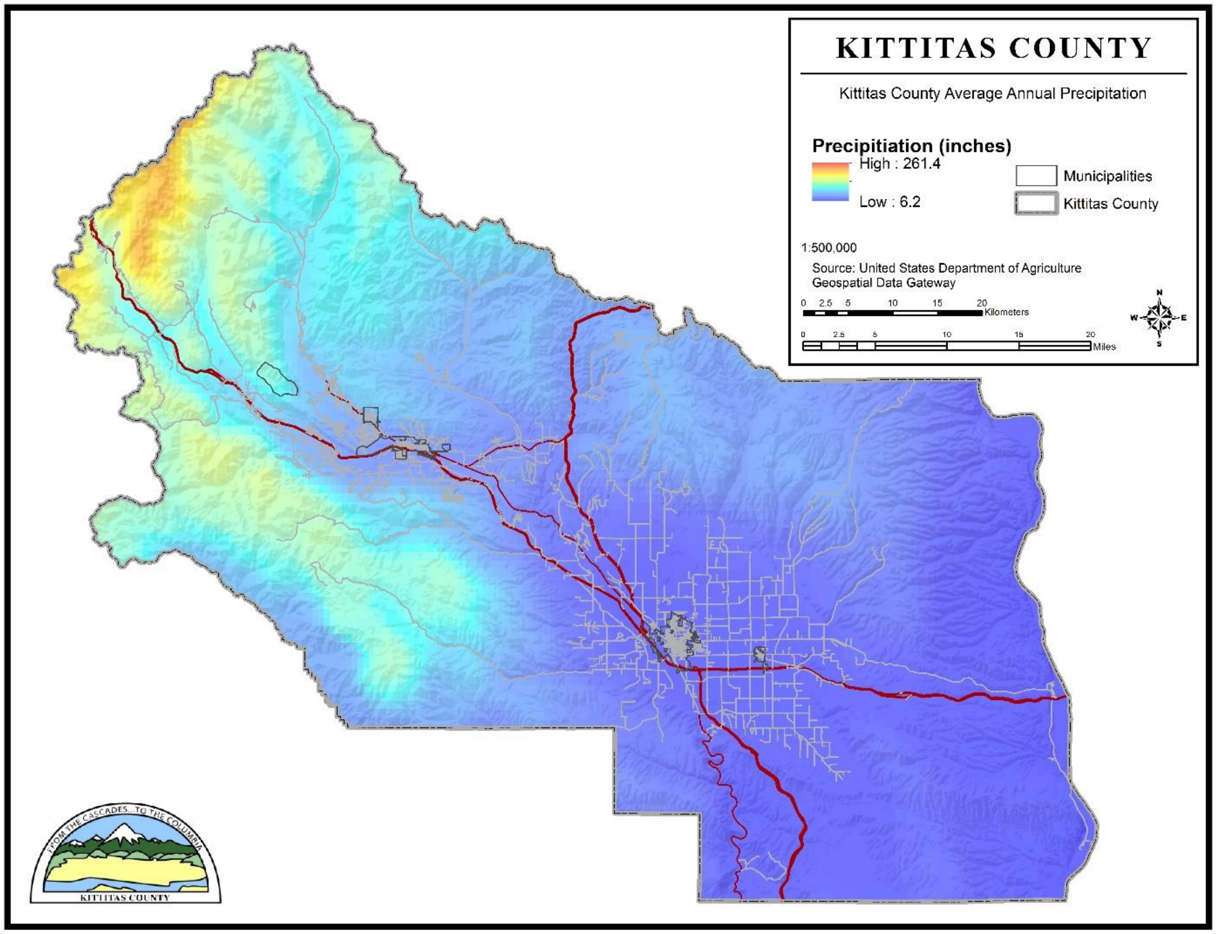


Figure 13-2. Kittitas County Average Annual Precipitation

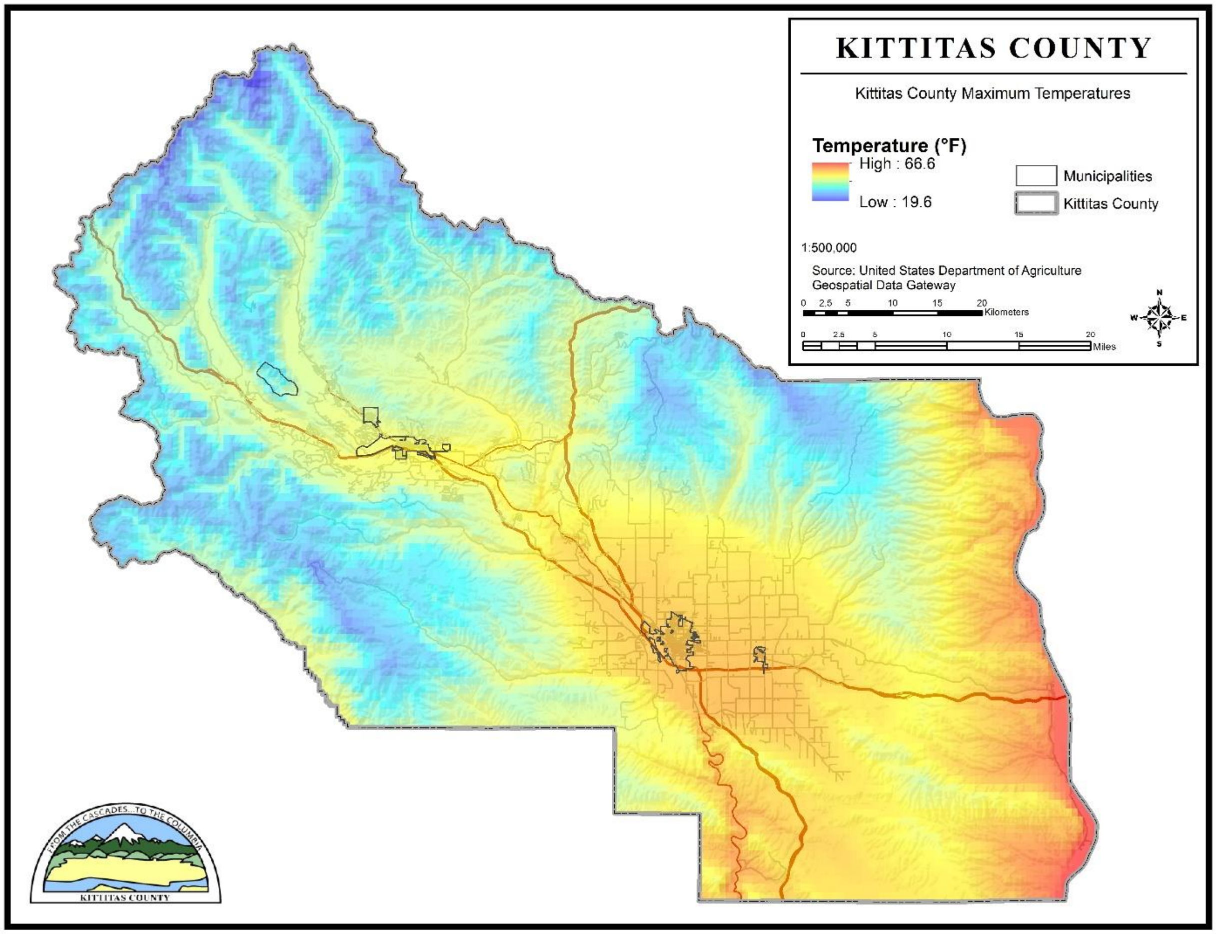


Figure 13-3. Kittitas County Maximum Temperatures

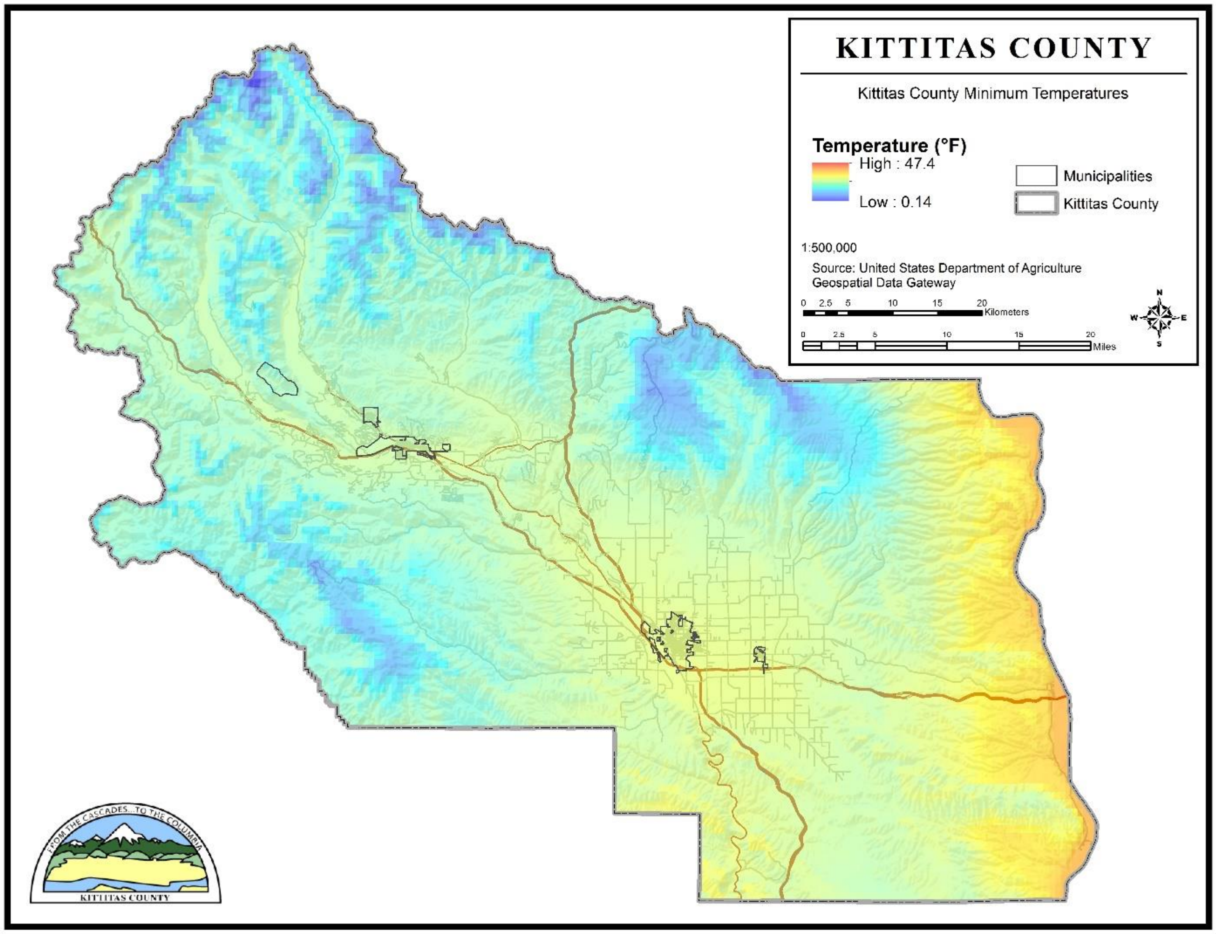


Figure 13-4. Kittitas County Minimum Temperatures

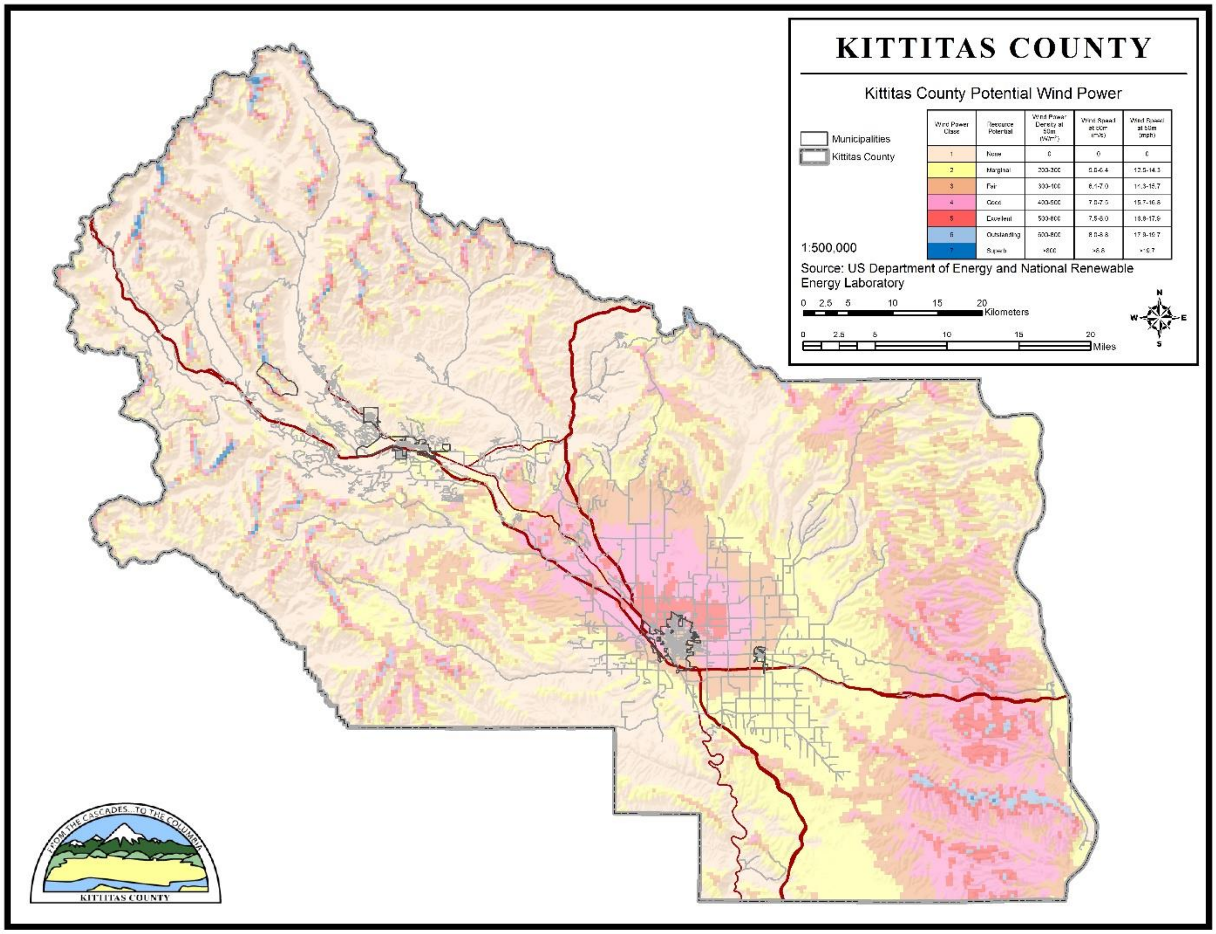


Figure 13-5. Kittitas County Potential Wind Power

13.2.3 Frequency

The severe weather events for Kittitas County shown in Table 13-1 are often related to high winds associated with winter storms and thunderstorms. The planning area can expect to experience exposure to some type of severe weather event at least annually. According to the Washington State Enhanced Hazard Mitigation Plan, Kittitas County has experienced 108 severe weather events from 1960 to 2017, which means that historically, the county experiences almost two events every year.

13.2.4 Severity

The most common problems associated with severe storms are immobility and loss of utilities. The National Weather Service refers to winter storms as “Deceptive Killers” because most deaths are indirectly related to the storm. Instead, people die in traffic accidents on icy roads and of hypothermia from prolonged exposure to cold. It is important to be prepared for winter weather before it strikes.

Roads may become impassable due to flooding, downed trees, ice or snow, 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.

Windstorms can be a frequent problem in the planning area and have been known to cause damage to utilities. The predicted wind speed given in wind warnings issued by the National Weather Service is for a one-minute average; gusts may be 25 to 30 percent higher.

Tornadoes are potentially the most dangerous of local storms, but they are not common in the planning area. If a major tornado were to strike within the populated areas of the county, damage could be widespread. Businesses could be forced to close for an extended period or permanently, fatalities could be high, many people could be homeless for an extended period, and routine services such as telephone or power could be disrupted. Buildings may be damaged or destroyed.

13.2.5 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.

13.3. 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.

13.4. 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. Historical data shows that the probability for severe weather events increases in a warmer climate (see Figure 13-6). 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. Climate models project an increased risk for more frequent extreme precipitation in the Northwest by the second half of the 21st century, although the patterns and level of intensity is highly variable (Salathé (2006); Rosenburg et al. (2010). Tebaldi et al. (2006)).

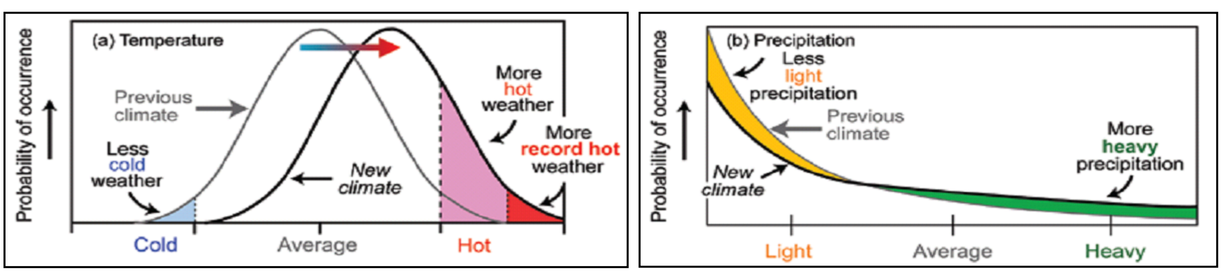


Figure 13-6. Severe Weather Probabilities in Warmer Climates

13.5. EXPOSURE

13.5.1 Population

A lack of data separating severe weather damage from flooding and landslide damage prevented a detailed analysis for exposure and vulnerability. However, it can be assumed that 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.

13.5.2 Property

According to the Kittitas County assessor, there are 15,364 buildings within the census tracts that define the planning area. Most of these buildings are residential. All of these buildings are considered to be exposed to the severe weather hazard.

13.5.3 Critical Facilities and Infrastructure

All critical facilities exposed to flooding (see Section 11.5.3) are also likely exposed to severe weather. Additional facilities on higher ground may also be exposed to wind damage or damage from falling trees. The most common problems associated with severe weather are loss of utilities. Downed power lines can cause blackouts, leaving large areas isolated. Phone, water and sewer systems may not function. Roads may become impassable due to ice or snow or from secondary hazards such as landslides.

13.5.4 Environment

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

13.6. VULNERABILITY

13.6.1 Population

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.

13.6.2 Property

All property is vulnerable during severe weather events, but properties in poor condition or in particularly vulnerable locations may risk the most damage. Those in higher elevations and on ridges may be more prone to wind damage. Those that are located under or near overhead lines or near large trees may be vulnerable to falling ice or may be damaged in the event of a collapse.

Loss estimates for the severe weather hazard were developed representing 10 percent, 30 percent and 50 percent of the assessed value of exposed structures. This allows emergency managers to select a range of potential economic impact based on an estimate of the percent of damage to the general building stock. Damage in excess of 50 percent is considered to be substantial by most building codes and typically requires total reconstruction.

Table 13-2 lists the loss estimates to the general building stock.

Table 13-2. Loss Estimates for Buildings Exposed to Severe Weather Hazard

Jurisdiction	Assessed Value of Buildings Exposed	10% Damage	30% Damage	50% Damage
Cle Elum	$88,005,625	$8,800,563	$26,401,688	$44,002,813
Ellensburg	$894,213,490	$89,421,349	$268,264,047	$447,106,745
Kittitas	$66,114,260	$6,611,426	$19,834,278	$33,057,130
Roslyn	$67,559,830	$6,755,983	$20,267,949	$33,779,915
South Cle Elum	$8,747,100	$874,710	$20,624,130	$4,373,550
Unincorporated	$3,410,937,810	$341,093,781	$1,023,281,343	$1,705,468,905
Total	**$4,535,578,115**	**$453,557,812**	**$1,360,673,435**	**$2,267,789,058**

13.6.3 Critical Facilities and Infrastructure

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 as well. High winds can cause significant damage to trees and power lines, blocking roads with debris, incapacitating transportation, isolating populations, 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 power and above-ground communication lines. Freezing of power and communication lines 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.

13.6.4 Environment

The vulnerability of the environment to severe weather is the same as the exposure.

13.7. FUTURE TRENDS IN DEVELOPMENT

All future development will be affected by severe storms. The ability to withstand impacts lies in sound land use practices and consistent enforcement of codes and regulations for new construction. The planning partners have adopted the International Building Code in response to Washington mandates. This code is equipped to deal with the impacts of severe weather events such as wind and snow loads. 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. With these tools, the planning partnership is well equipped to deal with future growth and the associated impacts of severe weather.

13.8. SCENARIO

The focus of severe local storms is on secondary impacts caused by flooding and landslides. However, the frequency of these storms dictates repeated response by the planning partnership. A worst-case event would involve prolonged high winds during a winter storm accompanied by thunderstorms. Such an event would have both short-term and longer-term effects. Initially, schools and roads would be closed due to power outages caused by high winds and downed tree obstructions. In more rural areas, some subdivisions could experience limited ingress and egress. Prolonged rain could produce flooding, overtopped culverts with ponded water on roads, and landslides on steep slopes. Flooding and landslides could further obstruct roads and bridges, further isolating residents.

13.9. ISSUES

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

- 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 weather events such as windstorms.
- Redundancy of power supply must be evaluated.
- The capacity for backup power generation is limited.
- Isolated population centers.
- Public education on dealing with the impacts of severe weather.
- Snow removal
- Debris management (downed trees, etc.).

CHAPTER 14.
VOLCANO

14.1. 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 (lava) forms a hill or mountain around the vent. The lava may flow out as a viscous liquid, or it may explode from the vent as solid or liquid particles. Ash and fragmented rock material can become airborne and travel far from the erupting volcano to affect distant areas.

Washington State has five active volcanoes: Mount Baker, Glacier Peak, Mount Rainier, Mount St. Helens, and Mount Adams. These volcanoes are all capable of generating destructive lahars, ash fall, lava, pyroclastic flows, and debris avalanches. The phenomena that pose the greatest threat are ash fall and lahars. Mount Hood in Oregon also poses a threat to communities along the Washington side of the Columbia River. All of these volcanoes pose a high to very high threat to life, property, the environment, and civil and military aviation in areas more than a few miles from the mountains' slopes.

DEFINITIONS

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

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

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

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

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

14.2. HAZARD PROFILE

14.2.1 Past Events

All five of Washington's volcanoes have been active in the last 4,000 years, with Mount St. Helens (more than a dozen eruptive events) and Glacier Peak (at least six eruptions) the most active. Mount St. Helens has been the most active in the past 40 years, with a massive eruption in 1980, followed by dome building eruptions in the 1980-1986 and 2004-present periods. In the 1980 Mount St. Helens eruption, 23 square miles of volcanic material buried the North Fork of the Toutle River and there were 57 human fatalities. All Washington volcanoes have had eruptions in the past 300 years that generated ash fall and/or lahars. Figure 14-1 and Table 14-1 summarize past eruptions in the Cascades.

14.2.2 Location

Figure 14-1 shows the location of the Cascade Range volcanoes, most of which have the potential to produce a significant eruption. The Cascade Range extends more than 1,000 miles from southern British Columbia into northern California and includes 13 potentially active volcanic peaks in the U.S.

Table 14-1. Past Eruptions in Washington

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

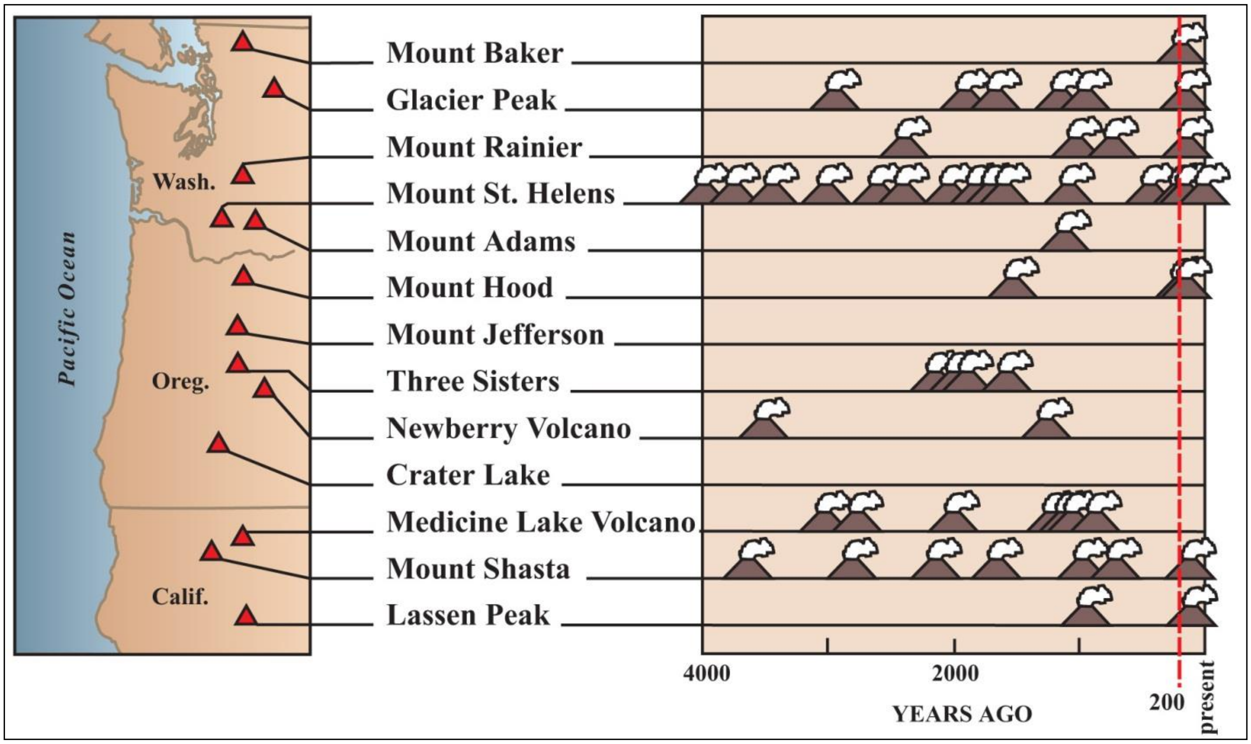


Figure 14-1. Past Eruptions in the Cascade Range

Four major Cascade volcanoes are relatively close to the Kittitas County planning area:

- Glacier Peak approximately 80 miles north-northwest of Ellensburg
- Mount Rainier approximately 58 miles west of Ellensburg

– Mount St Helens approximately 95 miles southwest of Ellensburg
– Mount Adams approximately 70 miles southwest of Ellensburg.

Mount Hood constitutes a low hazard because of distance, direction of prevailing winds, and evidence that its previous ash eruptions were confined to its immediate vicinity.

Ash Falls

Ash falls, also called "tephra," are from explosive eruptions that blast fragments of rock and ash into the air. Large fragments fall to the ground close to the volcano. Small fragments and ash can travel thousands of miles downwind and rise thousands of feet into the air. In some cases, ash can harm the human respiratory system. Heavy ash fall can create darkness. Ash can clog waterways and machinery, cause electrical short circuits, and drift into roadways, railways and runways. Ash harms mechanical and electronic equipment and can cause jet engines on aircraft to stall. The weight of ash, particularly when it becomes water saturated, can cause structural collapse. Ash carried by winds can be a hazard to machinery and transportation systems for months after an eruption.

The most serious tephra hazard in the region is from Mount St. Helens, the most prolific producer of tephra in the Cascades during the past few thousand years. Figure 14-2 provides estimates of the annual probability of tephra fall of 10 centimeters (about 4 inches) or greater affecting the region from all volcanoes. Probability zones extend farther to the east of the range than to the west because prevailing winds are from the west most of the time.

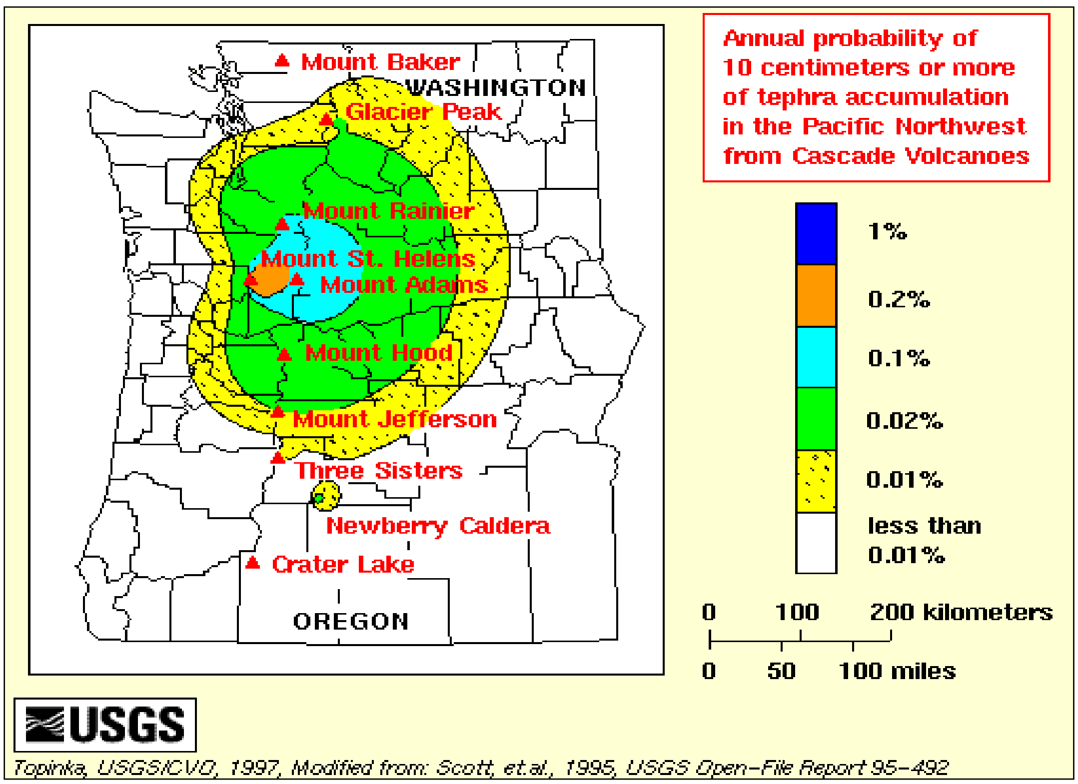


Figure 14-2. Probability of Tephra Accumulation in Pacific Northwest

14.2.3 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 Mount St. Helens have erupted with terrifying results. The U.S. Geological Survey classifies Glacier Peak, Mt. Adams, Mt. Baker, Mt. Hood, Mt. St. Helens, and Mt. Rainier as potentially active volcanoes in Washington State. Mt. St. Helens is by far the most active volcano in the Cascades, with four major explosive eruptions in the last 515 years.

14.2.4 Severity

The explosive disintegration of Mount St. Helens' north flank in 1980 vividly demonstrated the power that Cascade volcanoes can unleash. A 1-inch deep layer of ash weighs an average of 10 pounds per square foot, causing danger of structural collapse. Ash is harsh, acidic and gritty, and it has a sulfuric odor. 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 rain water to form diluted sulfuric acid that may cause minor, but painful burns to the skin, eyes, nose, and throat.

In an assessment published in April 2005, the U.S. Geological Survey rated the threat to civil and military aviation, life, and property posed by Mount St. Helens, Mount Rainier, Mount Baker and Glacier Peak to be "very high," the highest classification. The report rated the threat posed by Mount Adams as "high."

14.2.5 Warning Time

Constant monitoring of all active volcanoes means that there will be more than adequate time for evacuation before an event. Since 1980, Mount 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.

14.3. SECONDARY HAZARDS

The secondary hazards associated with volcanic eruptions are mud flows and landslides.

14.4. CLIMATE CHANGE IMPACTS

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.

14.5. EXPOSURE AND VULNERABILITY

According to the 2018 Washington State Enhanced Hazard Mitigation Plan, Kittitas County is not at risk of exposure to lahar or lava flow. As ash fall can travel much further, all of Kittitas County has exposure to ash fall from any of the active volcanos in the region. The plan estimates that Kittitas County has a 1 in 1,000 chance of receiving 10 centimeters (4 inches) of ash fall each year.

14.5.1 Population

The whole population of Kittitas County is exposed to the effects of a tephra. The populations most vulnerable to the effects of a tephra 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, although Kittitas County has few, if any, homeless people who would not be able to find adequate shelter or assistance during an event.

14.5.2 Property

All of the property and infrastructure exposed to nature in the county is exposed to the effects of a tephra fall. Vulnerable property includes equipment and machinery left out in the open, such as combines, whose parts can become clogged by the fine dust. Since Kittitas County receives snow every year, and roofs are built to withstand snow loads, most roofs are not vulnerable and would be able to withstand the potential load of ash. Infrastructure, such as drainage systems, is potentially vulnerable to the effects of a tephra fall, since the fine ash can clog pipes and culverts. This may be more of a problem if an eruption occurs during winter or early spring when precipitation is highest and floods are most likely.

To estimate the loss potential for this hazard, a qualitative approach was used, based on recommendations from FEMA guidelines on state and local mitigation planning. Loss estimation tools such as Hazus currently do not have the ability to analyze impacts from volcano hazards. For this study, it was decided to use 0.1 percent as the loss ratio for the volcano hazard. Assessed valuations provided by the Kittitas County assessor were the basis for these estimations. The results are summarized in Table 14-2.

Table 14-2. Ash Fall (Tephra) Loss Estimation

Jurisdiction	Assessed Value	Estimated Loss Potential at 0.1% Damage
Cle Elum	$88,005,625	$88,006
Ellensburg	$894,213,490	$894,213
Kittitas	$66,114,260	$66,114
Roslyn	$67,559,830	$67,560
South Cle Elum	$8,747,100	$8,747
Unincorporated	$3,410,937,810	$3,410,938
Total	**$4,535,578,115**	**$4,535,578**

14.5.3 Critical Facilities

All transportation routes are exposed to tephra accumulation, which could create hazardous driving conditions on roads and highways and hinder evacuations and response. Machinery and equipment using these transportation routes would also be vulnerable. Visibility in the short aftermath of an eruption would be problematic.

14.5.4 Environment

The environment is highly exposed to the effects of a volcanic eruption. Even if the related ash fall from a volcanic eruption were to fall elsewhere, it could still be spread throughout the county by the surrounding rivers and streams. 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. The sulfuric acid contained in volcanic ash could be very damaging to area vegetation, waters, wildlife and air quality.

14.6. FUTURE TRENDS IN DEVELOPMENT

All future development within the planning area will be susceptible to the potential impacts from volcanic eruptions within the region. While this potential impact on the built environment is not considered to be significant, the economic impact on industries that rely on machinery and equipment such as agriculture or civil engineering projects could be significant. Since the extent and location of this hazard is difficult to gauge because it is dependent upon many variables, the ability to institute land use recommendations based on potential impacts of this hazard is limited. While the impacts of volcanic hazards are sufficient to warrant risk assessment for emergency management purposes, the impacts are not considered to be sufficient to dictate land use decisions.

14.7. SCENARIO

Any eruption of Washington’s five Cascade Range volcanoes would likely produce significant amounts of ash fall that could impact the planning area. This impact is totally dependent upon the prevailing wind direction during and after the event. No one in the planning area would likely be injured or killed from these events, but businesses and non-essential government would be closed until the cloud passes. People and animals without shelter would be affected. Structures would be safe, but private property left out in the open, such as farm equipment, might be damaged by the fine ash dust. Clean-up from such an event could be costly, depending upon the magnitude of the event.

14.8. ISSUES

Since volcanic episodes have been fairly predictable in the recent past, there is not much concern about loss of life, but there is concern about loss of property and infrastructure and severe environmental impacts.

CHAPTER 15.
WILDFIRE

15.1. GENERAL BACKGROUND

The wildfire season in Washington usually begins in early July and ends with precipitation in late September, but wildfires have occurred in every month of the year. Drought, snow pack, and local weather conditions can affect the length of the fire season. How a fire behaves primarily depends on the following:

- **Fuel**—Lighter fuels such as grasses, leaves and needles quickly expel moisture and burn rapidly, while heavier fuels such as tree branches, logs and trunks take longer to warm and ignite. Snags and trees that are diseased, dying, or dead present special hazards. In 2002, about 1.8 million acres of the state's 21 million acres of forestland contained trees killed or defoliated by forest insects and diseases.
- **Weather**—Strong, dry winds in late summer and early fall produce extreme fire conditions. Wind events can persist up to 48 hours, with wind speed reaching 60 miles per hour; these winds generally reach peak velocities during the night and early morning.
- **Thunderstorm activity**—The thunderstorm season typically begins in June with wet storms, and turns dry with little or no precipitation reaching the ground as the season progresses into July and August.
- **Terrain**—Topography influences the amount and moisture of fuel; the impact of weather conditions; barriers to fire spread, such as highways and lakes; and land elevation and slope. Fire spreads uphill more easily than downhill, and the steeper the slope, the faster the fire travels. Fires travel in the direction of the ambient wind, which usually flows uphill. A wildfire is also able to preheat the fuel further up the hill because the smoke and heat are rising in that direction which, in turn, increases the fire's speed.
- **Time of Day**—A fire's peak burning period generally is between 1 p.m. and 6 p.m.

People start most wildfires through arson, recreational fires that get out of control, smoker carelessness, debris burning, or children playing with fire. From 2001 to 2017, humans have caused 196,335 fires and lightning has caused 1,441 fires in the Northwest according to the National Interagency Fire Center. Throughout the US, on average, people caused more than 61,952 wildfires each

DEFINITIONS

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

Firestorm—A fire that expands to cover a large area, often more than a square mile. A firestorm usually occurs when many individual fires grow together into one. The involved area becomes so hot that all combustible materials ignite, even if they are not exposed to direct flame. Temperatures may exceed 1000°C. Hot gases rise over the fire zone, drawing winds in from all sides at velocities as high as 50 miles per hour. Firestorms seldom spread because of the inward direction of the winds, but there is no known way of stopping them. Within the area of the fire, lethal concentrations of carbon monoxide are present; combined with the intense heat, this poses a serious life threat to responding fire forces. In very large events, the rising column of heated air and combustion gases carries enough particulate matter into the upper atmosphere to cause cloud nucleation, creating a locally intense thunderstorm and the hazard of lightning strikes.

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

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

year, compared to 10,143 fires caused by lightning annually. Fires during the early and late shoulders of the fire season usually are associated with human-caused fires; fires during the peak period of July, August and early September often are related to thunderstorms and lightning strikes.

15.2. HAZARD PROFILE

15.2.1 Physical Conditions

Fuels

Fuels that contribute to wildfires in Kittitas County range from sagebrush/grass to various types of conifers in the upper county. Fire exclusion and lack of thinning have resulted in dense stands of vegetation that act as ladder fuels. In the lower elevations, sagebrush, grass and weed areas provide fuel for wildfire spread and increased intensity. Drought, combined with these vegetation types, provides additional dead vegetation to fuel future wildfires. Other fuels are slash from logging and clearing for development. Homes in the wildland urban interface (WUI) are also fuel.

Weather

High temperatures in Kittitas County during wildfire season dry out fuel sources, allowing fuels to ignite and burn faster. Low humidity and lack of precipitation also increase the chance of wildfire ignition. The dry windy weather of Kittitas County can cause wildfires to grow quickly and can carry firebrands a mile or more from the original fire. Drought conditions must be taken into consideration, because drying vegetation can ignite and burn more easily.

Insect Damage

Mortality caused by the western pine beetle may be increasing over historical levels. Where there are more small Ponderosa pine present, moisture competition is high, which results in small stands that are of poor vigor. This can cause an increase of beetle infestation. Once the infestation begins in the small trees, they often attack large healthy Ponderosa pine still present in the stand. Western pine beetle is now the most common tree-killing beetle in second growth Ponderosa pine stands on the Wenatchee National Forest. Pole and small saw timber-sized trees, especially those in dense stands, are also affected. These trees are important for future replacement of the older Ponderosa pine removed by past harvesting.

Douglas fir beetle attacks have also become more frequent. Trees defoliated by the western spruce budworm are especially susceptible to attack by this insect. Some of the most serious damage occurs in riparian areas, putting these sensitive ecosystems at increased risk to future fires because an attack by certain insects can leave large patches of dead trees which dry out and will more easily ignite (Mason Community Countywide Fire Protection Plan, 2005).

15.2.2 Wildland Urban Interface

Wildland urban interface areas are areas that lack adequate fire flow and areas outside a fire district. In heavily timbered mountainous regions or sparsely populated areas, each jurisdiction designates additional WUI areas. As more development extends deeper into these regions, the risk of wildfire interacting with these residences increases. A WUI analysis conducted by the National Fire Protection Association for Kittitas County suggested that 33 percent of the region is classified as “high risk” for wildfire. Parcel delineation activity from 2001-2006 showed that approximately 60 percent of new parcels fall within the high-risk WUI areas (McColl, 2007).

The 2018 Kittitas County Community Wildfire Protection Plan identifies 10 Wildland Urban Interface Planning Areas (Table 15-1 and Figure 15-1) within the larger Kittitas County WUI boundary, which is approximately 1,018 square miles and covers 651,795 acres.

Table 15-1. WUI Planning Areas within Kittitas County (2018 Community Wildfire Protection Plan)

WUI Planning Area	Size of Planning Area (Acres)	Fire District Coverage
Eastern Kittitas County	109,854	BLM, Yakima Training Center, DNR, Vantage Fire Department, Kittitas Valley Fire & Rescue
Kittitas Valley Upland	150,789	DNR, Kittitas Valley Fire & Rescue, USFS
Swauk-Liberty	75,500	DNR, Kittitas County Fire District No. 7, USFS
Manastash-Taneum	113,098	DNR, Kittitas Valley Fire & Rescue, USFS
Teanaway	22,332	Kittitas County Fire District No. 7, DNR
North Lake Cle Elum	23,170	Kittitas County Fire District No. 6, DNR, USFS
Roslyn – Cle Elum	13,419	City of Roslyn FD, City of Cle Elum FD, Kittitas County Fire District No. 7, DNR, USFS
Domerie Flats	11,523	Kittitas County Fire District No. 7, DNR, USFS
West Kittitas County	94,084	Kittitas County Fire District No. 51, Kittitas County Fire District No. 8, Kittitas County Fire District No. 7, DNR, USFS
South Cle Elum	58,355	City of South Cle Elum Fire Department, Kittitas County Fire District No. 7, DNR, USFS

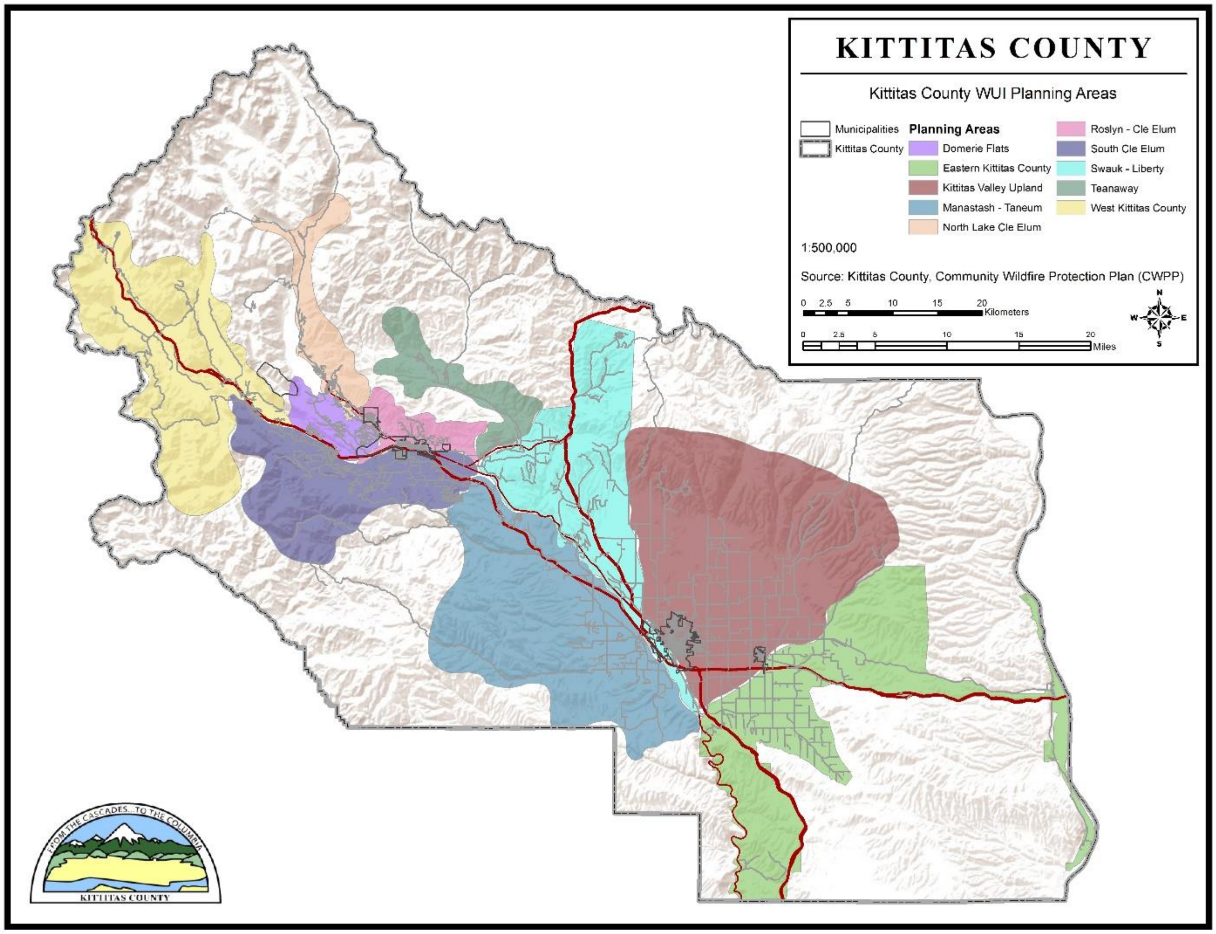


Figure 15-1. Kittitas County Wildland Urban Interface Planning Areas

15.2.3 Past Events

Kittitas County has a rich fire history. According to the Washington State Enhanced Hazard Mitigation Plan, there were five major wildfire events in Kittitas County from 1960 to 2017, with damages amounting to $3,012,334. In addition, there were FEMA disaster declarations in Kittitas County for wildfires on July 30, 2004 (Elk Heights Fire) and July 9, 2014. According to the Headwaters Economic WUI snapshot report (2018), Kittitas County was in the 85th percentile for existing WUI risk and 89th percentile for future WUI risk in the West, respectively. Existing WUI risk is defined as the amount of forested land where homes have already been built next to public lands, and future WUI risk is defined as the area of undeveloped, forested private land bordering fire-prone public lands. There are a total of 413 western counties and the higher the percentile the higher the risk. Kittitas County is in the 44th percentile in Washington State when ranked by existing risk and 69th percentile for future potential risk according 2010 data. As shown in Figure 15-2 and Figure 15-3, there have been a total of 372 wildfire on DNR land in Kittitas County, amounting to a total of 122,769 acres burned from 2008 to 2018 (WA DNR). The largest fire recorded in Kittitas County was the Colockum Tarps fire in 2013, which burned 81,733 acres of land in Chelan and Kittitas Counties. The Taylor Bridge Fire in 2012 caused 61 structures to be lost about 4 miles southeast of Cle Elum and 2 miles northwest of Ellensburg.

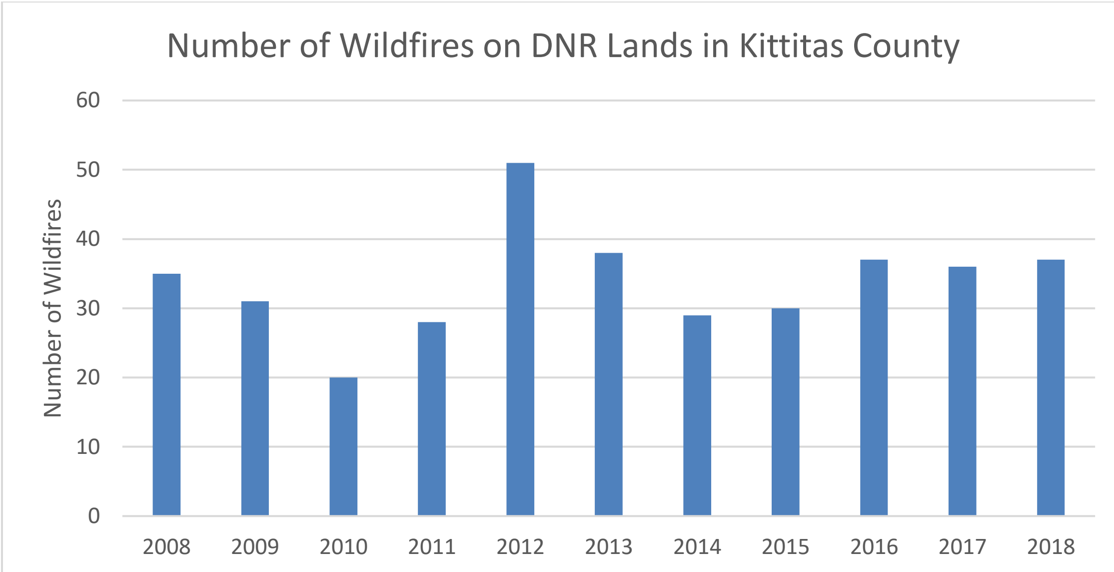


Figure 15-2. Number of Wildfires on DNR Lands in Kittitas County, 2008-2018

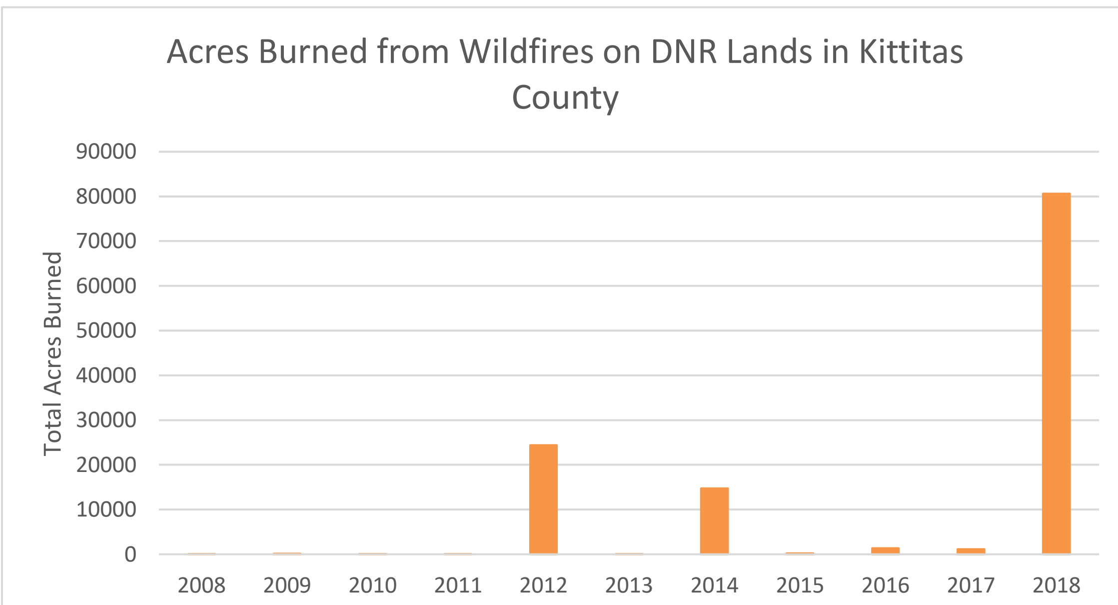


Figure 15-3. Number of Acres Burned from Wildfires on DNR Lands in Kittitas County, 2008-2018

15.2.4 Location

Two types of mapping produced by the Washington Department of Natural Resources have been used to identify the location of the wildfire hazard: wildfire hazard area mapping and fire regime mapping.

Wildfire Hazard Area Mapping

Figure 15-4 shows wildfire hazard areas, based on data from the Washington Risk Database. Areas are scored based on the risk and vulnerability of a planning area by looking at the following components:

– Subdivision design (ingress, egress, road width, road condition, fire service access, signage)

- Vegetation
- Topography
- Other rating factors (weather, history, building separation)
- Roofing material
- Building condition
- Available fire protection (water supply, response time, fire protection systems)
- Utilities.

Planning areas are ranked as low, moderate, high or extreme hazard areas, based on their score. Wildfire analysis was done using WUI data created by the Department of Natural Resources, which analyzed areas with population densities of at least 20 people per square mile. All jurisdictions in Kittitas County have some level or risk from wildfire. For more information on Exposure, see Section 5.5.

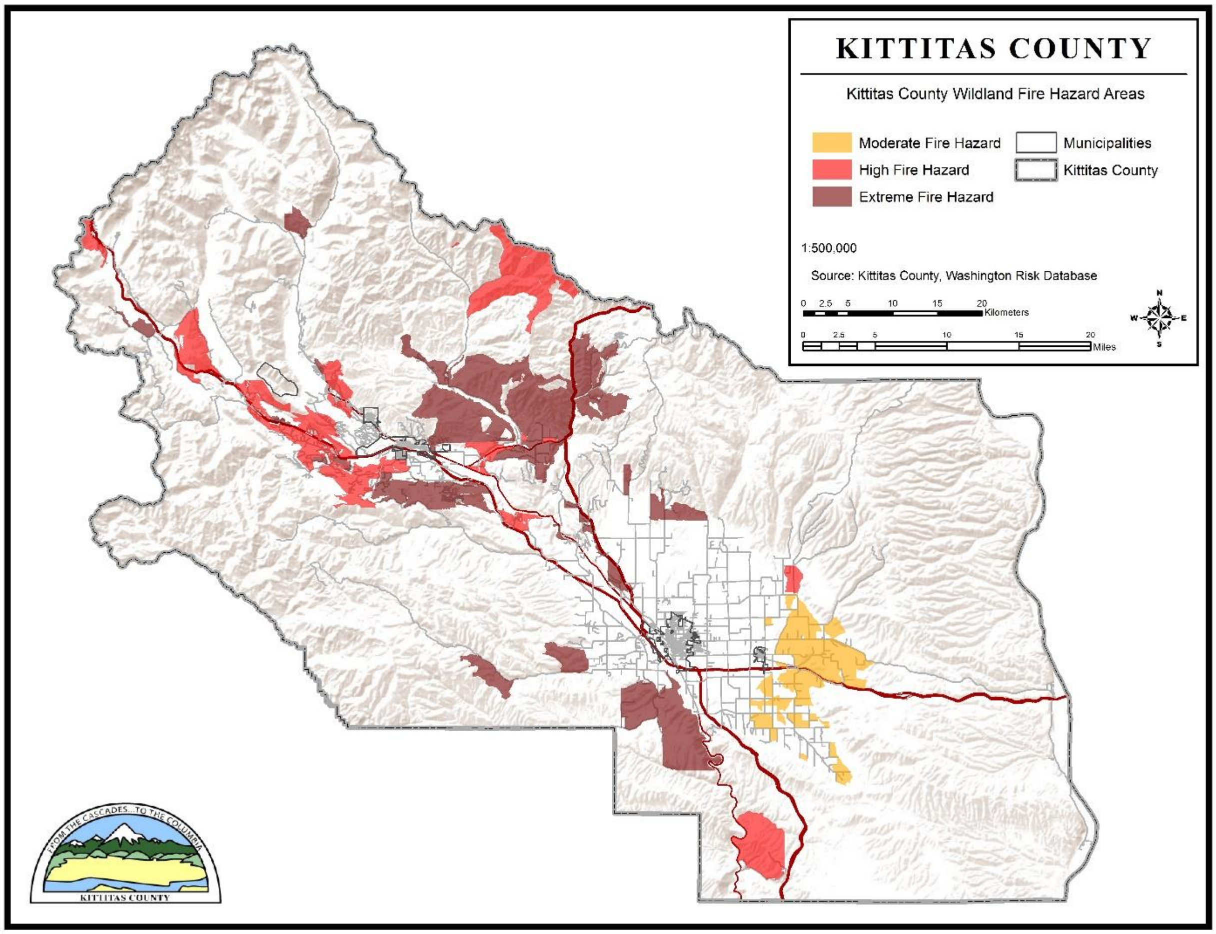


Figure 15-4. Kittitas County Wildland Fire Hazard Areas

Fire Regime Mapping

Figure 15-5 shows the Mean Fire Return Interval Fire Regimes for Kittitas County. These are fire regimes based on the frequency of when wildland fires are expected to occur in a given area. Fire regime is the term given to the pattern, frequency, and intensity of the bushfires and wildfires that naturally occur in a particular ecosystem over an extended period of time. It is an integral part of fire ecology and renewal for certain types of ecosystems. If fires are too frequent, plants may be killed before they have matured, or before they have set sufficient seed to ensure population recovery. If fires are too infrequent, plants may mature, deteriorate with age, and die without ever releasing their seed.

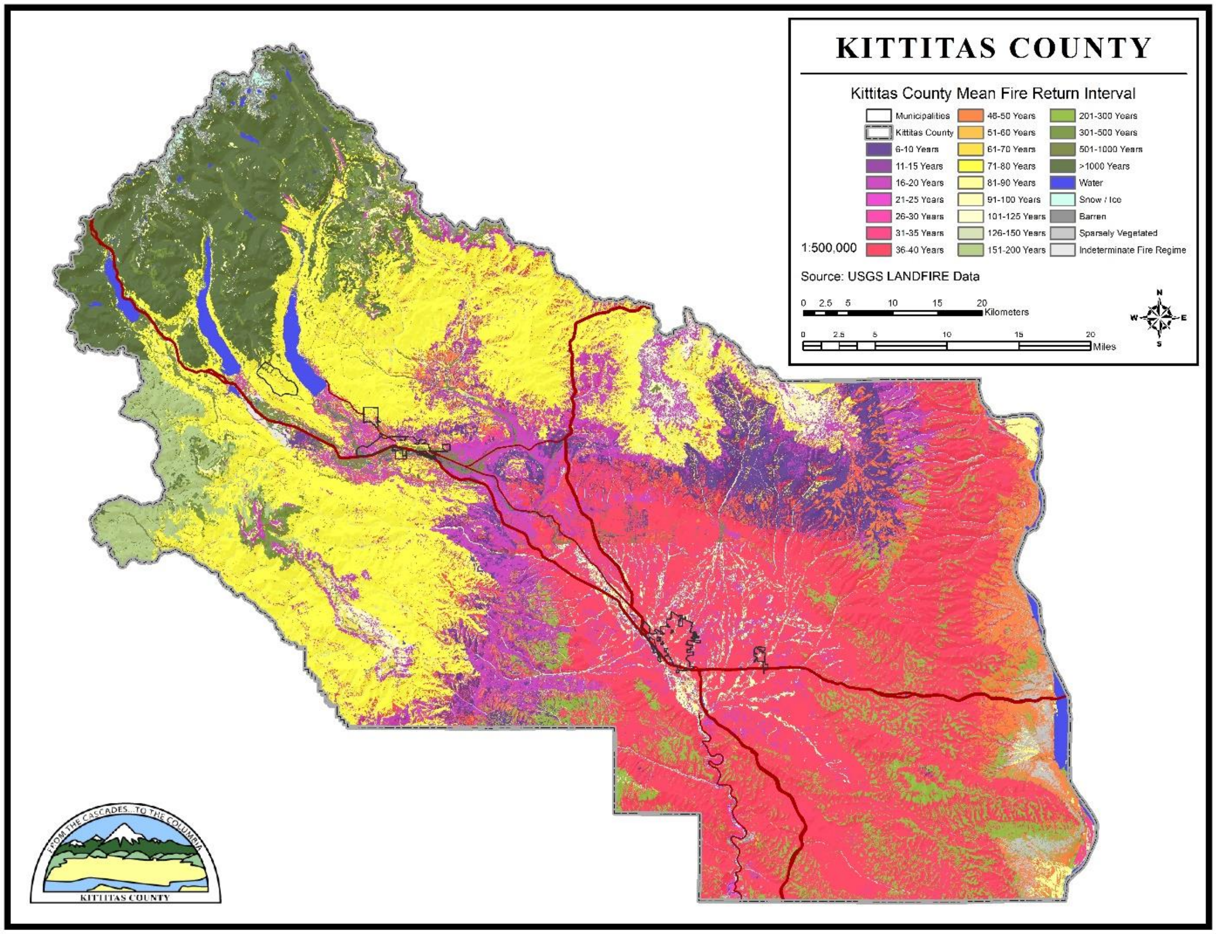


Figure 15-5. Kittitas County Mean Fire Return Interval

15.2.5 Frequency

Natural fire rotation (NFR) is defined as the number of years necessary for fires to burn over an area equal to that of the study area. NFR is calculated from the historical record of fires by dividing the length of the record period in years by the percentage of total area burned during that period. Since 1990, Kittitas County has seen an average of 36 wildfires per year, totaling about 500 acres burned each year. This yields an NFR for Kittitas County of 2,571 years. According to the national Landfire database prepared by the U.S. Departments of Interior and Agriculture, the average burn recurrence interval for the planning area is 65 years. This represents the average period between fires under a presumed historical fire regime.

15.2.6 Severity

Potential losses from wildfire include human life, structures and other improvements, and natural resources. There are no recorded incidents of loss of life from wildfires in Kittitas County. Given the immediate response times to reported fires, the likelihood of injuries and casualties is minimal. Smoke and air pollution from wildfires can be a health hazard, especially for sensitive populations including children, the elderly and those with respiratory and cardiovascular diseases. Wildfire may also threaten the health and safety of those fighting the fires. First responders are exposed to the dangers from the initial incident and after-effects from smoke inhalation and heat stroke. In addition, wildfire can lead to ancillary impacts such as landslides in steep ravine areas and flooding due to the impacts of silt in local watersheds.

15.2.7 Warning Time

Wildfires are often caused by humans, intentionally or accidentally. There is no way to predict when one might break out. Since fireworks often cause brush fires, extra diligence is warranted around the Fourth of July when the use of fireworks is highest. Dry seasons and droughts are factors that greatly increase fire likelihood. Dry lightning may trigger wildfires. Severe weather can be predicted, so special attention can be paid during weather events that may include lightning. Reliable National Weather Service lightning warnings are available on average 24 to 48 hours prior to a significant electrical storm.

If a fire does break out and spread rapidly, residents may need to evacuate within days or hours. A fire's peak burning period generally is between 1 p.m. and 6 p.m. Once a fire has started, fire alerting is reasonably rapid in most cases. The rapid spread of cellular and two-way radio communications in recent years has further contributed to a significant improvement in warning time. Improvements in GIS mapping of wildfires also increases understanding of the location and movements of wildfires, enabling more extensive warning times.

15.3. SECONDARY HAZARDS

Wildfires can generate a range of secondary effects, which in some cases may cause more widespread and prolonged damage than the fire itself. Fires can cause direct economic losses in the reduction of harvestable timber and indirect economic losses in reduced tourism. Wildfires cause the contamination of reservoirs, destroy transmission lines and contribute to flooding. They strip slopes of vegetation, exposing them to greater amounts of runoff. This in turn can weaken soils and cause failures on slopes. Major landslides can occur several years after a wildfire. Most wildfires burn hot and for long durations that can bake soils, especially those high in clay content, thus increasing the imperviousness of the ground. This increases the runoff generated by storm events, thus increasing the chance of flooding.

15.4. CLIMATE CHANGE IMPACTS

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

Historically, drought patterns in the West are related to large-scale climate patterns in the Pacific and Atlantic oceans. The El Niño–Southern Oscillation in the Pacific varies on a 5- to 7-year cycle, the Pacific Decadal Oscillation varies on a 20- to 30-year cycle, and the Atlantic Multidecadal Oscillation varies on a 65- to 80-year cycle. As these large-scale ocean climate patterns vary in relation to each other, drought conditions in the U.S. shift from region to region. El Niño years bring drier conditions to the Pacific Northwest and more fires.

The Northwestern US has experienced warming temperatures and declines in snowpack and streamflow in recent decades. Average annual temperatures have risen by about 1.3 degrees Fahrenheit over the last century, and are expected to increase by 3 to 10 degrees Fahrenheit by the end of this century. Summer precipitation is projected to decline by as much as 30%, with less frequent but heavier downpours. Declines in snowpack will reduce the amount of spring snowmelt. Combined, these changes will cause an increase in frequency and intensity of wildfire events. These conditions will exacerbate summer drought and further promote high-elevation wildfires, releasing stores of carbon and further contributing to the buildup of greenhouse gases. Forest response to increased atmospheric carbon dioxide—the so-called "fertilization effect"—could also contribute to more tree growth and thus more fuel for fires, but the effects of carbon dioxide on mature forests are still largely unknown. High carbon dioxide levels should enhance tree recovery after fire and young forest regrowth, as long as sufficient nutrients and soil moisture are available, although the latter is in question for many parts of the western United States because of climate change.

15.5. EXPOSURE

15.5.1 Population

Population could not be examined directly by wildfire regime zones because census blocks do not coincide with the zones. However, population was estimated using the residential building count in each zone and applying the census value of 2.32 persons per household for Kittitas County. The results are shown in Figure 15-2.

Table 15-2. Population Estimates Within Fire Regime Intervals

Jurisdiction	0 - 35 Year Interval	36 - 100 Year Interval	101 - 1000 Year Interval	>1000 Year Interval	Other Interval	Total
Cle Elum	42	1,097	580	7	51	1,777
Ellensburg	418	8,851	0	0	0	9,268
Kittitas	49	981	0	0	0	1,030
Roslyn	128	1,204	9	5	0	1,346
South Cle Elum	26	332	188	5	0	550
Unincorporated Kittitas County	6,510	9,491	1,462	724	346	18,532
Total	**7,171**	**21,956**	**2,239**	**740**	**397**	**32,503**

15.5.2 Property

Property damage from wildfires can be severe and can significantly alter entire communities. The number and value of buildings in the various fire regime zones within the planning area are summarized in Table 15-3 through Table 15-7 shows the general zoning of parcels exposed to the wildfire hazard in the unincorporated portions of the county.

Table 15-3. Buildings in Kittitas County Exposed to the 0-35 Year Fire Interval

Jurisdiction	Buildings Exposed to 0 - 35 Year Interval	0 - 35 Year Interval Exposed Value	Total Buildings Exposed	Total Exposed Value	% of Buildings Exposed	% Exposure Value
Cle Elum	18	$2,851,620	770	$88,005,625	2%	3%
Ellensburg	181	$45,612,585	4,032	$894,213,490	4%	5%
Kittitas	21	$3,823,755	445	$66,114,260	5%	6%

Jurisdiction	Buildings Exposed to 0 - 35 Year Interval	0 - 35 Year Interval Exposed Value	Total Buildings Exposed	Total Exposed Value	% of Buildings Exposed	% Exposure Value
Roslyn	55	$6,404,445	582	$67,559,830	9%	9%
South Cle Elum	11	$431,550	238	$8,747,100	5%	5%
Unincorporated Kittitas County	3,169	$1,254,954,300	9,297	$3,410,937,810	34%	37%
Total	**3,455**	**$1,314,078,255**	**15,364**	**$4,535,578,115**	**22%**	**29%**

Table 15-4. Buildings in Kittitas County Exposed to the 36-100 Year Fire Interval

Jurisdiction	Buildings Exposed to 36 - 100 Year Interval	36 - 100 Year Interval Exposed Value	Total Buildings Exposed	Total Exposed Value	% of Buildings Exposed	% Exposure Value
Cle Elum	474	$56,023,980	770	$88,005,625	62%	64%
Ellensburg	3,851	$848,600,905	4,032	$894,213,490	96%	95%
Kittitas	424	$62,290,505	445	$66,114,260	95%	94%
Roslyn	521	$60,464,830	582	$67,559,830	90%	89%
South Cle Elum	144	$5,914,065	238	$8,747,100	61%	68%
Unincorporated Kittitas County	4,996	$1,800,887,120	9,297	$3,410,937,810	54%	53%
Total	**10,410**	**$2,834,181,405**	**15,364**	**$4,535,578,115**	**68%**	**62%**

Table 15-5. Buildings in Kittitas County Exposed to the 101-1000 Year Fire Interval

Jurisdiction	Buildings Exposed to 101 - 1000 Year Interval	101 - 1000 Year Interval Exposed Value	Total Buildings Exposed	Total Exposed Value	% of Buildings Exposed	% Exposure Value
Cle Elum	253	$25,368,535	770	$88,005,625	33%	29%
Ellensburg	0	$0	4,032	$894,213,490	0%	0%
Kittitas	0	$0	445	$66,114,260	0%	0%
Roslyn	4	$485,565	582	$67,559,830	1%	1%
South Cle Elum	81	$2,401,485	238	$8,747,100	34%	27%
Unincorporated Kittitas County	660	$182,280,095	9,297	$3,410,937,810	7%	5%
Total	**998**	**$210,535,680**	**15,364**	**$4,535,578,115**	**6%**	**5%**

Table 15-6. Buildings in Kittitas County Exposed to the >1000 Year Fire Interval

Jurisdiction	Buildings Exposed to >1000 Years Interval	>1000 Years Interval Exposed Value	Total Buildings Exposed	Total Exposed Value	% of Buildings Exposed	% Exposure Value
Cle Elum	3	$572,775	770	$88,005,625	0%	1%
Ellensburg	0	$0	4,032	$894,213,490	0%	0%
Kittitas	0	$0	445	$66,114,260	0%	0%
Roslyn	2	$204,990	582	$67,559,830	0%	0%
South Cle Elum	2	$0	238	$8,747,100	1%	0%
Unincorporated Kittitas County	320	$128,334,395	9,297	$3,410,937,810	3%	4%
Total	**327**	**$129,112,160**	**15,364**	**$4,535,578,115**	**2%**	**3%**

Table 15-7. Buildings in Kittitas County Exposed to the Other Fire Intervals

Jurisdiction	Buildings Exposed to Other Intervals	Other Intervals Exposed Value	Total Buildings Exposed	Total Exposed Value	% of Buildings Exposed	% Exposure Value
Cle Elum	22	$3,188,715	770	$88,005,625	3%	4%
Ellensburg	0	$0	4,032	$894,213,490	0%	0%
Kittitas	0	$0	445	$66,114,260	0%	0%
Roslyn	0	$0	582	$67,559,830	0%	0%
South Cle Elum	0	$0	238	$8,747,100	0%	0%
Unincorporated Kittitas County	152	$44,481,900	9,297	$3,410,937,810	2%	1%
Total	**174**	**$47,670,615**	**15,364**	**$4,535,578,115**	**1%**	**1%**

Table 15-8. General Zoning Within the Wildfire Regimes (Unincorporated County)

Zoning	0-35 Year Interval Area (acres)	% of total	36-100 Years Interval Area (acres)	% of total	101-1000 Years Interval Area (acres)	% of total	>1000 Years Interval Area (acres)	% of total	Other Interval Area (acres)	% of total
Agriculture	41,416	17.74%	307,227	34.91%	56,727	30.61%	217	0.15%	11,264	23.12%
Commercial	37	0.02%	309	0.04%	55	0.03%	25	0.02%	56	0.12%
Commercial Forest	132,622	56.81%	400,686	45.53%	100,914	54.46%	139,424	96.32%	22,960	47.13%
Forest & Range	45,997	19.70%	136,104	15.46%	21,774	11.75%	3,375	2.33%	12,712	26.09%
Incorporated City	613	0.26%	5,569	0.63%	80	0.04%	9	0.01%	66	0.14%
Industrial	260	0.11%	1,968	0.22%	30	0.02%	2	0.00%	29	0.06%
Master Planned Resort	2,702	1.16%	2,800	0.32%	828	0.45%	20	0.01%	108	0.22%

Zoning	0-35 Year Interval Area (acres)	% of total	36-100 Years Interval Area (acres)	% of total	101-1000 Years Interval Area (acres)	% of total	>1000 Years Interval Area (acres)	% of total	Other Interval Area (acres)	% of total
Planned Unit Development	806	0.35%	493	0.06%	156	0.08%	422	0.29%	39	0.08%
Residential	6,190	2.65%	13,900	1.58%	3,689	1.99%	1,210	0.84%	1,192	2.45%
Urban Growth Area	2,790	1.20%	11,026	1.25%	1,043	0.56%	47	0.03%	295	0.60%
Total	**233,434**	**15.64%**	**880,082**	**58.98%**	**185,296**	**12.42%**	**144,751**	**9.70%**	**48,721**	**3.26%**

15.5.3 Critical Facilities and Infrastructure

Table 15-9 identifies critical facilities exposed to the wildfire hazard in the county. In the event of wildfire, there would likely be little damage to the majority of infrastructure. Most road and railroads would be without damage except in the worst scenarios. Power lines are the most at risk to wildfire because most are made of wood and susceptible to burning. In the event of a wildfire, pipelines could provide a source of fuel and lead to a catastrophic explosion.

Table 15-9. Critical Facilities Exposed to Wildfire Hazard Areas

Jurisdiction	Fire Station	Hospital	Emergency Facility	School	Total
Cle Elum	0	0	0	0	0
Ellensburg	0	0	0	0	0
Kittitas	0	0	0	0	0
Roslyn	0	0	0	0	0
South Cle Elum	0	0	0	0	0
Unincorporated Kittitas County	5	0	0	0	5
Total	**5**	**0**	**0**	**0**	**5**

15.5.4 Environment

Fire is a natural and critical ecosystem process in most terrestrial ecosystems, dictating in part the types, structure, and spatial extent of native vegetation. However, wildfires can cause severe environmental impacts:

- Damaged Fisheries—Critical fisheries can suffer from increased water temperatures, sedimentation, and changes in water quality.
- Soil Erosion—The protective covering provided by foliage and dead organic matter is removed, leaving the soil fully exposed to wind and water erosion. Accelerated soil erosion occurs, causing landslides and threatening aquatic habitats.
- Spread of Invasive Plant Species—Non-native woody plant species frequently invade burned areas. When weeds become established, they can dominate the plant cover over broad landscapes, and become difficult and costly to control.

- Disease and Insect Infestations—Unless diseased or insect-infested trees are swiftly removed, infestations and disease can spread to healthy forests and private lands. Timely active management actions are needed to remove diseased or infested trees.
- Destroyed Endangered Species Habitat—Catastrophic fires can have devastating consequences for endangered species.
- Soil Sterilization—Topsoil exposed to extreme heat can become water repellant, and soil nutrients may be lost. It can take decades or even centuries for ecosystems to recover from a fire. Some fires burn so hot that they can sterilize the soil.

Many ecosystems are adapted to historical patterns of fire occurrence. These patterns, called “fire regimes,” include temporal attributes (e.g., frequency and seasonality), spatial attributes (e.g., size and spatial complexity), and magnitude attributes (e.g., intensity and severity), each of which have ranges of natural variability. Ecosystem stability is threatened when any of the attributes for a given fire regime diverge from its range of natural variability.

15.6. VULNERABILITY

Structures, above-ground infrastructure, critical facilities and natural environments are all vulnerable to the wildfire hazard. There is currently no validated damage function available to support wildfire mitigation planning. Except as discussed in this section, vulnerable populations, property, infrastructure and environment are assumed to be the same as described in the section on exposure.

15.6.1 Population

There are no recorded incidents of loss of life from wildfires within the planning area. Given the immediate response times to reported fires, the likelihood of injuries and casualties is minimal; therefore, injuries and casualties were not estimated for the wildfire hazard.

Smoke and air pollution from wildfires can be a severe health hazard, especially for sensitive populations, including children, the elderly and those with respiratory and cardiovascular diseases. Smoke generated by wildfire consists of visible and invisible emissions that contain particulate matter (soot, tar, water vapor, and minerals), gases (carbon monoxide, carbon dioxide, nitrogen oxides), and toxics (formaldehyde, benzene). Emissions from wildfires depend on the type of fuel, the moisture content of the fuel, the efficiency (or temperature) of combustion, and the weather. Public health impacts associated with wildfire include difficulty in breathing, odor, and reduction in visibility.

Wildfire may also threaten the health and safety of those fighting the fires. First responders are exposed to the dangers from the initial incident and after-effects from smoke inhalation and heat stroke.

15.6.2 Property

Loss estimations for the wildfire hazard are not based on damage functions, because no such damage functions have been generated. Instead, loss estimates were developed representing 10 percent, 30 percent and 50 percent of the assessed value of exposed structures. This allows emergency managers to select a range of economic impact based on an estimate of the percent of damage to the general building stock. Damage in excess of 50 percent is considered to be substantial by most building codes and typically requires total reconstruction of the structure. Table 15-10 lists the loss estimates for the general building stock for jurisdictions that have an exposure to the wildfire hazard.

Table 15-10. Loss Estimates for Buildings Exposed to Wildfire Hazard

Jurisdiction	Assessed Value	10% Damage	30% Damage	50% Damage
Cle Elum	$0	$0	$0	$0
Ellensburg	$0	$0	$0	$0
Kittitas	$0	$0	$0	$0
Roslyn	$0	$0	$0	$0
South Cle Elum	$0	$0	$0	$0
Unincorporated Kittitas County	$966,026,000	$96,602,600	$289,807,800	$483,013,000
Total	**$966,026,000**	**$96,602,600**	**$289,807,800**	**$483,013,000**

15.6.3 Critical Facilities and Infrastructure

Critical facilities of wood frame construction are especially vulnerable during wildfire events. In the event of wildfire, there would likely be little damage to most infrastructure. Most roads and railroads would be without damage except in the worst scenarios. Power lines are the most at risk from wildfire because most poles are made of wood and susceptible to burning. Fires can create conditions that block or prevent access and can isolate residents and emergency service providers. Wildfire typically does not have a major direct impact on bridges, but it can create conditions in which bridges are obstructed. Many bridges in areas of high to moderate fire risk are important because they provide the only ingress and egress to large areas and in some cases to isolated neighborhoods.

15.7. FUTURE TRENDS IN DEVELOPMENT

The highly urbanized portions of the planning area have little or no wildfire risk exposure. Urbanization tends to alter the natural fire regime, and can create the potential for the expansion of urbanized areas into wildland areas. The expansion of the wildland urban interface can be managed with strong land use and building codes. The planning area is well equipped with these tools and this planning process has asked each planning partner to assess its capabilities with regards to the tools. As Kittitas County experiences future growth, it is anticipated that the exposure to this hazard will remain as assessed or even decrease over time due to these capabilities.

15.8. SCENARIO

A major conflagration in Kittitas County might begin with a wet spring, adding to fuels already present on the forest floor. Flashy fuels would build throughout the spring. The summer could see the onset of insect infestation. A dry summer could follow the wet spring, exacerbated by dry hot winds. Carelessness with combustible materials or a tossed lit cigarette, or a sudden lighting storm could trigger a multitude of small isolated fires.

The embers from these smaller fires could be carried miles by hot, dry winds. The deposition zone for these embers would be deep in the forests and interface zones. 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. While local fire districts would be extremely useful in the urban interface areas, they have limited wildfire capabilities or experience, and they would have a difficult time responding to the ignition zones. Even though the existence and spread of the fire is known, it may not be possible to respond to it adequately, so an initially manageable fire can become out of control before resources are dispatched.

To further complicate the problem, heavy rains could follow, causing flooding and landslides and releasing tons of sediment into rivers, permanently changing floodplains and damaging sensitive habitat and riparian areas. Such a fire followed by rain could release millions of cubic yards of sediment into streams for years, creating new floodplains and changing existing ones. With the forests removed from the watershed, stream flows could easily double. Floods that could be expected every 50 years may occur every couple of years. With the streambeds unable to carry the increased discharge because of increased sediment, the floodplains and floodplain elevations would increase.

15.9. 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 could affect the wildfire hazard.
- Future growth into interface areas should continue to be managed.
- Area fire districts need to continue to train on wildland-urban interface events.
- Vegetation management activities. 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.
- Fire department water supply in high risk wildfire areas.
- 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 level.

CHAPTER 16.
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 with the steering committee. Estimates of risk were generated with data from HAZUS-MH using methodologies promoted by FEMA. The results are used in establishing mitigation priorities.

16.1. PROBABILITY OF OCCURRENCE

The probability of occurrence of a hazard is indicated by a probability factor based on likelihood of annual occurrence:

- High—Hazard event is likely to occur within 25 years (Probability Factor = 3)
- Medium—Hazard event is likely to occur within 100 years (Probability Factor =2)
- Low—Hazard event is not likely to occur within 100 years (Probability Factor =1)
- No 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 16-1 summarizes the probability assessment for each hazard of concern for this plan.

Table 16-1. Probability of Hazards

Hazard Event	Probability (high, medium, low)	Probability Factor
Avalanche	High	3
Dam Failure	Low	1
Drought	High	3
Earthquake	High	3
Flood	High	3
Landslide	High	3
Severe Weather	High	3
Volcano	Low	1
Wildfire	High	3

16.2. 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 exposed*** to the hazard event. The degree of impact on individuals will vary and is not measurable, so the calculation assumes for simplicity and consistency that all people exposed to a hazard because they live in a hazard zone will be equally impacted when a hazard event occurs. It should be noted that planners can use an element of subjectivity when assigning values for impacts on people. Impact factors were assigned as follows:

- High—50 percent or more of the population is exposed to a hazard (Impact Factor = 3)
- Medium—25 percent to 49 percent of the population is exposed to a hazard (Impact Factor = 2)
- Low—25 percent or less of the population is exposed to the hazard (Impact Factor = 1)
- No impact—None of the population is exposed to a hazard (Impact Factor = 0)

- **Property**—Values were assigned based on the percentage of the total ***property value exposed*** to the hazard event:
- High—30 percent or more of the total assessed property value is exposed to a hazard (Impact Factor = 3)
- Medium—15 percent to 29 percent of the total assessed property value is exposed to a hazard (Impact Factor = 2)
- Low—14 percent or less of the total assessed property value is exposed to the hazard (Impact Factor = 1)
- No impact—None of the total assessed property value is exposed to a hazard (Impact Factor = 0)
- **Economy**—Values were assigned based on the percentage of the total ***property value vulnerable*** to the hazard event. Values represent estimates of the loss from a major event of each hazard in comparison to the total assessed value of the property exposed 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.

Table 16-2, Table 16-3 and Table 16-4 summarize the impacts for each hazard.

Table 16-2. Impact on People from Hazards

Hazard Event	Impact (high, medium, low)	Impact Factor	Multiplied by Weighting Factor (3)
Avalanche	Low	1	(3x1) = 3
Dam Failure	Low	1	(3x1) = 3
Drought	None	0	(3x0) = 0

Hazard Event	Impact (high, medium, low)	Impact Factor	Multiplied by Weighting Factor (3)
Earthquake	High	3	(3x3) = 9
Flood	Medium	2	(3x2) = 6
Landslide	Low	1	(3x1) = 3
Severe Weather	High	3	(3x3) = 9
Volcano	High	3	(3x3) = 9
Wildfire	Low	1	(3x1) = 3

Table 16-3. Impact on Property from Hazards

Hazard Event	Impact (high, medium, low)	Impact Factor	Multiplied by Weighting Factor (2)
Avalanche	Low	1	(1x2) = 2
Dam Failure	Medium	2	(2x2) = 4
Drought	No Impact	0	(0x2) = 0
Earthquake	High	3	(3x2) = 6
Flood	Medium	2	(2x2) = 4
Landslide	Low	1	(1x2) = 2
Severe Weather	High	3	(3x2) = 6
Volcano	Low	1	(1x2) = 2
Wildfire	Low	1	(1x2) = 2

Table 16-4. Impact on Economy from Hazards

Hazard Event	Impact (high, medium, low)	Impact Factor	Multiplied by Weighting Factor (1)
Avalanche	Low	1	(1x1) = 1
Dam Failure	Low	1	(1x1) = 1
Drought	High	3	(3x1) = 3
Earthquake	Low	1	(1x1) = 1
Flood	Low	1	(1x1) = 1
Landslide	Low	1	(1x1) = 1
Severe Weather	Medium	2	(2x1) = 2
Volcano	Low	1	(1x1) = 1
Wildfire	Low	1	(1x1) = 1

16.3. RISK RATING AND RANKING

The risk rating for each hazard was determined by multiplying the probability factor by the sum of the weighted impact factors for people, property and operations, as summarized in Table 16-5.

Based on these ratings, a priority of high, medium or low was assigned to each hazard. The hazards ranked as being of highest concern are earthquake and severe weather. Hazards ranked as being of medium concern are landslide, flood and wildfire. The hazards ranked as being of lowest concern are drought and dam failure. Table 16-6 shows the hazard risk ranking.

Table 16-5. Hazard Risk Rating

Hazard Event	Probability Factor	Sum of Weighted Impact Factors	Total (Probability x Impact)
Avalanche	3	(3+2+1) = 6	3x6 = 18
Dam Failure	1	(3+4+1) = 8	1x8 = 8
Drought	3	(0+0+3) = 3	3x3 = 9
Earthquake	3	(9+6+1) = 16	3x16 = 48
Flood	3	(6+4+1) = 11	3x11 =33
Landslide	3	(3+2+1) = 6	3x6 = 18
Severe Weather	3	(9+6+2) = 17	3x17 = 51
Volcano	1	(9+2+1) = 12	1x12 = 12
Wildfire	3	(3+2+1) = 6	3x6 = 18

Table 16-6. Hazard Risk Ranking

Hazard Ranking	Hazard Event	Category
1	Severe Weather	High
2	Earthquake	High
3	Flood	High
4	Avalanche	Medium
4	Landslide	Medium
4	Wildfire	Medium
5	Volcano	Low
8	Drought	Low
9	Dam Failure	Low

PART 3—MITIGATION STRATEGY

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 44 CFR (Section 201.6.c.3.ii), during the last plan update. One catalog was developed for each hazard of concern evaluated in the plan. The same catalogs used in the last update were reviewed for the 2019 update to determine if priorities or preferences have changes. The catalogs for each hazard are listed in Table 17-1 through Table 17-8. 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:
  - Individuals
  - Businesses
  - Government

Most hazard mitigation initiatives recommended in this plan update were selected from among the alternatives presented in the catalogs. Others arose out of thoughts generated by the review. 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.

No actions were reviewed for the avalanche hazard other than public education actions, since there is very little development exposed to this hazard within the planning area.

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

Personal Scale	Corporate Scale	Government Scale
Manipulate Hazard		
1. None	1. Remove dams 2. Remove levees 3. Harden dams	1. Remove dams 2. Remove levees 3. Harden dams
Reduce Exposure		
1. Relocate out of dam failure inundation areas	1. Replace earthen dams with hardened structures	1. Replace earthen dams with hardened structures 2. Relocate critical facilities out of dam failure inundation areas 3. Consider open space land use in designated dam failure inundation areas
Reduce Vulnerability		
1. Elevate home to appropriate levels	1. Flood-proof facilities within dam failure inundation areas	1. Adopt higher regulatory floodplain standards in mapped dam failure inundation areas 2. Retrofit critical facilities within dam failure inundation areas
Increase Preparation or Response Capability		
1. Learn about risk reduction for the dam failure hazard 2. Learn the evacuation routes for a dam failure event 3. Educate yourself on early warning systems and the dissemination of warnings	1. Educate employees on the probable impacts of a dam failure 2. Develop a continuity of operations plan	1. Map dam failure inundation areas 2. Enhance emergency operations plan to include a dam failure component 3. Institute monthly communications checks with dam operators 4. Inform the public on risk reduction techniques 5. Adopt real-estate disclosure requirements for the re-sale of property located within dam failure inundation areas 6. Consider the probable impacts of climate in assessing the risk associated with the dam failure hazard 7. Establish early warning capability downstream of listed high hazard dams 8. Consider the residual risk associated with protection provided by dams in future land use decisions

Table 17-2. Catalog of Mitigation Alternatives – Drought

Personal Scale	Corporate Scale	Government Scale
Manipulate Hazard		
1. None	1. None	1. Groundwater recharge through stormwater management
Reduce Exposure		
1. None	1. None	1. Identify and create groundwater backup sources
Reduce Vulnerability		
1. Drought-resistant landscapes 2. Reduce water system losses 3. Modify plumbing systems (through water saving kits)	1. Drought-resistant landscapes 2. Reduce private water system losses	1. Water use conflict regulations 2. Reduce water system losses 3. Distribute water saving kits
Increase Preparation or Response Capability		
1. Practice active water conservation	1. Practice active water conservation	1. Public education on drought resistance 2. Identify alternative water supplies for times of drought; mutual aid agreements with alternative suppliers 3. Develop drought contingency plan 4. Develop criteria “triggers” for drought-related actions 5. Improve accuracy of water supply forecasts 6. Modify rate structure to influence active water conservation techniques

Table 17-3. Catalog of Mitigation Alternatives – Earthquake

Personal Scale	Corporate Scale	Government Scale
Manipulate Hazard		
1. None	1. None	1. None
Reduce Exposure		
1. Locate outside of hazard area (off soft soils)	1. Locate or relocate mission-critical functions outside hazard area where possible	1. Locate critical facilities or functions outside hazard area where possible
Reduce Vulnerability		
1. Retrofit structure (anchor house structure to foundation) 2. Secure household items that can cause injury or damage (such as water heaters, bookcases, and other appliances) 3. Build to higher design	1. Build redundancy for critical functions and facilities 2. Retrofit critical buildings and areas housing mission-critical functions	1. Harden infrastructure 2. Provide redundancy for critical functions 3. Adopt higher regulatory standards
Increase Preparation or Response Capability		
1. Practice “drop, cover, and hold” 2. Develop household mitigation plan, such as creating a retrofit savings account, communication capability with outside, 72-hour self-sufficiency during an event 3. Keep cash reserves for reconstruction 4. Become informed on the hazard and risk reduction alternatives available 5. Develop a post-disaster action plan for your household	1. Adopt higher standard for new construction; consider “performance-based design” when building new structures 2. Keep cash reserves for reconstruction 3. Inform your employees on the possible impacts of earthquake and how to deal with them at your work facility 4. Develop a Continuity of Operations Plan	1. Provide better hazard maps 2. Provide technical information and guidance 3. Enact tools to help manage development in hazard areas (e.g., tax incentives, information) 4. Include retrofitting and replacement of critical system elements in capital improvement plan 5. Develop strategy to take advantage of post-disaster opportunities 6. Warehouse critical infrastructure components such as pipe, power line, and road repair materials 7. Develop and adopt a Continuity of Operations Plan 8. Initiate triggers guiding improvements (such as <50% substantial damage or improvements) 9. Further enhance seismic risk assessment to target high hazard buildings for mitigation opportunities 10. Develop a post-disaster action plan that includes grant funding and debris removal components

Table 17-4. Catalog of Mitigation Alternatives – Flood

Personal Scale	Corporate Scale	Government Scale
Manipulate Hazard		
1. Clear stormwater drains and culverts 2. Institute low-impact development techniques on property	1. Clear stormwater drains and culverts 2. Institute low-impact development techniques on property	1. Maintain drainage system 2. Institute low-impact development techniques on property 3. Dredging, levee construction, and providing regional retention areas 4. Structural flood control, levees, channelization, or revetments 5. Stormwater management regulations and master planning 6. Acquire vacant land or promote open space uses in developing watersheds to control increases in runoff
Reduce Exposure		
1. Locate outside of hazard area 2. Elevate utilities above base flood elevation 3. Institute low impact development techniques on property	1. Locate business critical facilities or functions outside hazard area 2. Institute low impact development techniques on property	1. Locate or relocate critical facilities outside of hazard area 2. Acquire or relocate identified repetitive loss properties 3. Promote open space uses in identified high hazard areas via techniques such as: planned unit developments, easements, setbacks, greenways, sensitive area tracks 4. Adopt land development criteria such as planned unit developments, density transfers, clustering 5. Institute low impact development techniques on property 6. Acquire vacant land or promote open space uses in developing watersheds to control increases in runoff
Reduce Vulnerability		
1. Retrofit structures (elevate structures above base flood elevation) 2. Elevate items within house above base flood elevation 3. Build new homes above base flood elevation 4. Flood-proof existing structures	1. Build redundancy for critical functions or retrofit critical buildings 2. Provide flood-proofing measures when new critical infrastructure must be located in floodplains	1. Harden infrastructure, bridge replacement program 2. Provide redundancy for critical functions and infrastructure 3 Adopt appropriate regulatory standards, such as: increased freeboard standards, cumulative substantial improvement or damage, lower substantial damage threshold; compensatory storage, non-conversion deed restrictions 4. Stormwater management regulations and master planning 5. Adopt "no-adverse impact" floodplain management policies that strive to not increase the flood risk on downstream communities

Personal Scale	Corporate Scale	Government Scale
Increase Preparation or Response Capability		
1. Buy flood insurance 2. Develop household mitigation plan, such as retrofit savings, communication capability with outside, 72-hour self-sufficiency during and after an event	1. Keep cash reserves for reconstruction 2. Support and implement hazard disclosure for the sale/re-sale of property in identified risk zones 3. Solicit cost-sharing through partnerships with other stakeholders on projects with multiple benefits	1. Produce better hazard maps 2. Provide technical information and guidance 3. Enact tools to help manage development in hazard areas (stronger controls, tax incentives, and information) 4. Incorporate retrofitting or replacement of critical system elements in capital improvement plan 5. Develop strategy to take advantage of post-disaster opportunities 6. Warehouse critical infrastructure components 7. Develop and adopt a Continuity of Operations Plan 8. Consider participation in the Community Rating System 9. Maintain existing data and gather new data needed to define risks and vulnerability 10. Train emergency responders 11. Create a building and elevation inventory of structures in the floodplain 12. Develop and implement a public information strategy 13. Charge a hazard mitigation fee 14. Integrate floodplain management policies into other planning mechanisms within the planning area 15. Consider the probable impacts of climate change on the risk associated with the flood hazard 16. Consider the residual risk associated with structural flood control in future land use decisions 17. Enforce National Flood Insurance Program 18. Adopt a Stormwater Management Master Plan

Table 17-5. Catalog of Mitigation Alternatives – Landslide

Personal Scale	Corporate Scale	Government Scale
Manipulate Hazard		
1. Stabilize slope (dewater, armor toe) 2. Reduce weight on top of slope 3. Minimize vegetation removal and the addition of impervious surfaces	1. Stabilize slope (dewater, armor toe) 2. Reduce weight on top of slope	1. Stabilize slope (dewater, armor toe) 2. Reduce weight on top of slope
Reduce Exposure		
1. Locate structures outside of hazard area (off unstable land and away from slide-run out area)	1. Locate structures outside of hazard area (off unstable land and away from slide-run out area)	1. Acquire properties in high-risk landslide areas 2. Adopt land use policies that prohibit the placement of habitable structures in high-risk landslide areas
Reduce Vulnerability		
1. Retrofit home	1. Retrofit at-risk facilities	1. Adopt higher regulatory standards for new development within unstable slope areas 2. Armor/retrofit critical infrastructure against the impact of landslides
Increase Preparation or Response Capability		
1. Institute warning system, and develop evacuation plan 2. Keep cash reserves for reconstruction 3. Educate yourself on risk reduction techniques for landslide hazards	1. Institute warning system, and develop evacuation plan 2. Keep cash reserves for reconstruction 3. Develop a Continuity of Operations Plan 4. Educate employees on the potential exposure to landslide hazards and emergency response protocol	1. Produce better hazard maps 2. Provide technical information and guidance 3. Enact tools to help manage development in hazard areas: better land controls, tax incentives, information 4. Develop strategy to take advantage of post-disaster opportunities 5. Warehouse critical infrastructure components 6. Develop and adopt a Continuity of Operations Plan 7. Educate the public on the landslide hazard and appropriate risk reduction alternatives

Table 17-6. Catalog of Mitigation Alternatives – Severe Weather

Personal Scale	Corporate Scale	Government Scale
Manipulate Hazard		
1. None	1. None	1. None
Reduce Exposure		
1. None	1. None	1. None
Reduce Vulnerability		
1. Insulate house 2. Provide redundant heat and power 3. Insulate structure 4. Plant appropriate trees near home and power lines ("Right tree, right place" National Arbor Day Foundation Program)	1. Relocate critical infrastructure (such as power lines) underground 2. Reinforce or relocate critical infrastructure such as power lines to meet performance expectations 3. Install tree wire	1. Harden infrastructure such as locating utilities underground 2. Trim trees back from power lines 3. Designate snow routes and strengthen critical road sections and bridges
Increase Preparation or Response Capability		
1. Trim or remove trees that could affect power lines 2. Promote 72-hour self-sufficiency 3. Obtain a NOAA weather radio 4. Obtain an emergency generator	1. Trim or remove trees that could affect power lines 2. Create redundancy 3. Equip facilities with a NOAA weather radio 4. Equip vital facilities with emergency power sources	1. Support programs such as "Tree Watch" that proactively manage problem areas through use of selective removal of hazardous trees, tree replacement, etc. 2. Establish and enforce building codes that require all roofs to withstand snow loads 3. Increase communication alternatives 4. Modify land use and environmental regulations to support vegetation management activities that improve reliability in utility corridors 5. Modify landscape and other ordinances to encourage appropriate planting near overhead power, cable, and phone lines 6. Provide NOAA weather radios to the public

Table 17-7. Catalog of Mitigation Alternatives – Volcano

Personal Scale	Corporate Scale	Government Scale
Manipulate Hazard		
1. None	1. None	1. Limited success has been experienced with lava flow diversion structures
Reduce Exposure		
1. Relocate outside of hazard area, such as lahar zones	1. Locate mission critical functions outside of hazard area, such as lahar zones whenever possible	1. Locate critical facilities and functions outside of hazard area, such as lahar zones, whenever possible
Reduce Vulnerability		
1. None	1. Protect corporate critical facilities and infrastructure from potential impacts of severe ash fall (air filtration capability)	1. Protect critical facilities from potential problems associated with ash fall 2. Build redundancy for critical facilities and functions
Increase Preparation or Response Capability		
1. Develop and practice a household evacuation plan	1. Develop and practice a corporate evacuation plan 2. Inform employees through corporate sponsored outreach 3. Develop a cooperative	1. Public outreach, awareness 2. Tap into state volcano warning system to provide early warning to county residents of potential ash fall problems

Table 17-8. Catalog of Mitigation Alternatives – Wildfire

Personal Scale	Corporate Scale	Government Scale
Manipulate Hazard		
1. Clear potential fuels on property such as dry overgrown underbrush and diseased trees	1. Clear potential fuels on property such as dry underbrush and diseased trees	1. Clear potential fuels on property such as dry underbrush and diseased trees 2. Implement best management practices on public lands
Reduce Exposure		
1. Create and maintain defensible space around structures 2. Locate outside of hazard area 3. Mow regularly	1. Create and maintain defensible space around structures and infrastructure 2. Locate outside of hazard area	1. Create and maintain defensible space around structures and infrastructure 2. Locate outside of hazard area 3. Enhance building code to include use of fire resistant materials in high hazard area
Reduce Vulnerability		
1. Create and maintain defensible space around structures and provide water on site 2. Use fire-retardant building materials 3. Create defensible spaces around home	1. Create and maintain defensible space around structures and infrastructure and provide water on site 2. Use fire-retardant building materials 3. Use fire-resistant plantings in buffer areas of high wildfire threat	1. Create and maintain defensible space around structures and infrastructure 2. Use fire-retardant building materials 3. Use fire-resistant plantings in buffer areas of high wildfire threat 4. Consider higher regulatory standards (such as Class A roofing) 5. Establish biomass reclamation initiatives
Increase Preparation or Response Capability		
1. Employ techniques from the National Fire Protection Association’s Firewise Communities program to safeguard home 2. Identify alternative water supplies for fire fighting 3. Install/replace roofing material with non-combustible roofing materials	1. Support Firewise community initiatives. 2. Create /establish stored water supplies to be utilized for firefighting	1. More public outreach and education efforts, including an active Firewise program 2. Possible weapons of mass destruction funds available to enhance fire capability in high-risk areas 3. Identify fire response and alternative evacuation routes 4. Seek alternative water supplies 5. Become a Firewise community 6. Use academia to study impacts/solutions to wildfire risk 7. Establish/maintain mutual aid agreements between fire service agencies 8. Create/implement fire plans 9. 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 planning partners and the steering committee determined that some initiatives from the mitigation catalogs could be implemented to provide hazard mitigation benefits countywide. Table ES-1-1 lists the recommended countywide initiatives, the lead agency for each, and the proposed timeline. The parameters for the timeline are as follows:

- Short Term = to be completed in 1 to 5 years
- Long Term = to be completed in greater than 5 years
- Ongoing = currently being funded and implemented under existing programs. For this update, an effort was made to look more closely at the ongoing activities, in the context of the five-year planning horizon of this plan.

The mitigation initiatives from the 2012 plan were reviewed by the full committee for status and progress made. The steering committee decided that all seven previous initiatives should be continued in the 2019 plan update.

Table 18-2 shows the status of each of the 2012 mitigation initiatives at the time of the 2019 plan update.

18.2. BENEFIT/COST REVIEW

44 CFR requires the prioritization of the action plan according to a benefit/cost evaluation 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 other HMA programs . Alternatively, 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.

For many of the strategies identified in this action plan, the partners may seek financial assistance under the HMGP, HMA or other programs, all 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.

Table 18-1. Countywide Mitigation Initiatives, 2019-2024

Initiative #	Initiative Description	Hazards Addressed	Lead Agency	Possible Funding Sources or Resources	Timeline
1	Continue to maintain a countywide hazard mitigation plan website to house the plan and plan updates, in order to provide the public an opportunity to monitor plan implementation and progress. Each planning partner may support the initiative by including an initiative in its action plan and creating a web link to the website. Updates will occur annually, or more often as appropriate.	All Hazards	Kittitas County Department of Public Works	General Fund	Short Term / Annually, 2019-2024
2	Leverage public outreach partnering capabilities to inform and educate the public about hazard mitigation and preparedness.	All Hazards	Kittitas County Department of Public Works/ All Planning Partners	General Fund	Short Term / Ongoing
3	Coordinate all mitigation planning and project efforts, including grant application support, to maximize all resources available to the planning partnership, with the County mentoring other jurisdictions with less grant application experience.	All Hazards	Kittitas County Department of Public Works	General Fund, FEMA mitigation grants	Short Term / 2019-2024
4	Support the collection of improved data (hydrologic, geologic, topographic, volcanic, historical, etc.) to better assess risks and vulnerabilities.	All Hazards	Kittitas County Department of Public Works	General Fund, FEMA mitigation grants	Short Term / 2019-2024
5	Provide coordination and technical assistance in grant application preparation that includes assistance in cost vs. benefit analysis for grant-eligible projects.	All Hazards	Kittitas County Department of Public Works	General Fund, FEMA mitigation grants	Short Term / Annually
6	Where appropriate, support retrofitting, purchase, or relocation of structures or infrastructure located in hazard-prone areas to protect structures/infrastructure from future damage, with repetitive loss and severe repetitive loss properties as priority when applicable.	All Hazards	All Planning Partners	FEMA mitigation grants	Long Term
7	Continue to maintain the steering committee as a viable committee to monitor the progress of the hazard mitigation plan, provide technical assistance to planning partners and oversee the implementation and update of the plan.	All Hazards	Kittitas County Department of Public Works	General Fund	Short Term / 2019-2024

Initiative #	Initiative Description	Hazards Addressed	Lead Agency	Possible Funding Sources or Resources	Timeline
8	Integrate mitigation plan requirements and actions into other appropriate planning mechanisms such as comprehensive plans and capital improvement plans.	All Hazards	Kittitas County / All Planning Partners	General Fund	At each update cycle
9	Support mitigation projects that will result in protection of public or private property from natural hazards. Eligible projects include but are not limited to: 1. Acquisition of flood prone property 2. Elevation of flood prone structures 3. Minor structural flood control projects 4. Relocation of structures from hazard prone areas 5. Retrofitting of existing buildings, facilities, and infrastructure 6. Retrofitting of existing building and facilities for shelter 7. Critical infrastructure protection measures 8. Stormwater management improvements 9. Advanced warning systems and hazard gauging systems (weather radios, reverse-911, stream gauges, I-flows) 10. Targeted hazard education 11. Wastewater and water supply system hardening and mitigation.	All Hazards	Kittitas County Department of Public Works / All Planning Partners	General Fund, FEMA mitigation grants	Annually, 2019-2024
10	Develop a system and designate responsible parties for capturing damage data after hazard events, to assist with capturing Public and Individual Assistance expenditures and to catalogue damages for use in developing future projects including. This data will assist with Benefit/Cost Analysis.	All Hazards	Kittitas County Department of Public Works / All Planning Partners	General Fund	Ongoing
11	With Kittitas County as lead, to provide guidance to other jurisdictions, evaluate the benefits of other jurisdictions joining the NFIP Community Rating System.	Flood	Kittitas County Department of Public Works / All Planning Partners	General Fund	Short Term / 2019-2021
12	Evaluate Countywide critical facilities list and GIS layer and update as appropriate, to continue improving the risk assessment in this plan.	All Hazards	Kittitas County Department of Public Works / All Planning Partners	General Fund	Short Term / 2019-2024

Initiative #	Initiative Description	Hazards Addressed	Lead Agency	Possible Funding Sources or Resources	Timeline
13	Increase stakeholder and public participation in the Kittitas County Hazard Mitigation Plan update process.	All Hazards	Kittitas County Department of Public Works / All Planning Partners	General Fund	2024
14	Prioritize Kittitas County's list of potential acquisitions of flood-prone properties.	Flood	Kittitas County Department of Public Works	FMAG Grant	2020
15	To more accurately show flood risks, develop maps that show alluvial fans, channel migration zones, and areas of cross-basin flow transfers	Flood	Kittitas County Department of Public Works and Information Technology	General Fund, FEMA mitigation grants	Long Term
16	Improve public health responses to hazard events. For example, testing drinking water for contamination after flood events or distributing masks and closing outdoor events when air quality declines due to wildfire.	Flood and Wildfire	Kittitas County Department of Public Health	General Fund	Short Term

Table 18-2. Status of 2012 - 2019 Mitigation Initiatives

Initiative #	Initiative Description	Hazards Addressed	Lead Agency	Possible Funding Sources or Resources	Timeline	Status
1	Continue to maintain a countywide hazard mitigation plan website to house the plan and plan updates, in order to provide the public an opportunity to monitor plan implementation and progress. Each planning partner may support the initiative by including an initiative in its action plan and creating a web link to the website.	All Hazards	Kittitas County Department of Public Works	General Fund	Short Term/ Ongoing	Partially Complete/Carry Over to 2019
2	Leverage public outreach partnering capabilities to inform and educate the public about hazard mitigation and preparedness.	All Hazards	Kittitas County Department of Public Works/ All Planning Partners	General Fund	Short Term/ Ongoing	Partially Completed, through the mitigation planning and Risk MAP processes/Carry-Over
3	Coordinate all mitigation planning and project efforts, including grant application support, to maximize all resources available to the planning partnership.	All Hazards	Kittitas County Department of Public Works	General Fund, FEMA mitigation grants	Short Term/ Ongoing	Complete CTP and other Grants, provided some support to other jurisdictions/Carry-over
4	Support the collection of improved data (hydrologic, geologic, topographic, volcanic, historical, etc.) to better assess risks and vulnerabilities.	All Hazards	Kittitas County Department of Public Works	General Fund, FEMA mitigation grants	Short Term/ Ongoing	Complete/Carry-over
5	Provide coordination and technical assistance in grant application preparation that includes assistance in cost vs. benefit analysis for grant-eligible projects.	All Hazards	Kittitas County Department of Public Works	General Fund, FEMA mitigation grants	Short Term/ Ongoing	Not Completed/ Carry-over
6	Where appropriate, support retrofitting, purchase, or relocation of structures or infrastructure located in hazard-prone areas to protect structures/infrastructure from future damage, with repetitive loss and severe repetitive loss properties as priority when applicable.	All Hazards	All Planning Partners	FEMA mitigation grants	Long Term	Complete/Carry-over
7	Continue to maintain the steering committee as a viable committee to monitor the progress of the hazard mitigation plan, provide technical assistance to planning partners and oversee the update of the plan as necessary.	All Hazards	Kittitas County Department of Public Works	General Fund	Short Term/ Ongoing	Partially Complete/Carry-over

18.3. COUNTY-WIDE ACTION PLAN PRIORITIZATION

Table 18-3 lists the priority of each countywide initiative, using the same parameters used by each of the planning partners in selecting their initiatives. A qualitative benefit-cost review was performed for each of these initiatives. The priorities are defined as follows:

- **High Priority**—A project that meets multiple objectives (i.e., multiple hazards), has benefits that exceed cost, has funding secured or is an ongoing project and meets eligibility requirements for the HMGP or PDM grant program. High priority projects can be completed in the short term (1 to 5 years).
- **Medium Priority**—A project that meets goals and objectives, that has benefits that exceed costs, and for which funding has not been secured but that is grant eligible under HMGP, PDM or other grant programs. Project can be completed in the short term, once funding is secured. Medium priority projects will become high priority projects once funding is secured.
- **Low Priority**—A project that will mitigate the risk of a hazard, that has benefits that do not exceed the costs or are difficult to quantify, for which funding has not been secured, that is not eligible for HMGP or PDM grant funding, and for which the time line for completion is long term (1 to 10 years). Low priority projects may be eligible for other sources of grant funding from other programs.

In addition to the benefit-cost ranking, the 2019 plan update conducted a ranking exercise at the January 9th, 2019 stakeholder meeting. Attendees ranked each mitigation initiative based on which actions they thought should be prioritized by the County. The results of this exercise are shown in the last column of Table 18-3.

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.

Table 18-3. Prioritization of Countywide Mitigation Initiatives

Initiative #	# of Objectives Met	Benefits	Costs	Do Benefits Equal or Exceed Costs?	Is Project Grant eligible?	Can Project Be Funded under Existing Programs/ Budgets?	Priority (High, Med., Low)	Stakeholder Meeting Ranking
CW-1	3	High	Low	Yes	No	Yes	High	Low
CW-2	3	Low	Low	Yes	No	Yes	Medium	Low
CW-3	5	Medium	Low	Yes	Yes	Yes	High	Medium
CW-4	3	High	High	Yes	Yes	No	High	High
CW-5	5	Medium	Low	Yes	Yes	No	High	Medium
CW-6	4	High	High	Yes	Yes	No	High	Medium
CW-7	2	Low	Low	Yes	No	Yes	High	Low
CW-8	5	High	Low	Yes	No	Yes	High	Medium
CW-9	5	High	High	Yes	Yes	Yes	High	High
CW-10	1	High	Low	Yes	No	Yes	High	Medium
CW-11	1	Medium	Low	Yes	No	Yes	Medium	Low
CW-12	2	Medium	Low	Yes	No	Yes	Medium	Low
CW-13	3	Medium	Low	Yes	Yes	Yes	Medium	Low
CW-14	4	Medium	Low	Yes	Yes	No	Medium	Low

Initiative #	# of Objectives Met	Benefits	Costs	Do Benefits Equal or Exceed Costs?	Is Project Grant eligible?	Can Project Be Funded under Existing Programs/ Budgets?	Priority (High, Med., Low)	Stakeholder Meeting Ranking
CW-15	2	High	Medium	Yes	Yes	No	High	High
CW-16	3	High	Medium	Yes	Yes	Yes	High	Medium

18.4. PLAN ADOPTION

Section 201.6.c.5 of 44 CFR 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 is has been formally adopted. This plan update will be submitted for a pre-adoption review to the Washington State Division of Emergency Management and FEMA prior to adoption. Once pre-adoption approval has been provided, all planning partners will formally adopt the plan. All partners understand that DMA compliance and its benefits cannot be achieved until the plan is adopted. Copies of the resolutions adopting this updated plan for all planning partners can be found in Appendix D of this volume. Some planning partners/jurisdictions are new to the plan and are adopting for the first time.

18.5. PLAN MAINTENANCE STRATEGY

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

- A section describing the method and schedule of monitoring, evaluating, and updating the mitigation plan over a 5-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 Kittitas 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 become available, resulting in a plan that will remain current and relevant. It is important to note that this process mirrors the one outlined in the 2012 plan. While the process was not followed closely during the last seven years, with new staff at the County level and on the Steering committee, it is our commitment to focus more carefully on the process over this planning horizon.

18.5.1 Plan Implementation

The effectiveness of the hazard mitigation plan depends on its 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 5 years. The planning team and the steering committee have established and recommitted to the goals and objectives and have prioritized mitigation actions that will be implemented through existing plans, policies, and programs.

Kittitas County Public Works will have lead responsibility for overseeing the plan implementation and maintenance strategy. Plan implementation and evaluation will be a shared responsibility among all planning partnership members and agencies identified as lead agencies in the mitigation action plans (see planning partner annexes in Volume 2 of this plan).

18.5.2 Steering Committee

The steering committee is a total volunteer body that oversaw the development of the Plan update and made recommendations on key elements of the plan, including the maintenance strategy. It was comprised primarily by representatives of the County and other participating jurisdictions. It was the steering committee's position that an oversight committee with representation similar to the initial steering committee should have an active role in the Plan maintenance strategy. Therefore, it is recommended that a steering committee remain a viable body involved in key elements of the Plan maintenance strategy. With this planning cycle, the steering committees will strive to include representation from the planning partners, as well as other stakeholders in the planning area.

The principal role of the steering committee in the plan maintenance strategy will be to review the annual progress report and provide input to Kittitas County on possible enhancements to be considered at the next update. Future plan updates will be overseen by a steering committee similar to the one that participated in this plan update process, so keeping an interim steering committee intact will provide a head start on future updates. Completion of the progress report is the responsibility of each planning partner, not the responsibility of the steering committee. It will simply be the steering committee's role to review the progress report in an effort to identify issues needing to be addressed by future plan updates.

18.5.3 Annual Progress Report

The minimum task of each planning partner will be the evaluation of the progress of its individual action plan during a 12-month performance period. These updates were not completed through the planning cycle beginning in 2012, primarily due to staff changes at the County and jurisdictional levels. The planning partners have renewed their commitment to the reports during this plan update process. 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 (grant opportunities)
- Impact of any other planning programs or initiatives that involve hazard mitigation.

Kittitas County Department of Public Works will assume the responsibility of initiating the annual progress reporting process. A template to guide the planning partners in preparing a progress was created as part of the 2012 planning process (see Appendix C), and will continue for use during this cycle. The plan maintenance steering committee will provide feedback to the planning team on items included in the template. Public Works will then prepare a formal annual report on the progress of the plan. This report should be used as follows:

- Posted on the Kittitas County website page dedicated to the hazard mitigation plan
- Provided to the local media through a press release
- Presented to planning partner governing bodies to inform them of the progress of actions implemented during the reporting period
- For those planning partners that participate in the Community Rating System, or choose to join in the future, the report can be provided as part of the CRS annual re-certification package. The CRS requires an annual recertification to be submitted by October 1 of every calendar year for which the community has not received a formal audit. To meet this recertification timeline, the planning team will strive to complete progress reports between June and September each year.

Uses of the progress report will be at the discretion of each planning partner. Annual progress reporting is not a requirement specified under 44 CFR. 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 DMA, 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 plan update , and each partner acknowledged these expectations when with submittal of a letter of intent to participate in this process.

18.5.4 Plan Update

44 CFR requires that local hazard mitigation plans be reviewed, revised if appropriate, and resubmitted for approval in order to remain eligible for benefits under the DMA (Section 201.6.d.3). This is the first five year plan update. The Kittitas County partnership intends to continue to update the hazard mitigation plan on a 5-year cycle from the date of adoption of this plan update. This cycle may be accelerated to less than 5 years based on the following triggers:

- A Presidential Disaster Declaration that impacts the planning area
- A hazard event that causes loss of life
- 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 action plans will be reviewed and revised to account for any initiatives completed, dropped, or changed and to account for changes in the risk assessment or new partnership policies identified under other planning mechanisms (such as the comprehensive plan).
- The draft update will be sent to appropriate agencies and organizations for comment.
- The public will be given an opportunity to comment on the update prior to adoption.
- The partnership governing bodies will adopt their respective portions of the updated plan.

18.5.5 Continuing Public Involvement

The public will continue to be apprised of the plan's progress through the Kittitas County website and by providing copies of annual progress reports to the media. Each planning partner has agreed to provide links to the County hazard mitigation plan website on their individual jurisdictional websites to increase avenues of public access to the plan. Kittitas County Public Works has agreed to maintain the hazard mitigation plan website. This site will not only house the final updated plan, it will become the one-stop shop for information regarding the plan, the partnership and plan implementation. Copies of the plan will be distributed to the Kittitas County Library system. 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. At a minimum, this strategy will include the use of local media outlets within the planning area, as was done for this update.

18.5.6 Incorporation into Other Planning Mechanisms

The information on hazard, risk, vulnerability, and mitigation contained in this plan update is based on the best science and technology available at the time this plan was prepared, within the limits of scope and budget constraints. The Kittitas 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 the Kittitas County. Future updates to a comprehensive plan may trigger an update to the hazard mitigation plan.

All municipal planning partners are committed to creating a linkage between the hazard mitigation plan and their individual comprehensive plans by identifying a mitigation initiative as such and giving that initiative a high priority. Other planning processes and programs to be coordinated with the recommendations of the hazard mitigation plan include the following:

- Partners' emergency response plans
- Capital improvement programs
- Municipal codes
- Critical areas regulation
- Growth management
- Water Resource Inventory Area planning
- Basin planning
- Community design guidelines
- Water-efficient landscape design guidelines
- Stormwater management programs
- Water system vulnerability assessments
- Master fire protection plans

Some action items do not need to be implemented through regulation. Instead, these items can be implemented through the creation of new educational programs, continued interagency coordination, or improved public participation. As information becomes available from other planning mechanisms that can enhance this plan, that information will be incorporated via the update process.

REFERENCES AND APPENDICES

REFERENCES

Advanced National Seismic System. 2012. http://www.quake.geo.berkeley.edu/anss/catalog-search.html

BERK Consulting. 2016. Kittitas County Population Projection Review and Analysis

Center for Disease Control. 2017. Water, Sanitation, & Hygiene (WASH)-related Emergencies & Outbreaks. https://www.cdc.gov/healthywater/emergency/extreme-weather/floods-standingwater.html. Accessed November 15, 2018.

Dalton, M.M., P.W. Mote, and A.K. Snover [Eds.]. 2013. Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities. Washington, DC: Island Press.

EPA 2018. Climate Impacts in the Northwest. https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-northwest_.html. Website accessed October 19, 2018.

FEMA. 2010. News Release: Mold Can Be a Danger After Flooding. https://www.fema.gov/news-release/2010/09/22/mold-can-be-danger-after-flooding. Accessed November 15, 2018.

FEMA. 2001. Understanding Your Risks; Identifying Hazards and Determining your Risks. FEMA (386-2). August 2001

FEMA. 2002. Getting Started; Building support for Mitigation Planning; FEMA (386-1). September 2002

FEMA. 2003. Developing the Mitigation Plan; Identifying Mitigation Actions and Implementing Strategies. FEMA (386-3). April 2003

FEMA. 2017. FEMA, National Flood Insurance Program, Community Rating System; Coordinator's Manual FIA-15/2017 OMB No. 1660-0022

FEMA. 2017. Federal Insurance and Mitigation Administration, Community Rating System Fact Sheet. June 2017. https://www.fema.gov/media-library-data/1507029324530-082938e6607d4d9eba4004890dbad39c/NFIP_CRS_Fact_Sheet_2017_508OK.pdf. Accessed November 11, 2018.

Headwaters Economics, 2018. Economic Profile System. Accessed May 8, 2018. Available at: https://headwaterseconomics.org/tools/economic-profile-system/.

International Strategy for Disaster Reduction. 11/11/2008. "Disaster Risk Reduction Strategies and Risk Management Practices: Critical Elements for Adaptation to Climate Change"

Kittitas County Comprehensive Flood Hazard Management Plan, December 1996

Kittitas County Comprehensive Plan, 2018.

Kittitas County Shoreline Master Program, 2016 Update. https://www.co.kittitas.wa.us/cds/smp/default.aspx

Kittitas County Wildfire Protection Plan. 2018. https://www.co.kittitas.wa.us/uploads/documents/cds/fire-marshal/Kittitas_County_CWPP_Update_10-9-2018.pdf.

NASA, 2004. http://earthobservatory.nasa.gov/Newsroom/view.php?id=25145 NASA Earth Observatory News Web Site Item, dated August 2, 2004.

National Interagency Fire Center. Statistics. https://www.nifc.gov/fireInfo/fireInfo_statistics.html. Accessed November 28, 2018/

NOAA. 2018. https://www.ncdc.noaa.gov/stormevents/. NOAA, National Centers for Environmental Information website, accessed 2018.

Northwest Avalanche Center. Statistics. https://www.nwac.us/accidents/statistics/

Pacific Northwest Seismic Network. Recent Earthquakes List. https://pnsn.org/events?custom_search=true. Accessed November 27, 2018.

Pearce, Fred. 2012. Yale Environment 360. Could a Changing Climate Set Off Volcanoes and Quakes? https://e360.yale.edu/features/could_a_changing_climate_set_off_volcanoes_and_quakes

Rosenberg, E.A., P.W. Keys, D.B. Booth, D. Hartley, J. Burkey, A.C. Steinemann, and D.P. Lettenmaier. 2010. Precipitation extremes and the impacts of climate change on stormwater infrastructure in Washington State. Climatic Change 102(1-2): 319-349.

Salathé, E.P., L.R. Leung, Y. Qian, and Y. Zhang. 2010. Regional climate model projections for the State of Washington. Climatic Change 102(1-2): 51-75.

SCS. 1983. Soil Survey of Chelan Area, Washington, Parts of Chelan and Kittitas County Area, Washington. Soil Interpretation Table for Kittitas County. U.S. Department of Agriculture Soil Conservation Service. June 1983.

Spatial Hazard Events and Losses Database for the United States maintained by the Arizona State University (ASU) Center for Emergency Management and Homeland Security

Tebaldi, C., K. Hayhoe, J.M. Arblaster, and G.A. Meehl. 2006. Going to the Extremes: An Intercomparison of Model-Simulated Historical and Future Changes in Extreme Events. Climatic Change 79(3-4): 185-211.

U.S. Census. 2010. Data from 2010 U.S. Census. U.S. Census Bureau. https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml

USDA, Natural Resources Conservation Service Web Soil Survey. 2010. https://www.nrcs.usda.gov/Internet/FSE_MANUSCRIPTS/washington/kittitasWA2010/Maps/Web/kittitas_wa_gsm.pdf

USGS Earthquake Hazards Program. Unified Hazard Tool. https://earthquake.usgs.gov/hazards/interactive/index.php. Accessed November 28, 2018.

USGS. 2018. National Water Information System: Web Interface. https://nwis.waterdata.usgs.gov/nwis/peak?site_no=12484500&agency_cd=USGS&format=html. Accessed November 13, 2018.

Washington Department of Ecology, Inventory of Dams Report. June, 2018. https://fortress.wa.gov/ecy/publications/documents/94016.pdf

Washington Department of Ecology, Washington State Notable Dam Failures and Incidents. February 2018. https://fortress.wa.gov/ecy/wrdocs/WaterRights/wrwebpdf/damfailure-ws.pdf

Washington Department of Ecology, Preparing for a Changing Climate: Washington State's Integrated Climate Change Response Strategy. April 2012. https://fortress.wa.gov/ecy/publications/publications/1201004.pdf

Washington Emergency Management Division. Washington State Enhanced Hazard Mitigation Plan. 2018.

Washington Seismic Safety Committee, Emergency Management Council. Resilient Washington State. November 2012. https://mil.wa.gov/uploads/pdf/seismic-safety-committee/RWS%20final%20report.pdf

William D. Ruckelshaus Center. Washington State Coast Resilience Assessment Final Report. May 2017. http://mrsc.org/getmedia/0498ef44-89e8-46c7-b834-469b992196c6/Washington-Coast-Resilience-Assessment-Report.aspx

APPENDIX A.
ACRONYMS AND DEFINITIONS

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ACRONYMS AND DEFINITIONS

ACRONYMS

ASHRAE—American Society of Heating, Refrigerating, and Air-Conditioning Engineers

BOR—U.S. Bureau of Reclamation

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

DSO – Dam Safety Office

EAP—Emergency Action Plan

EPA—U.S. Environmental Protection Agency

ESA—Endangered Species Act

FCAAP—Flood Control Assistance Account Program

FCMP—Flood Control Maintenance Program

FEMA—Federal Emergency Management Agency

FERC—Federal Energy Regulatory Commission

FIRM—Flood Insurance Rate Map

FIS—Flood Insurance Study

GIS—Geographic Information System

GMA—Growth Management Act

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

NFPA—National Fire Protection Association

NFR—Natural fire rotation

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

RCW—Revised Code of Washington

SCS—U.S. Department of Agriculture Soil Conservation Service

SFHA—Special Flood Hazard Area

SHELDUS—Special Hazard Events and Losses Database for the US

SPI—Standardized Precipitation Index

USGS—U.S. Geological Survey

WAC—Washington Administrative Code

WDFW—Washington Department of Fish and Wildlife

WUI— Wildland Urban Interface

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:

- Legal and regulatory capability
- Administrative and technical capability
- Fiscal capability

Community Rating System (CRS): The CRS is a voluntary program under the NFIP that rewards participating communities (provides incentives) for exceeding the minimum requirements of the NFIP and completing activities that reduce flood hazard risk by providing flood insurance premium discounts.

Critical Area: An area defined by state or local regulations as deserving special protection because of unique natural features or its value as habitat for a wide range of species of flora and fauna. A sensitive/critical area is usually subject to more restrictive development regulations.

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

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

Cubic Feet per Second (cfs): Discharge or river flow is commonly measured in cfs. One cubic foot is about 7.5 gallons of liquid.

Dam: Any artificial barrier or controlling mechanism that can or does impound 10 acre-feet or more of water.

Dam Failure: Dam failure refers to a partial or complete breach in a dam (or levee) that impacts its integrity. Dam failures occur for a number of reasons, such as flash flooding, inadequate spillway size, mechanical failure of valves or other equipment, freezing and thawing cycles, earthquakes, and intentional destruction.

Debris Avalanche: Volcanoes are prone to debris and mountain rock avalanches that can approach speeds of 100 mph.

Debris Flow: Dense mixtures of water-saturated debris that move down-valley; looking and behaving much like flowing concrete. They form when loose masses of unconsolidated material are saturated, become unstable, and move down slope. The source of water varies but includes rainfall, melting snow or ice, and glacial outburst floods.

Debris Slide: Debris slides consist of unconsolidated rock or soil that has moved rapidly down slope. They occur on slopes greater than 65 percent.

Disaster Mitigation Act of 2000 (DMA); The DMA is Public Law 106-390 and is the latest federal legislation enacted to encourage and promote proactive, pre-disaster planning as a condition of receiving financial assistance under the Robert T. Stafford Act. The DMA emphasizes planning for disasters before they occur. Under the DMA, a pre-disaster hazard mitigation program and new requirements for the national post-disaster hazard mitigation grant program (HMGP) were established.

Drainage Basin: A basin is the area within which all surface water- whether from rainfall, snowmelt, springs or other sources- flows to a single water body or watercourse. The boundary of a river basin is defined by natural topography, such as hills, mountains and ridges. Drainage basins are also referred to as **watersheds** or **basins**.

Drought: Drought is a period of time without substantial rainfall or snowfall from one year to the next. Drought can also be defined as the cumulative impacts of several dry years or a deficiency of precipitation over an extended period of time, which in turn results in water shortages for some activity, group, or environmental function. A hydrological drought is caused by deficiencies in surface and subsurface water supplies. A socioeconomic drought impacts the health, well-being, and quality of life or starts to have an adverse impact on a region. Drought is a normal, recurrent feature of climate and occurs almost everywhere.

Earthquake: An earthquake is defined as a sudden slip on a fault, volcanic or magmatic activity, and sudden stress changes in the earth that result in ground shaking and radiated seismic energy. Earthquakes can last from a few seconds to over 5 minutes, and have been known to occur as a series of tremors over a period of several days. The actual movement of the ground in an earthquake is seldom the direct cause of injury or death. Casualties may result from falling objects and debris as shocks shake, damage, or demolish buildings and other structures.

Exposure: Exposure is defined as the number and dollar value of assets considered to be at risk during the occurrence of a specific hazard.

Extent: The extent is the size of an area affected by a hazard.

Fire Behavior: Fire behavior refers to the physical characteristics of a fire and is a function of the interaction between the fuel characteristics (such as type of vegetation and structures that could burn), topography, and weather. Variables that affect fire behavior include the rate of spread, intensity, fuel consumption, and fire type (such as underbrush versus crown fire).

Fire Frequency: Fire frequency is the broad measure of the rate of fire occurrence in a particular area. An estimate of the areas most likely to burn is based on past fire history or fire rotation in the area, fuel conditions, weather, ignition sources (such as human or lightning), fire suppression response, and other factors.

Flash Flood: A flash flood occurs with little or no warning when water levels rise at an extremely fast rate

Flood Insurance Rate Map (FIRM): FIRMs are the official maps on which the Federal Emergency Management Agency (FEMA) has delineated the Special Flood Hazard Area (SFHA).

Flood Insurance Study: A report published by the Federal Insurance and Mitigation Administration for a community in conjunction with the community's Flood Insurance rate Map. The study contains such background data as the base flood discharges and water surface elevations that were used to prepare the FIRM. In most cases, a community FIRM with detailed mapping will have a corresponding flood insurance study.

Floodplain: Any land area susceptible to being inundated by flood waters from any source. A flood insurance rate map identifies most, but not necessarily all, of a community's floodplain as the Special Flood Hazard Area (SFHA).

Floodway: Floodways are areas within a floodplain that are reserved for the purpose of conveying flood discharge without increasing the base flood elevation more than 1 foot. Generally speaking, no development is allowed in floodways, as any structures located there would block the flow of floodwaters.

Floodway Fringe: Floodway fringe areas are located in the floodplain but outside of the floodway. Some development is generally allowed in these areas, with a variety of restrictions. On maps that have identified and delineated a floodway, this would be the area beyond the floodway boundary that can be subject to different regulations.

Fog: Fog refers to a cloud (or condensed water droplets) near the ground. Fog forms when air close to the ground can no longer hold all the moisture it contains. Fog occurs either when air is cooled to its dew point or the amount of moisture in the air increases. Heavy fog is particularly hazardous because it can restrict surface visibility. Severe fog incidents can close roads, cause vehicle accidents, cause airport delays, and impair the effectiveness of emergency response. Financial losses associated with transportation delays caused by fog have not been calculated in the United States but are known to be substantial.

Freeboard: Freeboard is the margin of safety added to the base flood elevation.

Frequency: For the purposes of this plan, frequency refers to how often a hazard of specific magnitude, duration, and/or extent is expected to occur on average. Statistically, a hazard with a 100-year frequency is expected to occur about once every 100 years on average and has a 1 percent chance of occurring any given year. Frequency reliability varies depending on the type of hazard considered.

Fujita Scale of Tornado Intensity: Tornado wind speeds are sometimes estimated on the basis of wind speed and damage sustained using the Fujita Scale. The scale rates the intensity or severity of tornado events using numeric values from F0 to F5 based on tornado wind speed and damage. An F0 tornado (wind speed less than 73 miles per hour (mph)) indicates minimal damage (such as broken tree limbs), and an F5 tornado (wind speeds of 261 to 318 mph) indicates severe damage.

Goal: A goal is a general guideline that explains what is to be achieved. Goals are usually broad-based, long-term, policy-type statements and represent global visions. Goals help define the benefits that a plan is trying to achieve. The success of a hazard mitigation plan is measured by the degree to which its goals have been met (that is, by the actual benefits in terms of actual hazard mitigation).

Geographic Information System (GIS): GIS is a computer software application that relates data regarding physical and other features on the earth to a database for mapping and analysis.

Hazard: A hazard is a source of potential danger or adverse condition that could harm people and/or cause property damage.

Hazard Mitigation Grant Program (HMGP): Authorized under Section 202 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, the HMGP is administered by FEMA and provides grants to states, tribes, and local governments to implement hazard mitigation actions after a major disaster declaration. The purpose of the program is to reduce the loss of life and property due to disasters and to enable mitigation activities to be implemented as a community recovers from a disaster

Hazards U.S. Multi-Hazard (HAZUS-MH) Loss Estimation Program: HAZUS-MH is a GIS-based program used to support the development of risk assessments as required under the DMA. The HAZUS-MH software program assesses risk in a quantitative manner to estimate damages and losses associated with natural hazards. HAZUS-MH is FEMA's nationally applicable, standardized methodology and software program and contains modules for estimating potential losses from earthquakes, floods, and wind hazards. HAZUS-MH has also been used to assess vulnerability (exposure) for other hazards.

Hydraulics: Hydraulics is the branch of science or engineering that addresses fluids (especially water) in motion in rivers or canals, works and machinery for conducting or raising water, the use of water as a prime mover, and other fluid-related areas.

Hydrology: Hydrology is the analysis of waters of the earth. For example, a flood discharge estimate is developed by conducting a hydrologic study.

Intensity: For the purposes of this plan, intensity refers to the measure of the effects of a hazard.

Inventory: The assets identified in a study region comprise an inventory. Inventories include assets that could be lost when a disaster occurs and community resources are at risk. Assets include people, buildings, transportation, and other valued community resources.

Landslide: Landslides can be described as the sliding movement of masses of loosened rock and soil down a hillside or slope. Fundamentally, slope failures occur when the strength of the soils forming the slope exceeds the pressure, such as weight or saturation, acting upon them.

Lightning: Lightning is an electrical discharge resulting from the buildup of positive and negative charges within a thunderstorm. When the buildup becomes strong enough, lightning appears as a “bolt,” usually within or between clouds and the ground. A bolt of lightning instantaneously reaches temperatures approaching 50,000ºF. The rapid heating and cooling of air near lightning causes thunder. Lightning is a major threat during thunderstorms. In the United States, 75 to 100 Americans are struck and killed by lightning each year (see http://www.fema.gov/hazard/thunderstorms/thunder.shtm).

Liquefaction: Liquefaction is the complete failure of soils, occurring when soils lose shear strength and flow horizontally. It is most likely to occur in fine grain sands and silts, which behave like viscous fluids when liquefaction occurs. This situation is extremely hazardous to development on the soils that liquefy, and generally results in extreme property damage and threats to life and safety.

Local Government: Any county, municipality, city, town, township, public authority, school district, special district, intrastate district, council of governments (regardless of whether the council of governments is incorporated as a nonprofit corporation under State law), regional or interstate government entity, or agency or instrumentality of a local government; any Indian tribe or authorized tribal organization, or Alaska Native village or organization; and any rural community, unincorporated town or village, or other public entity.

Magnitude: Magnitude is the measure of the strength of an earthquake, and is typically measured by the Richter scale. As an estimate of energy, each whole number step in the magnitude scale corresponds to the release of about 31 times more energy than the amount associated with the preceding whole number value.

Mass movement: A collective term for landslides, mudflows, debris flows, sinkholes and lahars.

Mitigation: A preventive action that can be taken in advance of an event that will reduce or eliminate the risk to life or property.

Mitigation Actions: Mitigation actions are specific actions to achieve goals and objectives that minimize the effects from a disaster and reduce the loss of life and property.

Objective: For the purposes of this plan, an objective is defined as a short-term aim that, when combined with other objectives, forms a strategy or course of action to meet a goal. Unlike goals, objectives are specific and measurable.

Peak Ground Acceleration: Peak Ground Acceleration (PGA) is a measure of the highest amplitude of ground shaking that accompanies an earthquake, based on a percentage of the force of gravity.

Preparedness: Preparedness refers to actions that strengthen the capability of government, citizens, and communities to respond to disasters.

Presidential Disaster Declaration: These declarations are typically made for events that cause more damage than state and local governments and resources can handle without federal government assistance. Generally, no specific dollar loss threshold has been established for such declarations. A Presidential Disaster Declaration puts into motion long-term federal recovery programs, some of which are matched by state programs, designed to help disaster victims, businesses, and public entities.

Probability of Occurrence: The probability of occurrence is a statistical measure or estimate of the likelihood that a hazard will occur. This probability is generally based on past hazard events in the area and a forecast of events that could occur in the future. A probability factor based on yearly values of occurrence is used to estimate probability of occurrence.

Repetitive Loss Property: Any NFIP-insured property that, since 1978 and regardless of any changes of ownership during that period, has experienced:

- Four or more paid flood losses in excess of $1000.00; or
- Two paid flood losses in excess of $1000.00 within any 10-year period since 1978 or
- Three or more paid losses that equal or exceed the current value of the insured property.

Return Period (or Mean Return Period): This term refers to the average period of time in years between occurrences of a particular hazard (equal to the inverse of the annual frequency of occurrence).

Riverine: Of or produced by a river. Riverine floodplains have readily identifiable channels. Floodway maps can only be prepared for riverine floodplains.

Risk: Risk is the estimated impact that a hazard would have on people, services, facilities, and structures in a community. Risk measures the likelihood of a hazard occurring and resulting in an adverse condition that causes injury or damage. Risk is often expressed in relative terms such as a high, moderate, or low likelihood of sustaining damage above a particular threshold due to occurrence of a specific type of hazard. Risk also can be expressed in terms of potential monetary losses associated with the intensity of the hazard.

Risk Assessment: Risk assessment is the process of measuring potential loss of life, personal injury, economic injury, and property damage resulting from hazards. This process assesses the vulnerability of people, buildings, and infrastructure to hazards and focuses on (1) hazard identification; (2) impacts of hazards on physical, social, and economic assets; (3) vulnerability identification; and (4) estimates of the cost of damage or costs that could be avoided through mitigation.

Risk Ranking: This ranking serves two purposes, first to describe the probability that a hazard will occur, and second to describe the impact a hazard will have on people, property, and the economy. Risk estimates 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.

Special Flood Hazard Area: The base floodplain delineated on a Flood Insurance Rate Map. The SFHA is mapped as a Zone A in riverine situations and zone V in coastal situations. The SFHA may or may not encompass all of a community's flood problems

Stakeholder: Business leaders, civic groups, academia, non-profit organizations, major employers, managers of critical facilities, farmers, developers, special purpose districts, and others whose actions could impact hazard mitigation.

Stream Bank Erosion: Stream bank erosion is common along rivers, streams and drains where banks have been eroded, sloughed or undercut. However, it is important to remember that a stream is a dynamic and constantly changing system. It is natural for a stream to want to meander, so not all eroding banks are "bad" and in need of repair. Generally, stream bank erosion becomes a problem where development has limited the meandering nature of streams, where streams have been channelized, or where stream bank structures (like bridges, culverts, etc.) are located in places where they can actually cause damage to downstream areas. Stabilizing these areas can help protect watercourses from continued sedimentation, damage to adjacent land uses, control unwanted meander, and improvement of habitat for fish and wildlife.

Steep Slope: Different communities and agencies define it differently, depending on what it is being applied to, but generally a steep slope is a slope in which the percent slope equals or exceeds 25%. For this study, steep slope is defined as slopes greater than 33%.

Sustainable Hazard Mitigation: This concept includes the sound management of natural resources, local economic and social resiliency, and the recognition that hazards and mitigation must be understood in the largest possible social and economic context.

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

Tornado: A tornado is a violently rotating column of air extending between and in contact with a cloud and the surface of the earth. Tornadoes are often (but not always) visible as funnel clouds. On a local scale, tornadoes are the most intense of all atmospheric circulations, and winds can reach destructive speeds of more than 300 mph. A tornado's vortex is typically a few hundred meters in diameter, and damage paths can be up to 1 mile wide and 50 miles long.

Vulnerability: Vulnerability describes how exposed or susceptible an asset is to damage. Vulnerability depends on an asset's construction, contents, and the economic value of its functions. Like indirect damages, the vulnerability of one element of the community is often related to the vulnerability of another. For example, many businesses depend on uninterrupted electrical power. Flooding of an electric substation would affect not only the substation itself but businesses as well. Often, indirect effects can be much more widespread and damaging than direct effects.

Watershed: A watershed is an area that drains downgradient from areas of higher land to areas of lower land to the lowest point, a common drainage basin.

Wildfire: These terms refer to any uncontrolled fire occurring on undeveloped land that requires fire suppression. The potential for wildfire is influenced by three factors: the presence of fuel, topography, and air mass. Fuel can include living and dead vegetation on the ground, along the surface as brush and small trees, and in the air such as tree canopies. Topography includes both slope and elevation. Air mass includes temperature, relative humidity, wind speed and direction, cloud cover, precipitation amount, duration, and the stability of the atmosphere at the time of the fire. Wildfires can be ignited by lightning and, most frequently, by human activity including smoking, campfires, equipment use, and arson.

Windstorm: Windstorms are generally short-duration events involving straight-line winds or gusts exceeding 50 mph. These gusts can produce winds of sufficient strength to cause property damage. Windstorms are especially dangerous in areas with significant tree stands, exposed property, poorly constructed buildings, mobile homes (manufactured housing units), major infrastructure, and aboveground utility lines. A windstorm can topple trees and power lines; cause damage to residential, commercial, critical facilities; and leave tons of debris in its wake.

Zoning Ordinance: The zoning ordinance designates allowable land use and intensities for a local jurisdiction. Zoning ordinances consist of two components: a zoning text and a zoning map.

APPENDIX B. PUBLIC OUTREACH

APPENDIX B.
PLANNING AND PUBLIC MEETING DOCUMENTS

KICK-OFF MEETING – JULY 16TH, 2018

STAKEHOLDER MEETING – JULY 18TH, 2018

RISK MAP MEETINGS – AUGUST 6TH AND 8TH, 2018

HIRA MEETING – NOVEMBER 8TH, 2018

STAKEHOLDER MEETING - DECEMBER 12TH, 2018

DRAFT PLAN REVIEW MEETINGS – JANUARY 9TH, 2019

During the public meeting held on January 9th, 2019, attendees participated in a ranking exercise of the hazards addressed in this plan by placing dots stickers on each hazard they perceived as having a high impact on Kittitas County. The results of this exercise are shows below:

Hazard	Number of Dots	Overall Ranking
Wildfire	8	1
Flood	7	2
Severe Weather	6	3
Drought	5	4
Landslide	3	5
Dam Failure	1	6
Avalanche	1	7
Earthquake	0	8
Volcano	0	9

PUBLIC SURVEY RESULTS

APPENDIX C.
EXAMPLE PROGRESS REPORT

Kittitas County

Hazard Mitigation Plan

Annual Progress Report

Reporting Period: (Insert reporting period)

Background: Kittitas County and participating cities and special purpose districts in the county developed a hazard mitigation plan to reduce risk from all hazards by identifying resources, information, and strategies for risk reduction. The federal Disaster Mitigation Act of 2000 requires state and local governments to develop hazard mitigation plans as a condition for federal disaster grant assistance. To prepare the plan, the participating partners organized resources, assessed risks from natural hazards within the county, developed planning goals and objectives, reviewed mitigation alternatives, and developed an action plan to address probable impacts from natural hazards. By completing this process, these jurisdictions maintained compliance with the Disaster Mitigation Act, achieving eligibility for mitigation grant funding opportunities afforded under the Robert T. Stafford Act. The plan can be viewed on-line at:

https://www.co.kittitas.wa.us/public-works/hazard-mitigation-plan/default.aspx

Summary Overview of the Plan's Progress: The performance period for the Hazard Mitigation Plan became effective on ____, 2019, 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 ______, 2024. As of this reporting period, the performance period for this plan is considered to be __% complete. The Hazard Mitigation Plan has targeted __ hazard mitigation initiatives to be pursued during the 5-year performance period. As of the reporting period, the following overall progress can be reported:

- __ out of __ initiatives (__%) reported ongoing action toward completion.
- __ out of __ initiatives (__%) were reported as being complete.
- __ out of __ initiatives (___%) reported no action taken.

Purpose: The purpose of this report is to provide an annual update on the implementation of the action plan identified in the Kittitas County Hazard Mitigation Plan. The objective is to ensure that there is a continuing and responsive planning process that will keep the Hazard Mitigation Plan dynamic and responsive to the needs and capabilities of the 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 Kittitas 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 within the planning area, reviewed and approved this progress report at its annual meeting held on _____, 201_. 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 AC-4. 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]				
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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. Copies of the report have been provided to the governing boards of all planning partners and to local media outlets and the report is posted on the Kittitas County Hazard Mitigation Plan website. Any questions or comments regarding the contents of this report should be directed to:*

Insert Contact Info Here

APPENDIX D.
PLAN ADOPTION RESOLUTIONS FROM PLANNING PARTNERS

APPENDIX D.
PLAN ADOPTION RESOLUTIONS FROM PLANNING PARTNERS