Grays Harbor County
2018 Multi-Jurisdiction
Hazard Mitigation Plan Update
Volume 1: Planning-Area-Wide Elements

FINAL

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BRIDGEVIEW
CONSULTING

GRAYS HARBOR COUNTY MULTI-JURISDICTION

2018 HAZARD MITIGATION PLAN UPDATE

VOLUME 1: PLANNING-AREA-WIDE ELEMENTS

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Grays Harbor County 2018 Multi-Jurisdiction Hazard Mitigation Plan Update
Volume 1—Planning-Area-Wide Elements

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EXECUTIVE SUMMARY

The federal Disaster Mitigation Act (DMA) 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, promoting 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 Grays Harbor County and local governments worked together to create this Grays Harbor County 2018 Multi-Jurisdiction Hazard Mitigation Plan Update to fulfill the DMA requirements for all fully participating partners.

PLAN UPDATE

Federal regulations require hazard mitigation plans to include a plan for monitoring, evaluating, and updating the hazard mitigation plan. An update provides an opportunity to reevaluate recommendations, monitor the impacts of actions that have been accomplished, and determine if there is a need to change the focus of mitigation strategies. A jurisdiction covered by a plan that has expired is not able to pursue funding under the Robert T. Stafford Act for which a current hazard mitigation plan is a prerequisite.

Initial Response to the DMA in Grays Harbor County

The inevitability of natural hazards and the growing population and activities within the planning region created an urgent need to develop information, concepts, strategies and a coordination of resources to increase public awareness of the hazards of concern and the risk associated with those hazards. In an effort to reduce the impact of the hazards and assist the public in protecting life, property and the economy, the County determined that it was in the best interests of its citizenry to develop the 2011 Grays Harbor County Hazard Mitigation Plan. This 2018 Hazard Mitigation Plan is an update to the 2011 plan.

As time has progressed, new technologies, information and increased awareness brought about a wealth of information to enhance the validity of the initial plan, providing the opportunity, through development of the 2018 update to the Grays Harbor County Multi-Jurisdiction Hazard Mitigation Plan, to increase the resilience of the planning region.

The 2018 Grays Harbor County Plan Update—What has changed?

The updated plan differs from the initial plan for a variety of reasons:

- Better guidance now exists on what is required to meet the intent of the DMA.
- Science and technology have improved since the development of the initial plan.
- Newly available data and tools provide for a more detailed and accurate risk assessment.

Grays Harbor County is using the five-year update process to enhance the Grays Harbor County Multi-Jurisdictional Mitigation Plan in scope and content. Based on availability of new data and a better understanding of the Federal Emergency Management Agency's (FEMA's) guidance to develop mitigation plans, the following changes have been incorporated in the 2018 plan which differ from the previous edition:

- The layout of the plan varies significantly for ease in use by the planning partners. The 2018 edition utilizes a two-volume approach. Volume 1 includes general planning information and hazard profile data which is consistent with all entities involved, as well as the County-specific data. Volume 2 includes each jurisdiction's separate annex, as well as the linkage procedure for partners wishing to join at a later date.
- Hazards of concern were modified for this 2018 update. Climate Change was added as a new hazard to address potential impacts on the various other hazards of concern; however, no risk assessment was performed as there currently is no damage function which addresses such impact. A new Drought profile was added due to the potential impact from Climate Change, as well as the potential economic impact resulting from a drought situation on the County and its planning partners. Erosion was added separate to the Landslide profile. The Erosion profile incorporates new studies completed within the region by Washington State Department of Ecology. Dr. George Kaminsky took the lead on developing the Erosion profile, utilizing the same format as the remaining hazard profiles to ensure consistency. Coastal flood was added to the flood profile to incorporate new RiskMap data completed by FEMA. Wildfire was enhanced due to the increase in wildfire occurrences throughout Washington over the course of the last several wildfire seasons, and the large amount of wooded lands. Severe Storm was expanded to Sever Weather, now inclusive of additional elements such as excessive heat and cold, wind, thunderstorms, tornado, and hail.
- The risk assessment was expanded to use additional methodologies and new studies to define risk and determine vulnerability. This edition is based on analysis using both GIS and Hazus (FEMA's hazard-modeling program), and focuses on determining impacts on people, property, environment, and the economy. The previous plan utilized primarily only GIS. This edition also utilizes FEMA's 2015 RiskMAP data, FEMA's 2017 RiskMAP data for the Chehalis and Wynoochee Rivers, and FEMA's new Westport Tsunami Model (March 2017). The planning process also enhanced structure data using the County's Assessor's data base.
- Critical infrastructure data was expanded and updated for the 2018 plan to include new structures within the planning area as identified throughout the process by the planning partners.
- The risk assessment has been prepared to better support future grant applications by providing risk and vulnerability information that will directly support the measurement of "cost-effectiveness" required under FEMA mitigation grant programs.
- The method of risk ranking is now based on a Calculated Priority Risk Index Ranking.
- A new vulnerability table was included, which addresses the social aspect of risk. The risk assessment was also broken down by planning partnership as appropriate, to include an analysis of the unincorporated areas of the County, and further by each planning partner involved. This will allow planning partners to annually review and determine accuracy of the greatest hazards of concern based on their impact, versus the entire planning area.
- All charts, graphs and maps have been updated with the most current data.
- All Census and Census-related data has been updated with the most current data available.
- Goals and objectives were reviewed and updated appropriately with some modifications.

- Strategies from the old edition were updated, and new strategies identified for the 2018 update. A new method of prioritizing strategies was used, including benefit cost analysis.
- Many new planning partners were included, as identified in the Planning Process. All cities are now part of the County's plan, where previous plans were independent, stand-alone documents. The process also includes several new planning partners.
- A new plan maintenance strategy was developed for use with the 2018 plan.

THE PLANNING PARTNERSHIP

The planning partnership assembled for this plan was greatly expanded to include all cities and towns, and several of the special purpose districts as defined as "local governments" under the Disaster Mitigation Act. Jurisdictional annexes for those 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 Volume 2 of this plan.

PLAN DEVELOPMENT METHODOLOGY

Update of the Grays Harbor 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 other stakeholders were 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:
  - Identification of new hazards and updating hazard profiles
  - 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 sources 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 goals and objectives were reviewed and updated, as well as a range of potential mitigation actions for each natural hazard identified. 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 created, 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 internal planning group for this effort 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 FEMA, the final adoption phase will begin. Each planning partner will be required to adopt the plan according to its own protocols.

MITIGATION GOALS

The 2011 goals were reviewed and modified for the 2018 update during the initial kick-off meeting. Objectives were also updated for the current update of the mitigation plan.

The goals and objectives were utilized to allow further assessment of mitigation strategies. Strategies were assessed to determine association with several general categories related not only to emergency management as a whole, but also inclusive of the Community Rating System, as follows:

- Prevention
- Public Information and Education
- Property Protection
- Emergency Services / Response
- Natural resources
- Structural projects
- Recovery

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 was grant funding eligibility, its purpose is more than just access to federal funding. It was important to the planning partnership 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 primary focus of the selection. Rather, the focus was the initiatives' effectiveness in achieving the goals of the plan and whether they are within each entities' capabilities.

This planning process resulted in the identification of 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 planning partnership identified countywide initiatives benefiting the whole partnership that will be implemented by pooling resources based on capability. These countywide initiatives are identified in Chapter 17.

CONCLUSION

Full implementation of the recommendations of this plan 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 Planning Team and a process that relied heavily on public input and support. The plan will succeed for the same reasons.

CHAPTER 1.
INTRODUCTION

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.

1.1 AUTHORITY

The federal Disaster Mitigation Act (DMA) (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. DMA 2000 amended the Robert T. Stafford Disaster Relief and Emergency Assistance Act (the Act) by repealing the previous mitigation planning section (409) and replacing it with a new mitigation planning section (322). This new section emphasizes the need for state and local entities to closely coordinate mitigation planning and implementation efforts. To implement the DMA 2000 planning requirements, the Federal Emergency Management Agency (FEMA) published an Interim Final Rule in the Federal Register on February 26, 2002. This rule (Part 201 of Title 44 of the Code of Federal Regulations (44 CFR 201)) established the mitigation planning requirements for states and local communities. In 2010, the guidance was further enhanced and expanded, with this document incorporating all required changes.

The DMA encourages state and local authorities to work together on pre-disaster planning, and it promotes sustainability for disaster resistance. Sustainable hazard mitigation includes the sound management of natural resources and the recognition that hazards and mitigation must be understood in the largest possible social and economic context. 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.

The Grays Harbor County 2018 Multi-Jurisdiction Hazard Mitigation Plan Update has been developed pursuant to the requirements of 44 CFR 201.6. The plan meets FEMA’s guidance for multi-jurisdictional mitigation planning.

1.2 ACKNOWLEDGEMENTS

Many groups and individuals have contributed to development of the Grays Harbor County 2018 Multi-Jurisdiction Hazard Mitigation Plan Update. The Grays Harbor County Department of Emergency Management provided support for all aspects of plan development. Grays Harbor County GIS also provided extensive assistance, including providing data identifying critical facilities and infrastructure. The Grays Harbor Planning Department provided assistance with respect to existing plans and studies in place, as well as guidance and information concerning implementation of the Growth Management Act countywide, and the National Flood Insurance Program. The FEMA Risk Map Team also provided assistance and information which was utilized throughout this document. Dr. George Kaminsky provided support by developing the erosion profile for this planning effort. The planning partners met on a regular basis to guide the project, identify the hazards most threatening to the County, develop and prioritize mitigation projects, review draft deliverables, and attend public meetings.

Local communities participated in the planning process by attending public meetings and contributed to plan development by reviewing and commenting on the draft plan. Several planning partners provided assistance and guidance to support the efforts of smaller entities by providing data and information to help develop specific annex documents. Citizens' participation was exceptionally good during the plan's development, with citizens attending various public outreach sessions and providing invaluable information with respect to concerns, strategy ideas, and hazard information. Input was incorporated as appropriate throughout the document.

1.3 PURPOSE OF HAZARD MITIGATION 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. FEMA encourages multi-jurisdictional planning under its guidance for the DMA. The plan will help guide and coordinate mitigation activities throughout Grays Harbor 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 Grays Harbor County hazards of concern.
- Create a single planning document that integrates all planning partners into a framework that supports partnerships within the county and puts all partners on the same planning cycle for future updates.
- Coordinate existing plans and programs so that high-priority initiatives and projects to mitigate possible disaster impacts are funded and implemented.

All citizens and businesses of Grays Harbor 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.

Planning efforts such as the Hazard Mitigation Plan also integrate into other planning efforts, which provide even greater benefits to the planning community and its citizens. Three such efforts which further benefit from a Hazard Mitigation Plan is the National Flood Insurance Program (NFIP), the Community Rating System (CRS), and Washington State's Flood Control Assistance Account Program (FCAAP), among others.

1.3.1 National Flood Insurance Program

The National Flood Insurance Program (NFIP) is a federal program enabling property owners in participating communities to purchase insurance as a protection against flood losses in exchange for state and community floodplain management regulations that reduce future flood damage. The U.S. Congress established the NFIP with the passage of the National Flood Insurance Act of 1968 (FEMA's 2002 *National*

Flood Insurance Program (NFIP): Program Description). There are three components to the NFIP: flood insurance, floodplain management, and flood hazard mapping. Nearly 20,000 communities across the U.S. and its territories participate in the NFIP by adopting and enforcing floodplain management ordinances to reduce future flood damage. In exchange, the NFIP makes federally backed flood insurance available to homeowners, renters, and business owners in these communities. Community participation in the NFIP is voluntary; however, in order to be a part of the NFIP, participants must regulate development in floodplain areas in accordance with NFIP criteria. More detail on the NFIP is provided within the flood hazard profile (Chapter 8). A part of the NFIP is the ability to administer a floodplain management program, regulated by the Community Rating System, which is an incentive program helping to reduce the flood insurance premiums.

1.3.2 CRS Steps for Comprehensive Floodplain Management

Throughout this Plan, activities that could count toward the Community Rating System (CRS) are included. As indicated, the CRS is a voluntary incentive program that recognizes and encourages community floodplain activities that exceed the minimum NFIP requirements. As a result, flood insurance premiums are discounted to reflect the reduced flood risk resulting from community actions that meet the three (3) goals of the CRS: (1) reduce flood losses; (2) facilitate accurate insurance rating; and (3) promote education and 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.) A minimum of 500 points are necessary to enter the CRS program and receive a 5% flood insurance premium discount. This HMP could contribute points toward participation in the CRS.

Savings in flood insurance premiums are proportional to the points assigned to various activities. The CRS classes (1-10) for local communities are based on 18 creditable activities in the following categories:

- Public information
- Mapping and regulations
- Flood damage reduction
- Flood preparedness.

The CRS program credits NFIP communities a maximum of 100 points for organizing a planning committee composed of staff from various departments; involving the public in the planning process; and coordinating among other agencies and departments to resolve common problems relating to flooding and other known natural hazards. The County's planning team incorporates a wide variety of planning partners which serve a role in the review and application of floodplain management.

Developing a comprehensive floodplain management plan is also among the activities that earn CRS credits toward reduced flood insurance rates. To earn CRS credit for a floodplain management plan, the community's process for developing the plan is very similar to that of developing a Hazard Mitigation Plan. The floodplain management plan must include at least one item from each of the 10 steps.

- Planning process steps:
  - ✓ Step 1 – Organize
  - ✓ Step 2 – Involve the public
  - ✓ Step 3 – Coordinate

- Risk assessment steps:
  - ✓ Step 4 – Assess the hazard
  - ✓ Step 5 – Assess the problem

- Mitigation strategy steps:
  - ✓ Step 6 – Set goals
  - ✓ Step 7 – Review possible activities which reduce the flood risk (mitigation strategies)
  - ✓ Step 8 – Draft an action plan

- Plan Maintenance Steps:
  - ✓ Step 9 – Adopt the plan
  - ✓ Step 10 – Implement, evaluate and revise the plan content as needed.

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, with over 66 percent of the NFIP's policy base is located in these communities. Communities receiving premium discounts through the CRS range from small to large and represent a broad mixture of flood risks, including both coastal and riverine flood risks.

At the time of this planning effort, only the City of Westport is a participating CRS community, recognized as a Class 8. Other planning partners may be moving forward during the life cycle of this plan to gain CRS points. As such, each annex profile may have additional data to support those efforts to gain CRS points.

1.3.3 FCAAP Requirements for Comprehensive Flood Control Management Plan

Washington has had a legislatively-established flood control maintenance program for more than 50 years. In 1984, the state Legislature established the Flood Control Assistance Account Program to help local jurisdictions in comprehensive planning and flood control maintenance efforts. This is one of very few state programs in the country that provides grant funding to local governments for flood plain management planning and implementation actions. The account is funded at $4 million per state biennium, unless modified by the state Legislature. Projects include planning, maintenance projects, feasibility studies, match for federal projects, and emergency projects. Eligibility for Washington's FCAAP funding for flood projects requires that the requesting jurisdiction complete a comprehensive flood control management plan. The plan must include six components, as summarized below.

- Determination of the need for flood control work;
- Alternative flood control work;
- Identification and consideration of potential impacts of in-stream flood control work on the in-stream uses and resources;
- Coverage, at a minimum, of the area of the 100-year floodplain within a reach of the watershed of sufficient length to ensure that a comprehensive evaluation can be made of the flood problems for a specific reach of the watershed, as well as flood hazard areas not subject to riverine flooding (e.g., coastal flooding, flash flooding, or flooding from inadequate drainage);
- Conclusion and proposed solutions;
- Certification from Washington State Military Department, Emergency Management Division that the local emergency management organization is administering an acceptable comprehensive emergency operations plan.

Additional information on the FCAAP program is available at the following link: https://www.ecology.wa.gov/About-us/How-we-operate/Grants-loans/Find-a-grant-or-loan/Flood-control-assistance

1.4 PLAN ADOPTION

44 CFR 201.6(c)(5) 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 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 the plan as well as the FEMA approval letter can be found in Appendix C of this volume.

1.5 SCOPE AND PLAN ORGANIZATION

The process followed to update the Grays Harbor County 2018 Multi-Jurisdiction Hazard Mitigation Plan included the following:

- Review and prioritize disaster events that are most probable and destructive. For planning purposes, this plan covers those incidents and information which have occurred since the previous plan was developed (2011), through August 31, 2017. Future updates shall begin assimilation of data beginning September 1, 2017.
- Update and identify new critical facilities.
- Review and update areas within the community that are most vulnerable.
- Update and identify new goals for reducing the effects of a disaster event.
- Review and identify new projects to be implemented for each goal.
- Review and identify new procedures for monitoring progress and updating the hazard mitigation plan.
- Review the draft hazard mitigation plan.
- Adopt the updated hazard mitigation plan.

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

- Volume 1 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 includes all federally required jurisdiction-specific elements, assimilated into specific annexes for each participating jurisdiction. Volume 2 also includes a description of the participation requirements for planning partners. 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, as well as contact information to obtain the annex template and instructions.

All planning partners will adopt Volume 1 and the associated appendices in their entirety, as well as each partner's jurisdiction-specific annex contained in Volume 2.

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

- Appendix A—A glossary of acronyms and definitions
- Appendix B—Public outreach information, including the hazard mitigation questionnaire/ survey and summary and documentation of public meetings
- Appendix C—Plan adoption resolutions from planning partners
- Appendix D—A template for progress reports to be completed as this plan is implemented.

CHAPTER 2.
PLANNING PROCESS

To develop the Grays Harbor County Hazard Mitigation Plan, the County applied the following primary objectives:

- Secure grant funding;
- Form an internal planning group;
- Establish a planning partnership;
- Coordinate with individual and agency stakeholders;
- Review existing plans and studies;
- Engage the public:
  - Conduct a hazard survey;
  - Hold public meetings;
  - Review the draft hazard mitigation plan.

These objectives are discussed in the following sections.

2.1 SECURE GRANT FUNDING

This planning effort was supplemented by a Hazard Disaster Mitigation Grant Program (HMGP) grant from FEMA. Grays Harbor County was the applicant agent for the grant. The grant was applied for originally in 2014, and funding was appropriated in 2016. It covered 75 percent of the cost for development of this plan; the County and its planning partners covered 12.5 percent of the cost through in-kind contributions, and the state of Washington provided the balance.

2.2 INTERNAL PLANNING GROUP FORMATION

Through an open solicitation process, Grays Harbor County hired Bridgeview Consulting, LLC to assist with development and implementation of the plan. The Bridgeview Consulting project manager assumed the role of the lead planner, reporting directly to a County-designated project manager. An internal planning group was formed to lead the planning effort, made up of the following members:

Grays Harbor County Hazards Mitigation Plan Development Staff

Charles Wallace	Deputy Director, Project Manager Department of Emergency Management
Carmin McCullough	Department of Emergency Management Assistant
Mark Sigler	Grays Harbor County Deputy Building Official / Deputy Fire Marshall, Floodplain Manager
Tim Triesch	Grays Harbor County GIS Coordinator
Dan Ehreth	Grays Harbor County GIS Coordinator

Beverly O'Dea	Bridgeview Consulting, LLC Project Manager Lead Planner
Ed Whitford	Bridgeview Consulting, LLC Risk Analyst
Adam Palmer	Bridgeview Consulting, LLC Research and Planning

2.3 PLANNING PARTNERSHIP

Grays Harbor County opened this planning effort to those eligible entities within the county which expressed an interest in participating in the planning process, including all cities, towns and special purpose districts. Emergency Management personnel made presentations at various meetings and conducted one-on-one meetings with potential planning partners to solicit letters of intent to participate to support the County's grant application. Each jurisdiction wishing to join the planning partnership was asked to provide an executed Letter of Intent to Participate. That letter designated a point of contact for the jurisdiction and confirmed the jurisdiction's commitment to the process and understanding of expectations.

Due to the time that had lapsed between the original Letters of Intent to Participate and award of the grant, the County felt it prudent to again solicit a second Letter of Intent to Participate. Table 2-1 summarizes the received Letters of Intent to Participate by the planning partners, as well as the level of participation and involvement throughout the planning process.

Table 2-1- Hazard Mitigation Planning Partners and Level of Participation

County, City, Town or Entity Represented	Primary Point of Contact	Alternate Point(s) of Contact	Date of Previous Plan	Letter of Participation	Kick-Off Meeting	Completed Risk Ranking	Completed Annex Template	Draft Plan Review	Final Plan Review	Adoption Month
County	Charles Wallace, Deputy Director Emergency Mgmt.; Chair, Planning Team	Carmin McCullough, Emergency Management Coordinator	2011	X	X	X	X	X	X	
County	Mark Seigler, GH County Planning Director, Floodplain Manager	Robert Wilson, PE			X	X	X	X	X	
County	Tim Triesch, GISP	Theressa Julius, GH COG GIS Coordinator				X		X	X	
Aberdeen	Chief Tom Hubbard, Aberdeen Fire Dept.	Rick Sangder, City of Aberdeen Public Works Director Kris Koski, PE, City of Aberdeen	2009	X	X	X	X	X	X	

County, City, Town or Entity Represented	Primary Point of Contact	Alternate Point(s) of Contact	Date of Previous Plan	Letter of Participation	Kick-Off Meeting	Completed Risk Ranking	Completed Annex Template	Draft Plan Review	Final Plan Review	Adoption Month
Cosmopolis	Darrin Raines, City Administrator	Chief Casey Stratton	2015	X	X	X	X	X	X	
Elma	Joe Chrystal, Community Development Official	Jim Starks and Jim Taylor	NA	X	X	X	X	X	X	
Hoquiam	Brian Shay, City Administrator		2015	X	X	X	X	X	X	
McCleary	Todd Baun, PW Director	Fire Chief Paul Nott Police Chief Steve Blumer PW Assistant Paul Morrison	NA	X	X	X	X	X	X	
Montesano	Corey Rux, Fire Chief	Brett Vance, Police Chief	NA		X	X	X	X	X	
Oakville	Richard Armstrong, PW Director		2015	X	X	X	X	X	X	
Ocean Shores	Mayor Crystal Dingler	Nick Bird, Public Works Director	NA	X	X	X	X	X	X	
Westport	Kevin Goodrich, PW Director		2013	X	X	X	X	X	X	
Fire										
Grays Harbor Fire District No. 2	Chief Leonard Johnson	Hannah Cleverly (3/27/18 forward)	NA		X	X	X	X	X	
Grays Harbor Fire District No. 5	Dan Prater, Fire Chief	FF Adam Fulbright	NA	X	X	X	X	X	X	
Grays Harbor Fire District No. 7	FF Nicklaus Falley	Chief Jim Westby	NA	X	X	X	X	X	X	
Grays Harbor Fire District No. 8	Chief John Collum	Commissioner Stephanie Allestad	NA	X	X	X	X	X	X	
Grays Harbor Fire Protection District 16	Chief Jodi Hartle	Stephanie Allestad Allan Landsiedel	N/A	X	X	X	X	X	X	
South Beach Regional Fire Authority	Dennis Benn, Chuck Wallace	Art Cole	NA	X	X	X	X	X	X	
Hospital Districts / Hospitals										
Grays Harbor County Hospital District	Hannah Cleverly (through 3/26/18)	David Bain	NA	X	X	X	X	X	X	
Summit Pacific Medical Center	Danny Scott		NA	X	X	X	N	N	N	N/A

County, City, Town or Entity Represented	Primary Point of Contact	Alternate Point(s) of Contact	Date of Previous Plan	Letter of Participation	Kick-Off Meeting	Completed Risk Ranking	Completed Annex Template	Draft Plan Review	Final Plan Review	Adoption Month
Port Districts										
Port of Grays Harbor	Randy Lewis, Director Environmental & Engineering Services ________ Mike Johnson		NA	X	X	X	X	X	X	
Transit District										
Grays Harbor Transit	Martin Best	Dave Wells Ken Mehin	NA	X	X	X	X	X	X	
Educational Facilities										
Grays Harbor College	Lance James, Safety & Security	Keith Penner	NA	X	X	X	X	X	X	
Consultants and Planning Team Facilitator										
Bridgeview Consulting, LLC										
Beverly O'Dea, Project Manager and Lead Facilitator										
Adam Palmer, Research and Planning (to November 2017)										
Cathy Walker, GISP										
David O'Dea, Meeting Facilitator, Planning										

For those jurisdictions invited but who could not participate, linkage procedures have been established (see Volume 2 of this plan) for any jurisdiction wishing to join the Grays Harbor County plan in the future; the process was revised from the previous plan to include the required items for this 2018 update edition.

Responsibilities of the planning partners included participating in mandatory planning workshops and conference calls to discuss plan development; providing data for analysis in the risk assessment; attending public meetings; providing input and feedback on mitigation strategies; developing an annex document; reviewing the draft plan document, and supporting the plan throughout the adoption process.

The initial kickoff planning workshop took place on September 14, 2017. Key workshop objectives were as follows:

- Provide an overview of the Disaster Mitigation Act.
- Describe the reasons for a plan.
- Outline the County work plan.

- Outline and adopt planning partner expectations necessary to establish a jurisdictional annex to the County's Plan.
- Confirm hazards of concern.
- Review and update, as appropriate, the Goals and Objectives.
- Establish the Planning Partnership's definition of Critical Facilities.
- Establish a Public Outreach Strategy for use during this update cycle.
- Discuss strategy development.

During the initial workshop, the planning partners also established meeting guidelines which applied to all meetings. In addition, the planning partnership also elected a chairperson to act as spokesperson for the planning effort; identified a minimum attendance by Planning Team members to gain an active level of participation; established the decision-making method (quorum or attendance); identified the concept of alternative representatives for Planning Team members unable to attend, and identified the method in which the public would address the Planning Team during meetings. Specific guidelines concerning public comments followed the same public meeting regulations as utilized by the Grays Harbor Board of Commissioners. During the initial workshop meeting, Charles Wallace was elected Chairperson of the Planning Team, and the team determined that decisions would be made based on the majority of members in attendance.

In advance of each meeting, an agenda and materials to be discussed (i.e. example mitigation strategies, examples of projects eligible for FEMA funding, etc.) were sent to meeting participants. All members issuing Letters Intent were engaged as a planning partner throughout this process.

2.4 COORDINATION WITH AGENCIES AND OTHER STAKEHOLDERS

Hazard mitigation planning enhances collaboration and support among diverse parties whose interests can be affected by hazard losses. 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)). Stakeholders were identified and invited to participate in this effort:

- County stakeholders included County Commissioners, Mayors, Public Administrators, emergency managers, the floodplain coordinator, Planning/Building Director, Community Development Director, the GIS Department, the Health Department, and the Sheriff's Office. Their participation included providing data, attending public meetings, and reviewing the draft hazard mitigation plan.
- Stakeholders from throughout the County were invited, as well as members of the Quinault and Chehalis Tribes. Invitations were also distributed to members of various other county departments, police and fire chiefs, representatives from the local PUDs, hospital, and port districts, Red Cross, and others. Their participation included providing data, attending public meetings, and reviewing the draft hazard mitigation plan.
- Washington State stakeholders and information included various representatives from the Department of Natural Resources, Department of Ecology, and Department of Transportation, the State Hazard Mitigation Officer, and the Hazard Mitigation Grant Program Officer. Their participation included providing data, attending meetings, and reviewing the draft hazard mitigation plan.

- Federal agency stakeholders and information included the FEMA Region X, National Weather Service (NWS), U.S. Army Corps of Engineers, U.S. Geologic Survey, U.S. Forest Service, and U.S. Fish and Wildlife Service, among others. These agencies provided information on plan development, attended public meetings, and were invited to review the draft hazard mitigation plan.
- Non-government stakeholders included the American Red Cross, Chamber of Commerce, and local private industries, among others. The Chehalis River Basin Flood Authority (Flood Authority), comprised of 11 member agencies including Grays Harbor County, Lewis County, Thurston County, City of Aberdeen, Town of Bucoda, City of Centralia, City of Chehalis, City of Montesano, City of Oakville, Town of Pe Ell, and the Confederated Tribes of the Chehalis Reservation were also involved during this process with respect to the potential of establishing CRS communities throughout the County. The Flood Authority was originally formed in response to a number of historic flooding events with the purpose of developing flood hazard mitigation measures for the Chehalis River Basin. Improvements to the Flood Early Warning capabilities are considered of high importance to the Flood Authority with the goal of improving the communication of flood warnings to the residents of the basin (Chehalis River Basin Early Flood Warning Program, 2010).

The County's Emergency Management email distribution list was utilized, which reaches in excess of 1,600 individuals from various departments, agencies, and organizations throughout the region. Many of these entities provided information for plan development, attended the public meetings, and/or reviewed the draft hazard mitigation plan update. In addition, information was distributed to over 5,000 Facebook viewers throughout the planning effort, as well as regular broadcasts via local radio stations.

Stakeholders received a variety of information during the project, including meeting notices, documents for review, and the draft mitigation strategy. Stakeholders also provided input on the plan, particularly for the risk assessment.

Table 2-2- Hazard Mitigation Stakeholders and Areas of Participation

Stakeholders			Data and Information Provided
Quinault Nation	Michael Cardwell	Charles Warsinski	Data concerning Nation's 2016 HMP; Climate Change and other hazard specific data.
FEMA Region X	Kelly Stone		Risk Report, Tsunami data, Hazus data/reports
WA DNR	Tim Walsh		Landslide information and data
WA DOE	Jerry Franklin		Flood data, SRL and CRS data and information
WA DOE	Sadie Whitener	Dave Byers	Reporting Hazmat sites in county
WA DOE	Bobbak Talebi	George Kaminsky	Coastal Erosion study data and information
USGS			Earthquake and Tsunami Data

2.5 REVIEW OF PLANS AND STUDIES

44 CFR states that hazard mitigation planning must include review and incorporation as appropriate of existing plans, studies, reports and technical information (Section 201.6.b(3)). Laws and ordinances in effect in the planning area that can affect hazard mitigation initiatives are reviewed in Chapter 18. The list of references at the end of this volume presents sources used to capture information necessary to complete this planning effort. In addition to data referenced as footnotes, additional plans, studies, and reports used for this process include, but are not limited to:

- Grays Harbor County Hazard Mitigation Plan (2011)

- Grays Harbor County Comprehensive Emergency Management Plan (CEMP)
- Grays Harbor County Comprehensive Land Use Management Plan
- Grays Harbor Resilience Coalition Project Report (2017)
- Flood Insurance Study; Grays Harbor County and Incorporated Areas (2017)
- Grays Harbor County Draft Critical Areas Protection Ordinance (2017)[1]
- WRIA 16: Skokomish-Dosewallips Fact Sheet (2012)
- WRIA 21: Queets-Quinault Watershed and Water Quality Improvement Projects (http://www.ecy.wa.gov/programs/wq/tmdl/TMDLsbyWria/tmdl-wria21.html
- WRIA 22: Lower Chehalis Watershed Data
- WRIA 23: Upper Chehalis Watershed
- WRIA 24: Willapa
- Washington State Enhanced Hazard Mitigation Plan (2010 and 2013)
- Washington Department of Natural Resources (WDNR) Landslide Report
- Coastal erosion data (various)
- NOAA Global Sea Level Rise Scenarios for the United States National Climate Assessment (2012).
- Climate Change in the Chehalis River and Grays Harbor Estuary (2013)
- Climate change data – various reports and information
- Washington Department of Ecology Coastal Zone Atlas
- Washington State Department of Ecology Drought Studies/Data (2015, 2016)
- Washington Department of Ecology Hazardous Materials 2017 Annual Report for Grays Harbor County
- Washington State DNR 2015 Technical Memo concerning January 5, 2015 landslides in Hoquiam
- FEMA Region X Risk Report (2015);
- FEMA Region X Risk Report (2017)
- FEMA (and others) Westport Tsunami Study (March 2017)
- Cities of Aberdeen, Cosmopolis, Hoquiam, Oakville, and Westport Hazard Mitigation Plans
- Quinault Nation 2016 Hazard Mitigation Plan Update
- Grays Harbor County Comprehensive Plan
- Grays Harbor County Comprehensive Flood Hazard Management Plan (2001)
- Chehalis River Basin Early Flood Warning Program (2010)

[1] Grays Harbor County Draft Critical Areas Protection Ordinance (DRAFT 9/2017): http://www.co.grays-harbor.wa.us/Public%20Services/Planning/Documents/Draft%20Critical%20Areas%20Protection%20Ordinance%2009-07-2017.pdf

- Washington State Department of Natural Resources Annual Report (various years)
- Various jurisdictions' Water System Reliability, Source Protection, and Water Shortage Plans

Data obtained from the plan and regulation review was incorporated into various sections of the hazard mitigation plan. The risk assessment in Chapter 5 through Chapter 13 refer to plans and ordinances that affect the management of each hazard. Section 19.2 describes how mitigation can be implemented through existing programs. An assessment of all planning partners' regulatory, technical, and financial capabilities to implement hazard mitigation initiatives is presented in the jurisdiction-specific annexes in Volume 2 and in Chapter 18. Many of these relevant plans, studies and regulations are cited in the capability assessment.

2.6 PUBLIC INVOLVEMENT

Broad public participation in the planning process helps ensure that diverse points of view about the planning area's needs are considered and addressed. The public must have opportunities to comment on disaster mitigation plans during the drafting stages and prior to plan approval (44 CFR Section 201.6(b), 201.6(c)(1)(i) and 201.6(c)(1)(ii)).

The County and its planning partners did extensive outreach and used different methods to increase involvement, such as pairing meetings with existing council and commission meetings, holding web-based meetings, and scheduling conference calls that allowed participation by agencies and individuals. Interviews with individuals and specialists from outside organizations identified common concerns related to natural and manmade hazards, and key long- and short-term activities to reduce risk. Interviews included public safety personnel, planning department personnel, natural resources personnel, cultural resource personnel, and representatives from other government agencies from surrounding jurisdictions. The public outreach strategy for involving the public in this plan emphasized the following elements:

- Include members of the public on the Planning Team.
- Use a questionnaire to determine general perceptions of risk and support for hazard mitigation and to solicit direction on alternatives. The questionnaire was available to anyone wishing to respond via the website and was distributed by hard copy for those without computer access (hard-copy results were entered by the consultant). The County distributed a news release to the local papers and identified the survey on the hazard mitigation website. Several Planning Team Members throughout the County also posted the link to the survey on their various Facebook and Twitter accounts.
- Attempt to reach as many citizens as possible using multiple formats. This is important because of the somewhat geographically remote areas in the county.
- Identify and involve planning area stakeholders.
- Provide newsletter articles about mitigation efforts, such as the update of FEMA flood maps, etc.
- Use of the County's Recorded Meetings feature as a way to provide information to citizens unable to personally attend Commissioner's Meetings where the hazard mitigation planning effort was discussed – available at: (http://www.co.grays-harbor.wa.us/government/board_of_county_commissioners/video_library.php).
- Use of local radio station segments (Friday interviews).

2.6.1 Planning Team Input

Most members of the Planning Team live or work in the planning area. Planning team participation by individuals with varied backgrounds and from varied organizations added details and information that were valuable in identifying direction for the plan development process.

The County utilized its Emergency Management webpage, which hosted a mitigation section, wherein all notices and survey links were posted. During meetings within the planning area or attended elsewhere by Planning Team members, individuals were directed to the website to gain better insight of the County's endeavors and to solicit input. The Planning Team identified stakeholders to target through the public involvement strategy. Members of the Planning Team attending conferences or meetings provided updates to those in attendance, asking for input and review of the plan. Some of the outreach sessions are identified in Table 2-3. This list is not all-inclusive, but rather demonstrative of the various efforts of the Planning Team.

2.6.2 Hazard Questionnaire

A hazard mitigation plan questionnaire developed by the Planning Team was used to gauge household preparedness for natural hazards and the level of knowledge of tools and techniques for reducing risk and loss from natural hazards. This questionnaire was designed to help identify areas vulnerable to one or more natural hazards. The answers to its questions helped guide the planning partners in selecting goals, objectives and mitigation strategies. Hard copies were disseminated throughout the planning area, and a web-based version was made available on the hazard mitigation plan website which was distributed and announced during meetings, during public outreach sessions, and announced through twitter and email distributions countywide.

Over 300 questionnaires were completed. Appendix B presents the questionnaire and a summary of its findings. Figure 2-1 illustrates a sample from the web-based questionnaire.

Figure 2-1 Grays Harbor County Web Page

The Survey also provided an opportunity for citizens to provide comments during the entire process, from the initial drafting stages when the survey was deployed, until the draft plan was available for review. Comments received, which were relevant to the planning process and provided applicable information to the various sections of the plan were incorporated as appropriate.

Generally, most comments received were of the “response” nature with respect to evacuation areas in the event of a tsunami or earthquake, and various mechanisms and efforts citizens have performed already to prepare themselves – an information exchange.

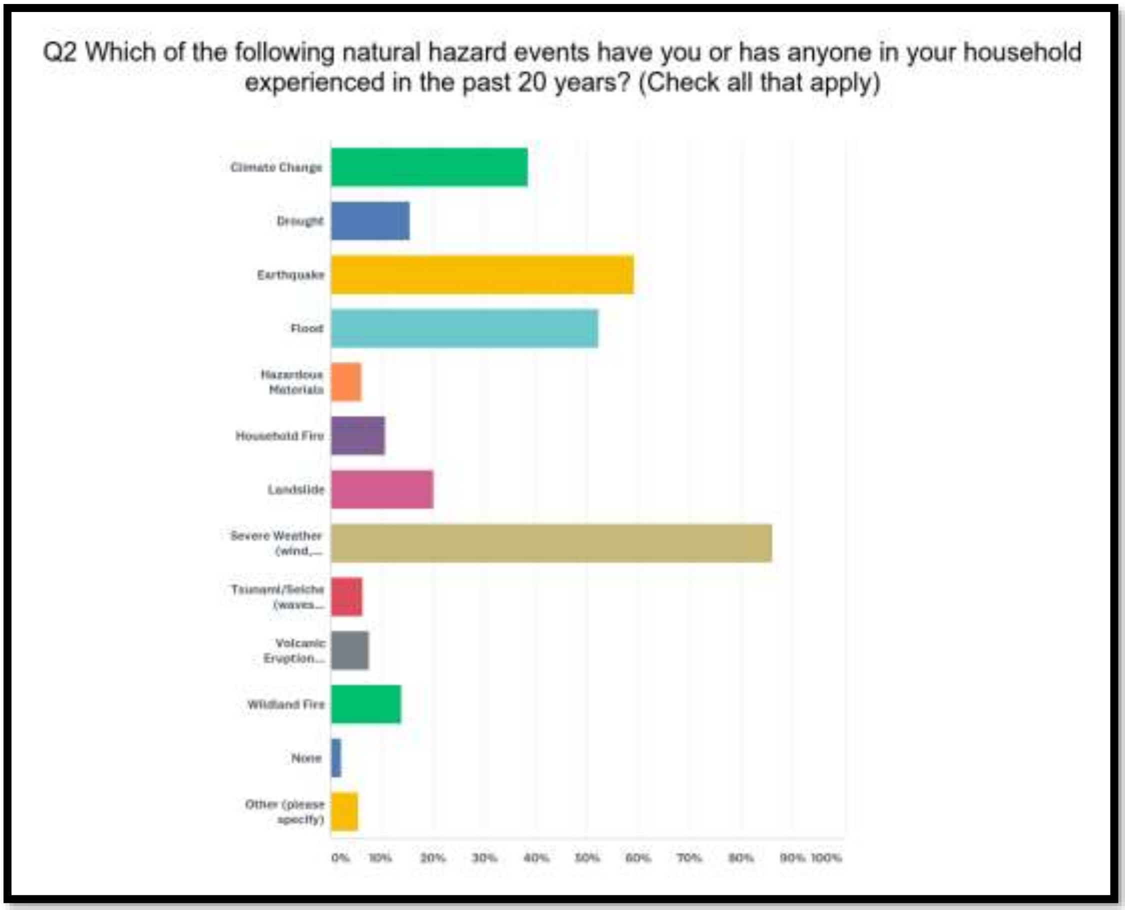
A few citizens discussed mitigation efforts underway, such as the City of Aberdeen’s levee project, and landslide mitigation efforts, which the homeowner felt was ineffective.

Other outreach comments included a recommendation to incentivize mitigation efforts during the permitting process; several of the planning partners did in fact include similar such recommendations as potential mitigation strategy.

One of citizens’ greatest concern is the limited time for evacuation associated with a tsunami event along the coast, especially when attempting to evacuate with supplies. Several citizens offered volunteer assistance to local emergency management.

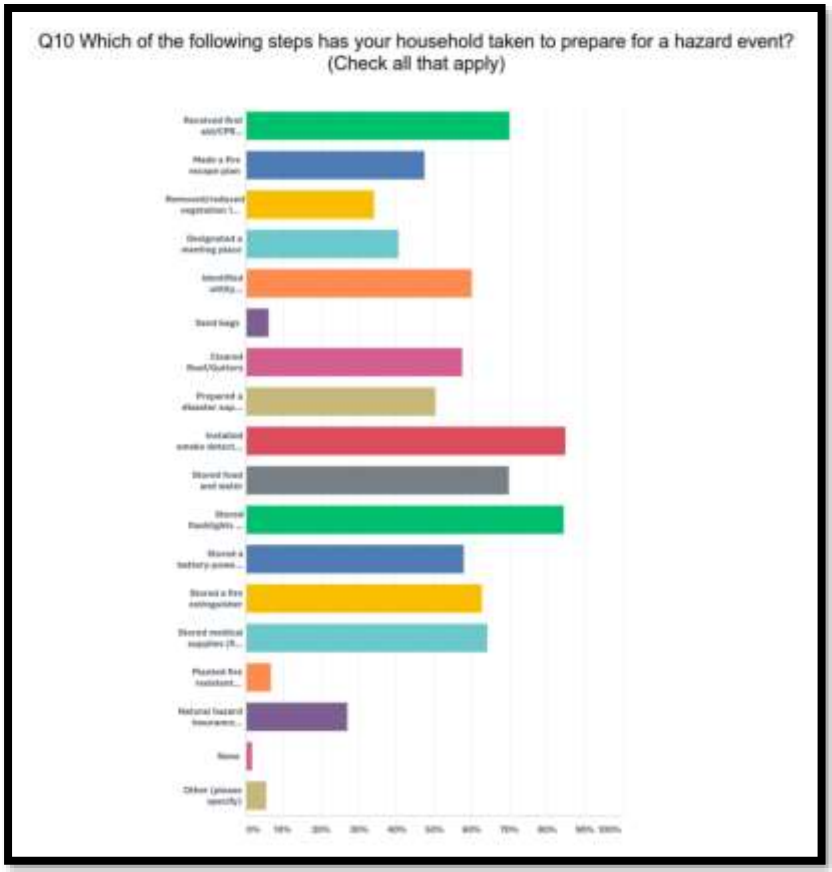
Praise was also given to all of the effort extended by all of the planning team with respect to dissemination of information, and the ability for the citizens to learn of the hazards of concern, and ways in which to better prepare themselves.

With respect to the survey responses as they relate to the hazards of concern, the response closely match the hazards of greatest concern as identified through the Planning Team’s risk ranking.



Additional points of interest from the survey results include:

- 59 percent of respondents have experienced an earthquake; 6 percent have experienced a tsunami; 7 percent have experienced a volcanic eruption, and 86 percent have experienced a severe weather event. Of the 25 disaster declarations occurring in the County, 10 have been as a result of Severe Weather, while 12 have been as a result of Flood events. Floods are the majority of hazards that have impacted the County in the last 20 years.
- 61 percent of respondents have experienced one to three disaster events in their lifetime, with over half of those occurring while the respondent resided in Grays Harbor County.
- Of those impacted by a disaster event, 3 percent indicate that they or a family member sustained injuries as a result of that incident.



- 39 percent of respondents indicated that the impact of disasters did not restrict the use of their residence, while 27 percent indicate that it did impact their ability to work.
- 52 percent of respondents indicate that while they were impacted by disaster incidents, they sustained no financial impact, while 32 percent did sustain financial impact.
- Earthquake and Tsunami are the hazards of greatest concern to citizens, with the prioritized scoring closely mirroring that identified by the HMP Planning Team. Severe Weather and Flood were next in order of significance.
- Volcano was of higher concern than Drought to the citizens.
- Of those financially damaged by a disaster incident, 16 percent impacted had no insurance coverage for the incident, while 13 percent had insurance coverage.
- 27 percent or 66 respondents indicate they have flood insurance through the NFIP.
- 59 percent of respondents indicated some level of self-preparedness. The type of preparedness varies.
- 51 percent of respondents indicated that the impact of disaster incidents played a role in their decision to purchase their residence.

2.6.3 Radio Broadcasts and News Releases

The County takes part in weekly broadcasts concerning public safety issues in the county, including the development of the hazard mitigation plan update. At the onset of this project, the effort was discussed on various broadcasts, as was the survey link when it was deployed. The County also distributed a news release concerning an invitation to the general public to learn about emergency management as a whole, including presentation of risk data and hazard maps (see Figure 2-3). When the draft plan was available for public review, notice was published in an effort to draw in as many comments as possible.

2.6.4 Internet

At the beginning of the plan development process, a website was created to keep the public posted on plan development milestones and to solicit input (see Figure 2-4). The plan was provided via a file-transfer site, which allowed for the plan downloading for review. The County intends to keep a website active after the plan's completion to keep the public informed about successful mitigation projects and future plan updates.

The County's website address was publicized in all press releases, mailings, questionnaires and public meetings. Information on the plan development process, the Planning Team, the questionnaire and phased drafts of the plan was made available to the public on the site throughout the process. Hazard maps were published on this site, and were available for download. A link was also made available to the County's survey, available at: https://www.surveymonkey.com/r/Grays_Harbor_County_Mitigation_Survey. In addition, several of the planning partners also posted information on their respective websites, posting frequently asked questions, and asking for citizen comments. As comments were received, they were reviewed by the planning team and integrated into the plan if appropriate.

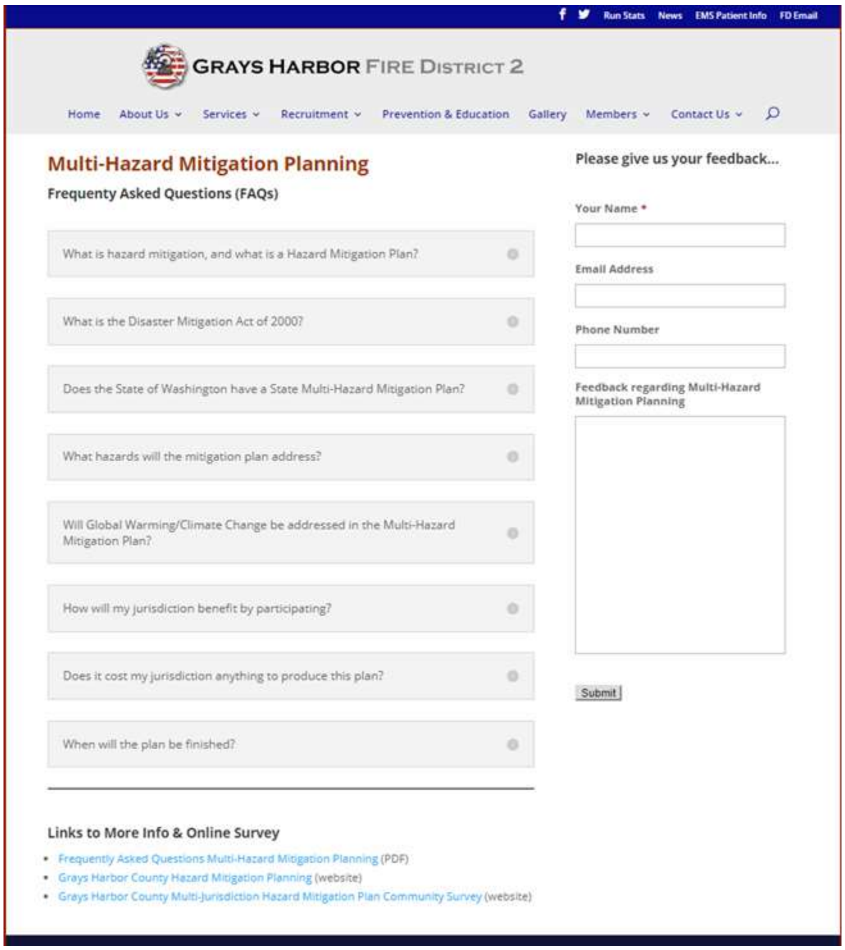


Figure 2-2 Grays Harbor Fire District 2 Hazard Mitigation Website

2.6.5 Social Media

In addition to the website, the County also has a Twitter account with over 1,300 followers (https://twitter.com/ghcdem), and a Facebook account which has approximately 5,000 followers (https://www.facebook.com/Grays-Harbor-County-Emergency-Management-426601594068767/). Both were utilized to distribute information concerning the plan's update; to distribute information concerning the survey; advise citizens of the availability of the hazard maps for review and comment; announcing public outreach events, and when the final plan was complete, alerting citizens to the draft plan, asking for review and comment during the open public comment period.

2.6.6 Public Meetings

Several public meetings and events which were open to the public were held during this effort. All planning meetings were open to the public, and citizens did attend those meetings, providing information and input. Table 2-3 highlights some of the public outreach efforts conducted. All public meetings which were held in conjunction with County Commissioner's Meetings were also recorded for viewing at a later date by citizens or other interested parties. In addition, the Fire Districts each held monthly meetings, all of which were open to the public, during which various elements of the HMP process were discussed, in addition to the hazard risks associated with each district. For example, during a public outreach session, Fire District 2, currently in the process of building a new structure, identified the location of the new facility during these monthly meetings, and discussed the engineering specifications associated with the construction of that facility. Demonstrating its intended ability to withstand natural hazard impact due to the various building codes in place to which the structure will be built, then comparing that building to the existing buildings to demonstrate the benefits of mitigation efforts. The District also discussed the new location in relation to the risk assessment completed.

Table 2-3
Public Outreach Events

Date	Jurisdiction	Description	Attendance
2017			
September	Countywide	Press release announcing the up-coming project	N/A
September 4	Countywide	Website developed; announcement of upcoming meeting posted. Agenda posted for upcoming meeting.	
September 13	City of Aberdeen Public Safety Meeting	During the Public Safety Meeting prior to Aberdeen City Council Meeting, a Hazard Mitigation Plan (HMP) Frequently Asked Questions (FAQ) document developed for this planning effort was presented to the Public Safety Council members for discussion. A brief overview of the purpose of the planning process and benefits was discussed.	~15
September 13	City of Aberdeen City Council Meeting	Council Member Denny Lawrence provided a briefing to the entire City Council and the public during the regular council meeting concerning the City's current participation in the Countywide Hazard Mitigation Plan Update process, and addressed the HMP FAQ. This briefing was captured as part of the audio recording of the meeting.	30
September	Countywide	Survey deployed	
October	Countywide	Frequently asked questions and minutes were posted	N/A
Monthly Meetings	Countywide	Discussions and presentation on the status of project to senior leadership, representatives from all local communities, county departments, and local departments.	15-20 monthly
October	Countywide Fire Chiefs' Meeting	Hazard Mitigation Planning Effort discussed; current plan status and level of effort to complete annex documents discussed.	~15
October	Countywide	Planning Team Members posted a link on Facebook accounts concerning the availability of the County's survey.	N/A

Table 2-3
Public Outreach Events

Date	Jurisdiction	Description	Attendance
October 7	Countywide	Safety Zone Fair—The County held its annual Safety Zone Fair which included maps and posters presenting risk information for all hazards of concern. Presenters at the event included subject matter experts, emergency manager, police and fire personnel. The presentation included posters identifying the hazards of concern and the areas of impact, as well as specific structure loss data. In addition, Washington State Dept. of Emergency Management also attended, providing input and information on some of the hazards of concern. The posters also included general hazard mitigation planning data, and solicitation for public involvement..	+250
Multiple	Countywide	County Emergency Manager conducted radio interviews on various occasions during the planning process, discussing the planning effort, announcing availability of the survey, and discussing the various hazards of concern.	Radio
Nov 27	Chehalis River Basin Planning Group	Flood hazard addressed and discussed; discussions concerning the mitigation plan and various local planning partners' potential enrollment in CRS was discussed. Attendees involved planning team members, Basin representatives, contractors, citizens and various news agencies.	15
November 29	Local Radio Announcement – Countywide	The hazard mitigation planning effort was discussed, with citizens advised of the County's survey and website.	Unknown
Dec 15	Community Meeting	Chuck Wallace made a presentation to a diverse group of community members, during which he discussed the on-going hazard mitigation planning effort, risk assessment findings, and mitigation opportunities, including the Safe Haven Vertical Evacuation Project, and the on-going Westport effort to also construct a vertical evacuation. The public was given an opportunity to provide comments and ask questions. Citizens were again reminded of the opportunity to take the County's on-line survey.	150
Feb 13	Fire District 7	During the regularly scheduled Fire Commissioner's Meeting, Planning Team Member Nick Falley made a presentation concerning the mitigation planning process, and the findings of the risk assessment, including the risk rankings for all of the planning partners. Copies of the County's disaster history was also distributed, and the Power Point presentation utilized was available in hard copy for review. Attendees were engaged in reviewing the information provided, and were given an opportunity to ask questions during the process.	8

Table 2-3
Public Outreach Events

Date	Jurisdiction	Description	Attendance
Feb 26	Fire Districts 8 and 16	During a regularly scheduled meeting, the planning teams for Districts 8 and 16 worked through the risk ranking exercise discussing the impacts to the various structures of each district. Various handouts were provided, including the overview of risk, maps, and disaster history data. Citizens living within the districts and beyond regularly attend such meetings, and actively engage in discussions. Once completed, the risk ranking exercise was reviewed and confirmed by all attendees.	11
Feb 28	Countywide	During the February planning team meeting, the risk assessment findings were presented. This meeting was announced via the County's website in the same fashion as Commissioner's meetings, inviting citizen attendance. The meeting was also announced on other planning team members' websites. While advertised to the public, no citizens attended.	28
March 8	County Fire Commissioner's Meeting	At the County Fire Commissioner's Meeting, Fire District #8 planning team members presented information on the risk both at the district and county levels. The meeting was open to the public, in addition to fire personnel who attended.	6
March 12	City of Oakville	The Public Works Director and County Emergency Manager presented the risk findings with respect to the City of Oakville during the City Council Meeting. The meeting is regularly held, and notice of the meeting was published. Citizens were able to pose questions to the planning team members throughout the meeting. Posters of the hazards of concern were posted throughout the room. Notice of the meeting was also erected on the City's reader board.	~15
March 21	Community Meeting	Several of the planning partners conducted an outreach effort hosted by the City of Aberdeen. This was a combined outreach effort involving several of the planning partners (see Press Release) to reach citizens throughout the County. The effort was widely publicized via a press release, website announcements, twitter, and Facebook announcements. Several presentations were made during the two-hour outreach effort, during which an update to the planning process was made, as well as information provided concerning the impacts of the hazards of concern. In addition, planning team members also discussed potential strategies which were identified for the 2018 update. Citizens were invited to review the risk assessment data and maps / posters which were distributed throughout the facility, in addition to other types of handouts. Citizens were asked to provide input and comments, and were asked to take the HMP Survey. The presenters also announced that the draft plan would be available for review within the next three-four weeks, and provided the County's website, which is where the plan will be posted for review. While the event was heavily publicized, only five citizens attended, in addition to the 15 planning partners.	~16

Table 2-3
Public Outreach Events

Date	Jurisdiction	Description	Attendance
March 26	GH Community Hospital	Director Bain prepared a public presentation concerning the hospital's involvement in the mitigation planning process, as well as the assets and risk factors associated with the natural hazards of concern on the hospital. The meeting was open to anyone wishing to attend, and is a regularly scheduled meeting, with an established notification process. One participant asked how the hospital was involved in the planning process, which was discussed during the presentation.	13
March 26	Ocean Shores Council Meeting	Mayor Crystal Dingler presented an update to the planning process during the City Council Meeting. Citizens were invited to take the survey and to review the hazard maps which were posted in council chambers. The Mayor also informed attendees to the County's mitigation planning website for additional information. The Mayor reviewed the hazard impacts specific to the City of Ocean Shores, providing an overview of the impact to the County utilizing a power point presentation. Strategies which the City has developed for the 2018 update were also discussed. Attendees were provided an opportunity to ask questions, and provide input to the data provided. Mayor Dingler also advised attendees that the draft plan would be available for review on the County's website during the second or third week of April, and asked them to check the website to review the plan. The meeting was broadcast simultaneously and recorded on the radio. The meeting was also recorded ditigatlly by the local television station, and aired again on March 27 and 30, 2018. A copy is also available at the City library. The City also posted the televised version on the City's website for anyone wishing to watch the broadcast via computer.	30
March 28	McCleary Council Meeting	Todd Baun presented an update to the planning process during the City Council Meeting. Citizens were invited to take the HMP Survey and to review the hazard maps posted in council chambers. Individuals were also provided information concerning the County's mitigation planning website, where they could obtain additional information about the process followed and the risk assessment completed countywide. Director Baun reviewed the impacts specific to the City of McCleary, as well as providing an overview of the impact to the County. Strategies which the City had developed were also discussed. Attendees were provided an opportunity to ask questions, and provide input to the data provided. Director Baun also advised attendees that the draft plan would be available for review on the County's website during the first few weeks of April.	15

Table 2-3
Public Outreach Events

Date	Jurisdiction	Description	Attendance
March 28	Countywide	Fire Chief Tom Hubbard with the City of Aberdeen conducted an interview and presentation on the KBKW Coffee Talk local morning radio show. During the information exchange, the Chief discussed the various public outreach efforts which have occurred to date, the risk assessment completed with results, also identifying the hazards of concern, discussed the CRS program, and the City of Aberdeen's flood mitigation projects. The Chief also invited citizens to take part in the process by completing the on-line survey, which includes not only capturing information from citizens concerning the hazards of concern, but also insurance information, which the jurisdictions can use to focus outreach efforts. The Chief also announced that the plan will be available for public review within the next few weeks, directing citizens to the County's website for more information.	NA
March	Newsletter	A quarterly newsletter was distributed to residents in the Pacific Beach, Moclips, and Tahola areas. The newsletter discussed the HMP process, as well as presenting information on the risk assessment, and providing mitigation-related examples for residents to help reduce the risk of the hazards of concern. The newsletter is distributed quarterly, with each quarters' letter presenting various mitigation-related activities.	~300
April 10	Grays Harbor Transit	Public meeting to review and discuss the Authority's annex template, and announcing the availability of the County's plan for review commencing the 13th. While citizens were provided an opportunity to provide comments, none were received, although there were questions and dialogues which occurred.	13
April	Grays Harbor County Board of Commissioners	Plan review before Commissioners; invitation extended to citizens to review existing plan; announcement of website address and that hard a copy is available for review at the office of Grays Harbor County Emergency Management. The Commissioner's meeting is televised, and can be viewed by citizens at any time.	~20+
April	Countywide	Information concerning the planning process and risk at the various levels throughout the county was presented within the Fire Association Report which was distributed. Also announced at the meeting was the announcement of the plan's availability for review and comment.	Unknown

Table 2-3
Public Outreach Events

Date	Jurisdiction	Description	Attendance
April 11	Countywide	Tsunami Road Show at the Ocosta School District and Ocean Shores – presentations by planning team members and various subject matter experts. The Ocosta School District held an open house for citizens to view the first vertical evacuation site, as well as learn about the earthquake and tsunami hazards based on new studies completed, including the Westport Study which was utilized in this risk assessment. At the Ocean Shores location, citizens were provided new information about the hazards of concern, including new earthquake and tsunami studies, and the impacts of erosion.	Ocosta ~100 Ocean Shores ~250
April 13	Grays Harbor County	Press Release announcing plan availability for review on Website and hard copy available for review at Grays Harbor County Emergency Management. Facebook and Twitter announcements also went out. Each of the planning partners utilized their existing social media tools to distribute the plan's availability, and some of the Planning Partners posted notices on reader boards.	NA

The kickoff meeting was open to the public and was publicized in the local paper. Table 2-4 summarizes the review and analysis of the 2011 plan discussed at that meeting. Figure 2-3 are photos of the kick-off meeting.

Table 2-4
Review and Analysis of 2010 Hazard Mitigation Plan

2010 PDM Sections	How Reviewed and Analyzed
Section 1—Introduction and Purpose	Reviewed existing section through discussion at public meeting. No analysis needed.
Section 2—Planning Process	Reviewed and analyzed existing section through discussion at public meeting. Planning process expanded by utilizing project website and scoring hazards using Calculated Priority Risk Index.
Section 3—Hazard Identification and Vulnerability Analysis	Reviewed and analyzed existing section through discussion during public meeting and Planning Partner conference calls. Reviewed and updated hazards, critical facilities and vulnerable populations. Updated section with recent hazard data.
Section 4—Critical Facilities and Infrastructure	CIKR data was reviewed and planning partners were asked to update the data for the 2017 edition. This information, when completed, will be incorporated into the CDMS layer for the Hazus model, and utilized during the risk assessment portion of the planning effort.
Section 5—Mitigation Initiatives	Reviewed by planning partners during conference calls, public meeting and subsequent mitigation workshop. New projects developed, existing projects re-worded and/or deleted, completed projects documented.
Section 6—Plan Maintenance	Reviewed and analyzed existing section through discussion during Planning Partner conference calls. Determined that plan maintenance procedures outlined in previous plan had not been implemented.

Presentation of Risk

During public outreach events, maps from the various hazards were presented (see figures below for examples). The meeting formats allowed attendees to examine maps and handouts, and have direct conversations with project staff. Risk data was shared with attendees, as were various mitigation strategy efforts developed to help reduce risk. Maps and posters were set up for each primary hazard to which the planning area is most vulnerable. This allowed citizens to see information related to their property. Each citizen attending was also asked to complete a survey, and each was given an opportunity to provide comments to Planning Team members concerning the hazard maps. The Planning Team reviewed those comments, and as appropriate, incorporated the comments into the plan.

In addition, once completed, the County also posted all of the hazard maps on its website to allow citizens who were unable to attend any of the public outreach sessions to view the maps on line, and provide comments. Notice of the availability of the maps on the County's website was distributed via social media and press releases.

Figure 2-3 Grays Harbor County Kick-Off Meeting

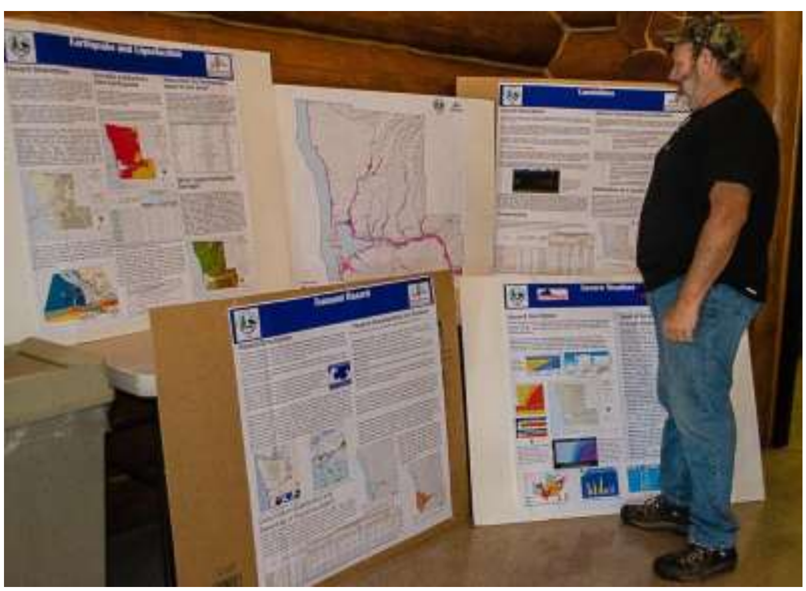


Figure 2-4 Preparedness Expo Poster Displaying Hazards and Impact

Figure 2-5 Presentation of Risk Results

Figure 2-6 Ocean Shores Map Presentation During March 26th Council Meeting

Figure 2-7 Ocean Shores March 26th Public Outreach Meeting

Figure 2-8 City of Oakville Notice of Public Meeting

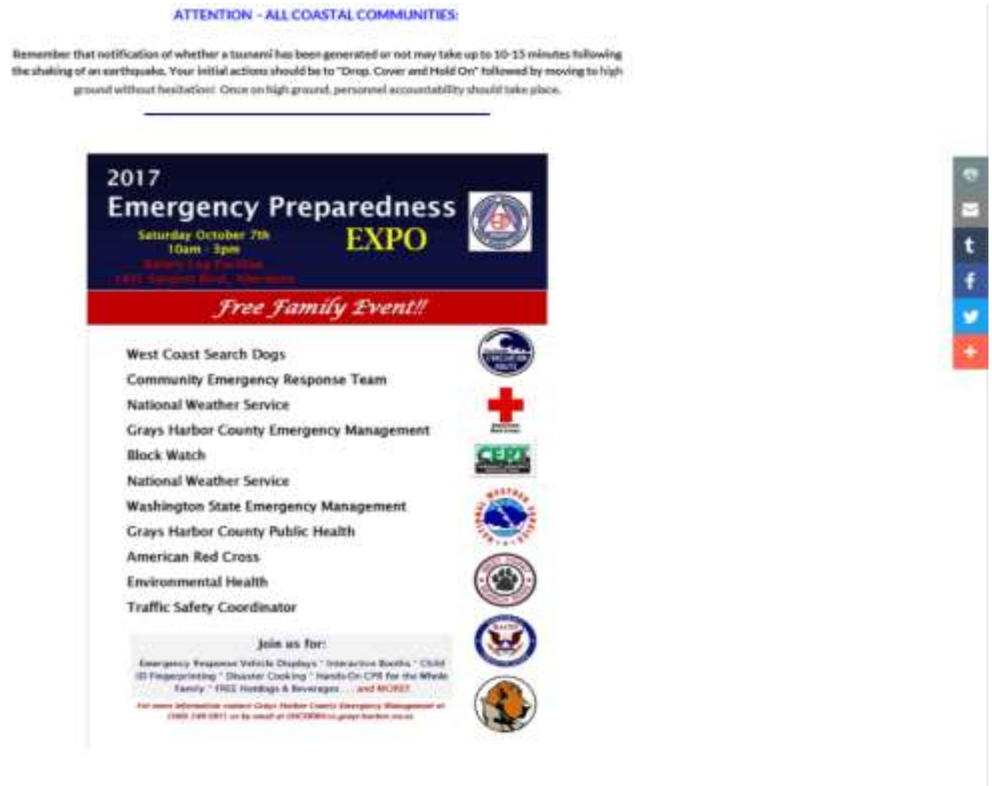


Figure 2-9 Emergency Preparedness Expo October 2017

Figure 2-10 Elma Area Safety Fair

FOR IMMEDIATE RELEASE
Date: 3/14/2018
Contact: Kris Koski, Aberdeen City Engineer
Tel. 360.537.3218
Email: kkoski@aberdeenwa.gov

HAZARD MITIGATION PLAN PUBLIC OUTREACH SESSION

Citizens of Aberdeen, Hoquiam, Cosmopolis, and any other nearby area are invited to attend a public outreach session hosted by the City of Aberdeen to learn about the risks associated with natural hazards that may impact our area, and to provide input that will assist planners in updating the Grays Harbor County Multi-Jurisdiction Hazard Mitigation Plan.

Location: PUD Nichols Building
220 Myrtle Street
Hoquiam, WA 98550
(ADA accessibility off Sumner Avenue entrance)

Time: 2:00 PM to 4:00 PM, Wednesday, March 21, 2018

Background:

Grays Harbor County, its jurisdictions, and its special purpose districts are in the process of updating the Hazard Mitigation Plan. The Planning Team recently completed a Risk Assessment and is holding this public outreach session to allow the public an opportunity to review information, provide comments, and provide input. During the session, maps and posters illustrating areas of concern and other data will be available for review and comment. Presentations will also be made by various members of the Planning Team.

Citizen input is vital to assisting the agencies involved in this process to accurately present information in the Hazard Mitigation Plan. Hazards to which our community are at risk include earthquake, tsunami, flood, landslide, severe weather, climate change, drought, wildfire, volcano, and erosion. Our community's local agencies are committed to understanding these risks and developing strategies to reduce the impact that these hazards may have on our community.

The final plan will be available for review by citizens in mid to late April. Citizens should continue to view the County's website for information on this effort, as they will be provided another opportunity to review and comment on the final plan prior to its submission to the Federal Emergency Management Agency.

http://www.co.grays-harbor.wa.us/departments/emergency_management/Hazard_Mitigation_Planning.php

Agencies Participating in Session:

City of Aberdeen, City of Cosmopolis, City of Hoquiam, Grays Harbor College, Grays Harbor Community Hospital, Grays Harbor County, Grays Harbor Fire District No. 2 (Central Park), Grays Harbor Transit, Port of Grays Harbor

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Figure 2-11 Press Release for Presentation of Risk

2.6.7 Draft Plan Review

Once the draft plan was completed, the public was invited to provide comments on the hazard mitigation plan. The final public review period began April 13, 2018 lasting through April 30, 2018. The County and its planning partners completed the following outreach activities:

- The draft plan was posted on the project website and stakeholders were notified through press releases and e-mail messages of its availability, including Twitter and Facebook. This included notification on reader boards in the communities, and planning partners' websites, Twitter and Facebook accounts.
- During the Commissioner's Meetings and Department Head Meetings, Emergency Management Deputy Director Charles Wallace announced that the draft plan was available for review, and citizens were asked to review the draft plan and provide comments. Each Commissioner was

provided the plan for review. A brief overview of the planning process was provided, including an overview of the hazards of concern, and the various types of data and reports which were utilized to help profile the hazards, and identify associated risk. While citizens were provided an opportunity to provide feedback and ask questions, that communication did not provide any additional data which required inclusion in the plan.

– Planning partners provided notification of the plan's availability for review during their respective council and commission meetings, advising citizens of the plan's availability.
– Each planning partner held their own final public meeting, at which the plan was presented to their commission or council and the approving authority adopting the plan.

No comments were received during the public review period. Once the review period closed, the plan was submitted to FEMA for review. Once pre-adoption approval was received from FEMA, the plan was provided to the Grays Harbor Board of County Commissioners and the incorporated communities for adoption. After adoption, final copies of the plan were submitted to the Washington State Department of Emergency Management and FEMA. Appendix C includes the adoption resolutions.

The final plan will remain on the County's website over the next five years. Future comments on the plan should be addressed to:

Charles Wallace, Deputy Director
Grays Harbor County Department of Emergency Management
310 West Spruce Street
Montesano, WA 98563
(360) 249-3911

2.7 PLAN DEVELOPMENT MILESTONES

Table 2-5 summarizes important milestones in the development of the Grays Harbor County Multi-Jurisdiction Hazard Mitigation Plan.

Table 2-5
Plan Development Milestones

Date	Event	Description	Attendance
2015			
2015	Submit initial grant application	Seek funding for plan development process	N/A
2017			
2017	Receive notice of grant award	Funding secured.	N/A
July	Initiate consultant procurement	Seek a planning expert to facilitate the process	N/A
Aug	Contractor interviews conducted and contractor secured	Select Bridgeview Consulting to facilitate plan development	N/A
Aug	Commission Presentation	Identification of Hazard Mitigation Project discussed; vendor selection identified; contract with consultant approved by Commissioners	

Table 2-5
Plan Development Milestones

Date	Event	Description	Attendance
Aug	Begin identifying Planning Team members	Begin formation of the Planning Team; Consultant begins review of various documentation and assimilating data, reports, studies, etc.	N/A
Aug	County HMP Team Identified	Formation of the County's HMP planning and core project management team. Continue review of existing plan and existing documentation supporting effort (e.g., studies, other planning documents, etc.)	N/A
Sept 14th	Planning Team Kick-Off meeting	Presentation on plan process, hazards, goals, objectives and public outreach strategy. Review of 2011 plan. General plan template discussed. Discussed hazards to be addressed in plan update; discussed methodology which would be used to conduct the analysis. Hazards to be addressed were reviewed and confirmed. The Planning Team discussed public presentation of hazard maps at October 7th Grays Harbor Safety Fair. Goals and objectives were reviewed, updated and confirmed.	26
10/2	Planning Team	Initial maps were presented to the Planning Team members for review and comment. The survey was also provided for review and comment, with the finalized version made public via Survey Monkey. Notice of the survey's availability and a link to the survey was posted on the County's website	10
2018			
1/8	Planning Team Meeting	Reviewed the plan update; captured information concerning capability assessment; provided first draft of hazard profiles (with the exception of erosion); reviewed existing strategies to obtain update; and began formulating countywide and county specific strategies.	4
2/28	Planning Team Meeting	Risk ranking exercise completed and confirmed; strategy/action items reviewed and discussed; incorporation of risk data into other planning mechanisms discussed (e.g., land use, CEMP, evacuation plans, etc.).	28
2/28	Planning Team Workshop	Annex development workshop conducted. After the general planning team meeting where the risk assessment data was again presented and reviewed, the Annex Development Workshop was conducted. Planning team members brought staff from their respective jurisdictions to continue working on their annex templates throughout the workshop session.	12
3/28	Draft Plan Internal Review	Draft provided by Planning Team to Planning Team (additional strategies added during review process).	All
4/13	Public Review	Draft provided on website with press releases inviting citizens to review and comment for 17 day period.	All
July	FEMA Approval	Final Plan Approval was received and Planning Partners began the adoption process.	

CHAPTER 3.
COMMUNITY PROFILE – DEFINING THE PLANNING AREA

3.1 PHYSICAL SETTING

Located in western Washington, the topography of Grays Harbor County is diverse, encompassing a land area of 1,917 square miles. The County has a total area of 2, 224 square miles, with 322 square miles (or 14%) of water. Forest land encompasses 88% of land coverage. It ranks 15th largest of Washington's 39 counties.

Named after a large estuarine bay near its southwestern corner, Grays Harbor County is known as the Gateway to the Pacific Ocean and the Olympic Peninsula. The confluence of Grays Harbor and the Chehalis Rivers is 50 miles west of Olympia, 100 miles southwest of Seattle, and 140 miles northwest of Portland, Oregon. Montesano, the County seat, is located 40 miles west of Olympia. The area is naturally varied from tree-covered hills to ocean beaches. The Olympic Mountains form the northern border of the county, the Pacific Coastline lies to the west, and steep foothills fill the remainder of the county.

The County is bordered to the north by Jefferson County, to the northeast by Grays Harbor County, to the south by Pacific County, the south/southeast by Lewis County, and to the east/southeast by Thurston County. There are nine incorporated cities within its boundaries: Aberdeen, Cosmopolis, Elma, Hoquiam, McCleary, Montesano (county seat), Oakville, Ocean Shores, and Westport. Two Native American Tribes, the Chehalis Indian Reservation and the Quinault Indian Reservation, are also in the county boundary. A portion of both the Olympic National Park and the Olympic National Forest fall within the county (see figure below).

The Cities of Aberdeen and Hoquiam were originally developed over 100 years ago on a broad, flat pain adjacent to the Grays Harbor Estuary, Chehalis River, Wishkah River, and the Hoquiam River. Elevations within the area generally range from 10 to 15 feet NAVD 88, with some areas, such as the Port of Grays Harbor, as high as 18 feet. Some areas are as low as 9 feet in elevation (Steepy, 2017).

The Grays Harbor Estuary, the mouth of the Chehalis River, is a predominate feature that extends about 25 miles inland and covers 58,000 acres. There are seven state parks in the area, including:

- Griffiths-Priday Ocean State Park
- Lake Sylvia State Park
- Ocean City State Park
- Pacific Beach State Park
- Twin Harbors State Park
- Westhaven State Park
- Westport Light State Park

The county has six major river valleys, including: the Chehalis, Satsop, Wynoochee, Wishkah, Hoquiam, and Humptulips Rivers. The Chehalis River flows across the southern part of the county with the Black, Satsop, Wynoochee and Wishkah Rivers flowing into it. Additional major rivers in the county include the: Johns, Elk, Copalis, Moclips and Quinault Rivers. Other geographic features include, but are not limited to:

- Aberdeen Lake
- Duck Lake
- Failor Lake
- Lake Quinault
- Olympic Peninsula
- Quinault Rain Forest
- Satsop River
- Wishkah River
- Wynoochee Lake
- Wynoochee River

The approximately 4.4 mile long Wynoochee Lake lies behind the 177- foot high Wynoochee Dam. Tacoma Power Utilities operates the dam and produces power. The U.S. Army Corps of Engineers regulates the Dam flow during major flood events.

Figure 3-1 Grays Harbor County

3.1.1 Geology

The Pacific coast of Washington is characterized by river and alpine glacier sediments above basalt and marine sedimentary rocks that were accreted to the continent. The southern coastline is lined with sandy sediment that works its way from the mouths of its rivers. This sediment forms beaches and sand spits like Long Beach, Ocean Shores, and Westport. Sediment from the Columbia River migrated north on ocean tides and formed the Long Beach peninsula, which is still actively growing. The northern coast is made up of basalt from lava flows on the ocean floor that have been accreted onto the continent over the last several million years.

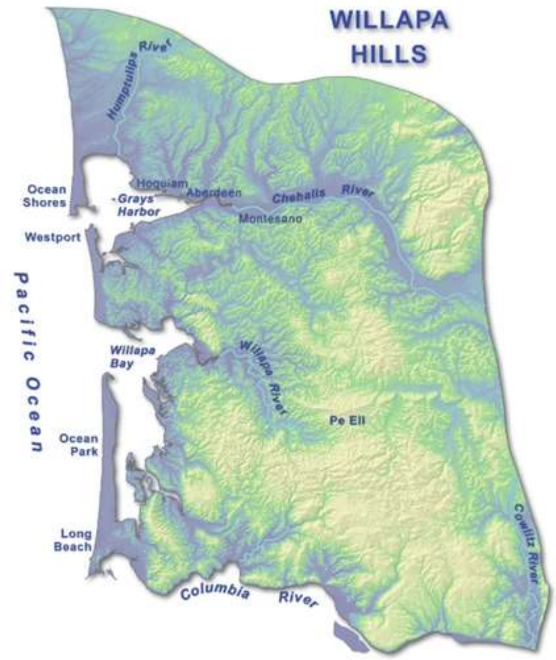


Figure 3-2 Willapa Hills

The Willapa Hills rise to 3,110 feet above sea level and are part of the Coast Range. They are bounded by the Olympic Mountains to the north and the Columbia River to the south. The Willapa Hills province includes the Black Hills, Doty Hills, and the adjacent broad valleys that open up to the Pacific Ocean. Barrier beaches characterize the low-lying coastline. Major estuaries include Grays Harbor and Willapa Bay. The hills have a rounded topography due to extensive weathering.

During the last ice age in the Pleistocene, most of the northern half of Washington experienced several episodes of continental and alpine glacier advance and retreat. The Willapa Hills were never glaciated, though glacial deposits are found in river valleys. At this time, a major river existed in the present-day Chehalis River valley. This ancestral river channeled glacial meltwater from the Cascades and Puget lobe ice sheet toward the Pacific Ocean. This ancient river deposited vast quantities of sand and gravel. These deposits locally provide much of the road building materials for the area.

The Willapa Hills Province records several major events: the accretion of thick oceanic basalt onto western North America, a prolonged episode of flood basalt flows, and repeated catastrophic glacial flooding.

Geology for the area (see figure right) is underlain by Crescent Formation basalts, which are a thick deposit of marine volcanics accreted to the continent by subduction processes formed during the Eocene about 56 million years ago. Sedimentary rocks formed in shallow seas and deposited with and after the Crescent basalts yield many fossils. These include pelecypods (clams), gastropods (snails), and crustaceans such as crabs. Thick lignite coal units and interbedded basalts are characteristic of the eastern part of the Willapa Hills, formed within a nearshore marine environment during the Paleogene, about 65 to 23 million years ago.[2]

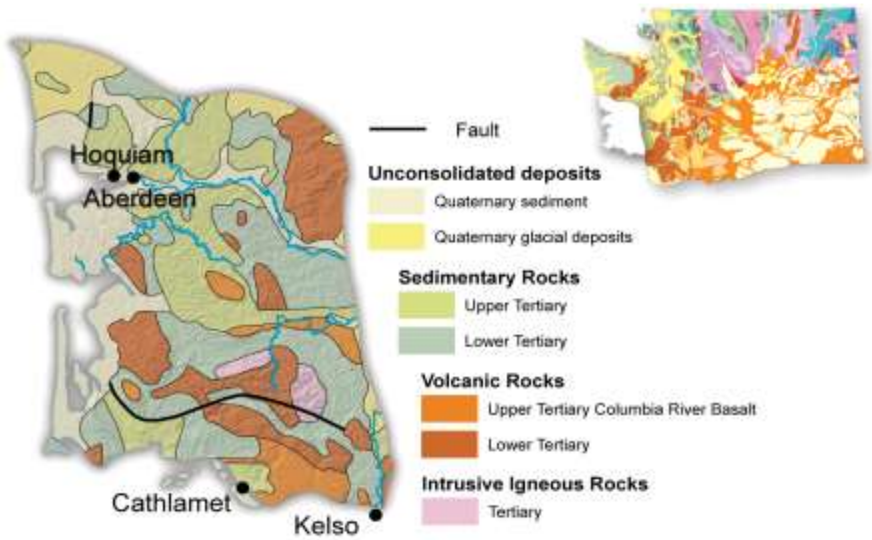


Figure 3-3 Grays Harbor County Geology

The Willapa Hills include exposures of Miocene-age Columbia River Basalt Group flows. These voluminous basalts flowed down the ancestral Columbia River from what is now eastern Washington and northeastern Oregon to reach the Pacific Ocean. Flows are also found in the Willapa Bay and Grays Harbor estuary. In many areas along their travels, the basalts burrowed into the underlying soft sedimentary rocks. These unique flow features are called invasive flows.

Except for sand, gravel, and rocks, there are no mineral resources being exploited from the area. On the coast, near Ocean Shores, the state's most productive petroleum well was drilled in 1957. It produced 12,000 barrels of crude oil from Eocene Ozette melange rocks. Offshore bars, in particular at the mouth of the Columbia River, contain ilmenite-rich sands.

3.1.2 Watersheds

Six primary watersheds exist in the area identified in the table below. One of these watersheds, the Skokomish, is associated with a National Estuary Program. (This table contains links to various information associated with the watersheds should readers seek additional information.)

Watershed	USGS Cataloging Unit	Counties Associated with Watershed	Watershed(s) Upstream	Watershed(s) Downstream	National Estuary Programs Associated
Queets-Quinault	17100102	Grays Harbor Jefferson Mason	Hoh-Quillayute	Grays Harbor	None
Upper Chehalis	17100103	Cowlitz Pacific Grays Harbor	None	Lower Chehalis	None

[2] Washington State Department of Natural Resources, available at: https://www.dnr.wa.gov/programs-and-services/geology/explore-popular-geology/geologic-provinces-washington/willapa-hills

Watershed	USGS Cataloging Unit	Counties Associated with Watershed	Watershed(s) Upstream	Watershed(s) Downstream	National Estuary Programs Associated
		Thurston Lewis			
Lower Chehalis	17100104	Grays Harbor Jefferson Thurston Mason	Upper Chehalis	Grays Harbor	None
Grays Harbor	17100105	Pacific Grays Harbor	Queets-Quinault Lower Chehalis	Willapa Bay	None
Willapa Bay	17100106	Pacific Wahkiakum Grays Harbor Lewis	Grays Harbor	Lower Columbia	None
Skokomish	17110017	Grays Harbor Jefferson Mason	None	Hood Canal	Puget Sound
Source: EPA - https://cfpub.epa.gov/surf/county.cfm?fips_code=53027					

3.2 CLIMATE

Grays Harbor County lies adjacent to the Pacific Ocean and is influenced by the prevailing wind direction, the surface temperature of the Pacific Ocean, the Coast and Cascade Ranges, and the position and intensity of the large high and low pressure centers that lie over the ocean. Figure 3-4 illustrates the prevailing wind path for the area. The air is generally moist, and the fluctuation in annual temperature is moderate. Summers are relatively cool and dry, and winters are mild, wet, and cloudy. Grays Harbor County enjoys an average temperature in winter of 41°F and in summer of 60°F. Annual precipitation is 65" to 75" on the coast, 80" to 90"near the foothills, 125" to 150" on the windward slopes of the Olympic Mountains, and 100" for the Willapa Hills.

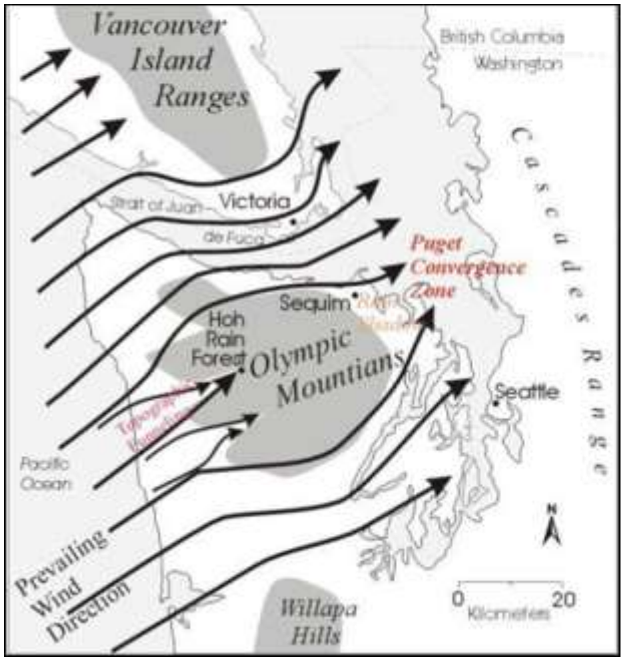


Figure 3-4 Prevailing Wind Path for Olympic Mountains

3.3 MAJOR PAST HAZARD EVENTS

Major hazard events are often identified by federal disaster declarations, which are issued for hazard events that cause more damage than state and local governments can handle without assistance. FEMA categorizes disaster declarations as one of three types (FEMA, 2012a):

- **Presidential major disaster declaration**—Major disasters are hurricanes, earthquakes, floods, tornados or major fires that the President determines warrant supplemental federal aid. The event must be clearly more than state or local governments can handle alone. Funding comes from the President's Disaster Relief Fund, managed by FEMA and disaster aid programs of other participating federal agencies. A presidential major disaster declaration puts into motion long-term federal recovery programs, some of which are matched by state programs, to help disaster victims, businesses and public entities.
- **Emergency declaration**—An emergency declaration is more limited in scope and without the long-term federal recovery programs of a presidential major disaster declaration. Generally, federal assistance and funding are provided to meet a specific emergency need or to help prevent a major disaster from occurring.
- **Fire management assistance declaration** (44 CFR 204.21)—FEMA approves declarations for fire management assistance when a fire constitutes a major disaster, based on the following criteria:
  - Threat to lives and improved property, including threats to critical facilities and critical watershed areas
  - Availability of state and local firefighting resources
  - High fire danger conditions, as indicated by nationally accepted indices such as the National Fire Danger Ratings System
  - Potential major economic impact.

Since 1951 until December 31, 2017, 25 federal disaster declarations have affected Grays Harbor County, as listed in Table 3-1 (FEMA, 2012b). 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.

Table 3-1
Grays Harbor County Disaster History 2015-2017

Disaster Number	Declaration Date	Incident Type	Title	Incident Begin Date	Incident End Date
4253	2/2/2016	Flood	Severe Winter Storm, Straight-Line Winds, Flooding, Landslides, Mudslides	12/1/2015	12/14/2015
4242	10/15/2015	Severe Storm(s)	Severe Windstorm	8/29/2015	8/29/2015
4056	3/5/2012	Severe Storm(s)	Severe Winter Storm, Flooding, Landslides, and Mudslides	1/14/2012	1/23/2012
1825	3/2/2009	Severe Storm(s)	Severe Winter Storm, Record and Near Record Snow	12/12/2008	1/5/2009
1817	1/30/2009	Flood	Severe Winter Storm, Landslides, Mudslides, and Flooding	1/6/2009	1/16/2009
1734	12/8/2007	Severe Storm(s)	Severe Storms, Flooding, Landslides, and Mudslides	12/1/2007	12/17/2007
1682	2/14/2007	Severe Storm(s)	Severe Winter Storm, Landslides, and Mudslides	12/14/2006	12/15/2006
1671	12/12/2006	Severe Storm(s)	Severe Storms, Flooding, Landslides, and Mudslides	11/2/2006	11/11/2006
1641	5/17/2006	Severe Storm(s)	Severe Storms, Flooding, Tidal Surge, Landslides, and Mudslides	1/27/2006	2/4/2006
1499	11/7/2003	Severe Storm(s)	Severe Storms and Flooding	10/15/2003	10/23/2003
1361	3/1/2001	Earthquake	Earthquake	2/28/2001	3/16/2001
1172	4/2/1997	Flood	Heavy Rains, Snow Melt, Flooding, Land and Mudslides	3/18/1997	3/28/1997
1159	1/17/1997	Severe Storm(s)	Severe Winter Storms, Land and Mudslides, Flooding	12/26/1996	2/10/1997
1100	2/9/1996	Flood	High Winds, Severe Storms, Flooding	1/26/1996	2/23/1996

Table 3-1
Grays Harbor County Disaster History 2015-2017

Disaster Number	Declaration Date	Incident Type	Title	Incident Begin Date	Incident End Date
1079	1/3/1996	Severe Storm(s)	Severe Storms, High Wind, and Flooding	11/7/1995	12/18/1995
1037	8/2/1994	Fishing Losses	The El Nino (The Salmon Industry)	5/1/1994	10/31/1994
883	11/26/1990	Flood	Severe Storms, Flooding	11/9/1990	12/20/1990
852	1/18/1990	Flood	Severe Storms, Flooding	1/6/1990	1/14/1990
623	5/21/1980	Volcano	Volcanic Eruption, Mt. St. Helens	5/21/1980	5/21/1980
612	12/31/1979	Flood	Storms, High Tides, Mudslides, Flooding	12/31/1979	12/31/1979
545	12/10/1977	Flood	Severe Storms, Mudslides, Flooding	12/10/1977	12/10/1977
492	12/13/1975	Flood	Severe Storms and Flooding	12/13/1975	12/13/1975
322	2/1/1972	Flood	Severe Storms and Flooding	2/1/1972	2/1/1972
300	2/9/1971	Flood	Heavy Rains, Melting Snow, Flooding	2/9/1971	2/9/1971
185	12/29/1964	Flood	Heavy Rains and Flooding	12/29/1964	12/29/1964
EMERGENCY DECLARATIONS					
3227	9/7/2005	Coastal Storm	Hurricane Katrina Evacuation	8/29/2005	10/1/2005
SIGNIFICANT LOCAL INCIDENTS					
NA	NA	Landslides/Floods	Heavy Rains and Landslides (Countywide)	1/4/2015	1/5/2017

Power Loss

Downed trees and wind storms continue to be the leading cause of power outages in Grays Harbor County, resulting in 152 service interruptions, or 77% of the utility outages in 2016. The most commonly impacted areas included the north and south shores of Lake Quinault and the North River, Copalis Beach, Elma Gate and Elma McCleary Roads.

The total number of significant outages (50 or more customers) rose in 2016 to 369, but was still 19% under the five year average. Remarkably, the total customer outages fell from 83,755 in 2015 to 59,334 in 2016 while the total customer outage hours fell from 303,880 in 2015 to 171,220.

3.4 CRITICAL FACILITIES AND INFRASTRUCTURE

3.4.1 Definition

Critical facilities and infrastructure are those that are essential to the health and welfare of the population. Loss of a critical facility could also result in a severe economic or catastrophic impact. These facilities 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.

Under the Grays Harbor County hazard mitigation plan definition, during its September 14, 2017 kick-off meeting, the Planning Team elected to expand its definition of critical facilities for the 2018 update to include the following:

- Police stations, fire stations, vehicle and equipment storage facilities, communication centers and towers, and emergency operations centers needed for disaster response before, during, and after hazard events.
- Public and private utilities and infrastructure vital to maintaining or restoring normal services to areas damaged by hazard events. These include, but are not limited to:
  - Public and private (large scale) water supply infrastructure, water and wastewater treatment facilities and infrastructure, potable water pumping, flow regulation, distribution and storage facilities and infrastructure.
  - Public and private power generation (electrical and non-electrical), regulation and distribution facilities and infrastructure.
  - Data and server communication facilities.
  - Structures that manage or limit the impacts of natural hazards such as regional flood conveyance systems, potable water trunk main interconnect systems and redundant pipes crossing fault lines and reservoirs.
  - Major road and rail systems including bridges, airports, and marine terminal facilities.
- Hospitals, including large medical facilities that provide critical medical services.
- Structures or facilities that produce, use, or store highly volatile, flammable, explosive, toxic, and/or water-reactive materials (e.g., hazmat facilities).
- Public gathering places that could be used as evacuation or feeding centers (or suppliers) during large-scale disasters, including those with which the County or its planning partners have MOU's or MOA's for use during disaster incidents.
- Schools (as listed within Hazus default data or provided by County).

- Governmental facilities central to governance and quality of life along with response and recovery actions taken as a result of a hazard event.

3.4.2 Comprehensive Data Management System Update

This process included an update of the database contained in FEMA's Hazus software (a hazard-modeling program). Concurrent with this planning process, FEMA was updating flood maps and Hazus data for the County. FEMA data provided to the County in August 2017 was incorporated into the Comprehensive Data Management System (CDMS) update and joined with the critical facilities data gathered by the Planning Team. All critical infrastructure data and the assessor's data for the county has therefore been updated with the most current data available as of August 2017. Limitations associated with the updated CDMS data and the FEMA dataset are discussed in Chapter 4.

While all critical facilities identified are incorporated into this planning process, due to the sensitivity of this information, a detailed list of facilities is not provided. The list is on file with each planning partner. Table 3-2 and Table 3-3 provide summaries of the general types of critical facilities and infrastructure. These tables indicate the location of critical facilities and infrastructure, not jurisdictional ownership. All critical facilities/infrastructure were analyzed in Hazus to help rank risk and identify mitigation actions. The risk assessment for each hazard qualitatively discusses critical facilities with regard to that hazard.

Figure 3-5 and Figure 3-6 illustrate the location of critical facilities and infrastructure in the planning area. The first figure is representative of all structures, while the second represents structures minus the many bridges which are located within the County.

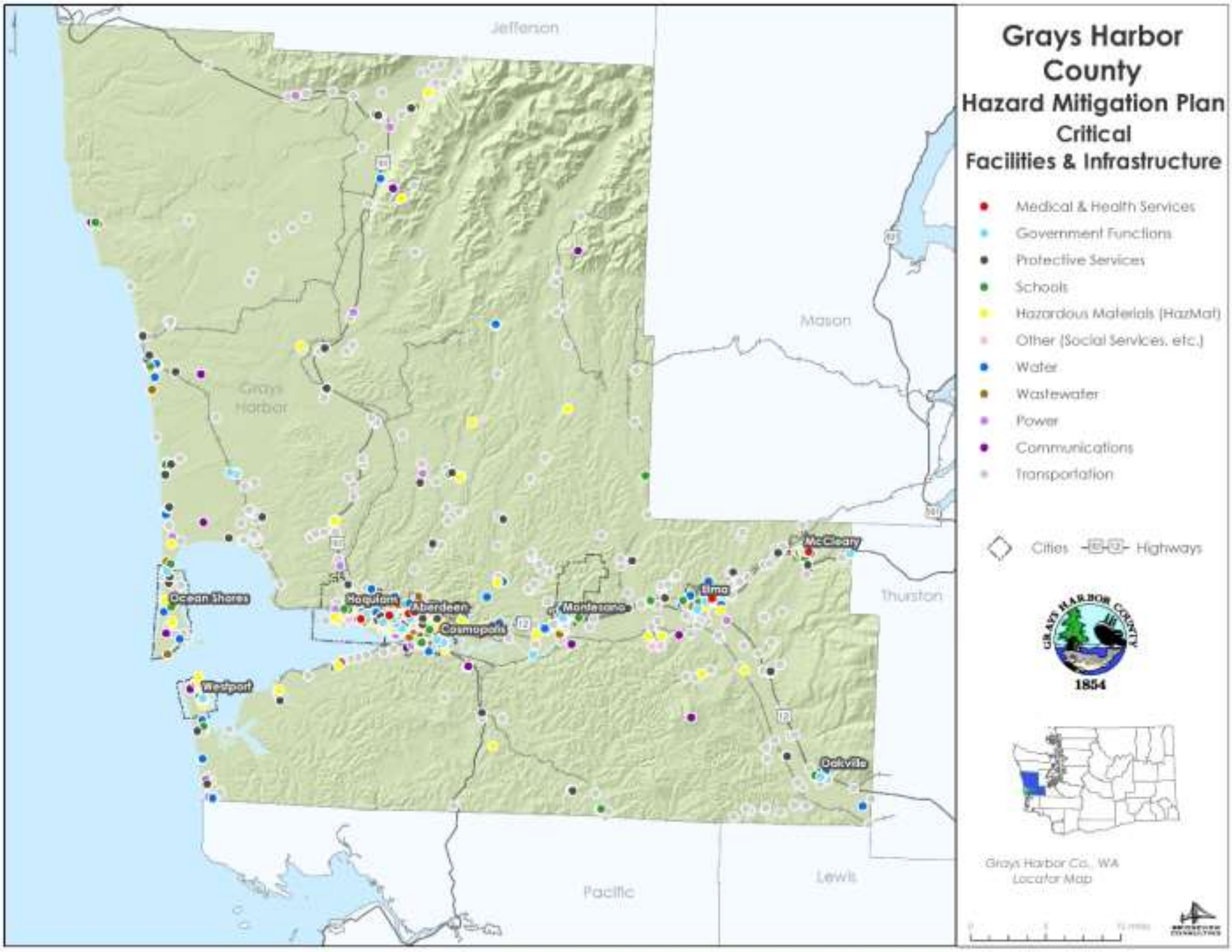


Figure 3-5 Planning Area Critical Facilities and Infrastructure

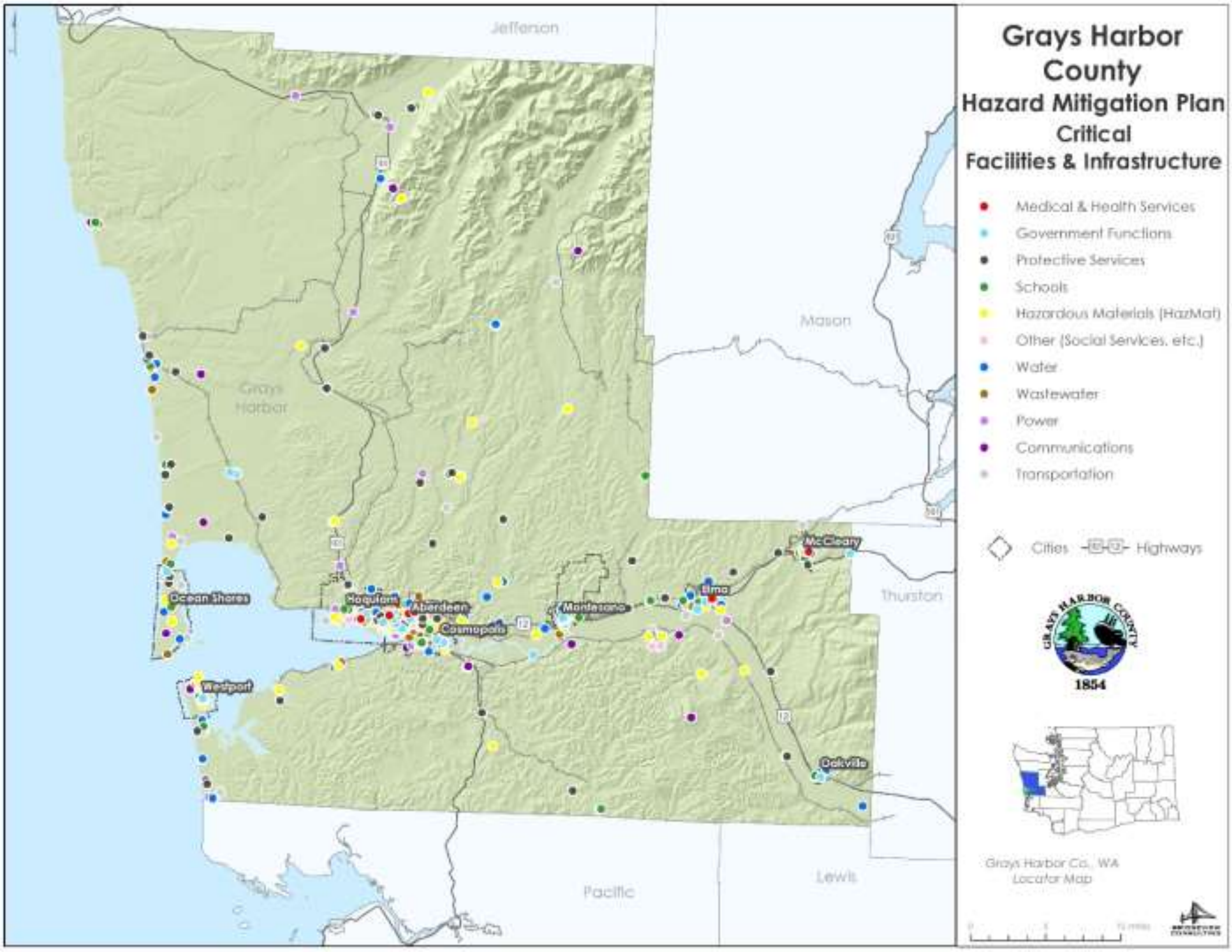


Figure 3-6 Planning Area Critical Facilities and Infrastructure – Bridges Removed

Table 3-2
Grays Harbor Countywide Critical Facilities

Jurisdiction	Medical and Health	Government Functions	Protective Functions	Schools	Hazmat	Other*	Total
Unincorporated Grays Harbor County	0	6	34	28	24	0	**92**
Aberdeen, City of	3	6	12	27	19	4	**71**
Cosmopolis, City of	0	2	2	1	3	0	**8**
Elma, City of	2	2	2	4	2	0	**12**
Hoquiam	1	6	5	10	9	3	**34**
McCleary	1	1	3	3	1	0	**9**
Montesano	0	9	7	5	4	2	**27**
Oakville	0	1	2	4	0	0	**7**
Ocean Shores	0	1	2	1	2	0	**6**
Westport	0	3	3	0	9	1	**16**
Total	**7**	**37**	**72**	**83**	**73**	**10**	**282**

Table 3-3
Grays Harbor Countywide Critical Infrastructure

Jurisdiction	Trans-portation	Water Supply	Wastewater	Power	Communications	Other*	Total
Unincorporated Grays Harbor County	252	29	15	18	28	3	**345**
Aberdeen, City of	13	10	36	10	15	3	**87**
Cosmopolis, City of	1	2	0	5	0	0	**8**
Elma, City of	11	3	1	2	1	0	**18**
Hoquiam	10	10	18	4	7	0	**49**
McCleary	5	1	1	1	1	0	**9**
Montesano	9	3	1	1	1	0	**15**
Oakville	0	0	0	0	0	0	**0**
Ocean Shores	11	5	1	1	4	0	**22**
Westport	4	1	1	1	4	0	**11**
Total	**316**	**64**	**74**	**43**	**61**	**6**	**564**

*Other critical facilities include gathering areas (parks), food banks, marinas, and ports

3.5 TRANSPORTATION

Roads

Major transportation in the area consists of State Routes 8, 105, 107 and 109, as well as U.S. Routes 12 and 101. US Highways 12 and 101, and State Routes 8 and 105, are the main thoroughfares connecting

Grays Harbor County to the east, south, and north. SR 8 crosses the Grays Harbor/ Thurston County line approximately 4 miles east McCleary, and terminates in Elma at its intersection with US 12. US Highway 12 enters the county southeast of Oakville and terminates at the US Highway 101 intersection in Aberdeen. US Highway 101 is miles in length and runs from Pacific County to Jefferson County. Other lesser State Routes include 105 (23.1 mi), 107 (8 mi), 109 (40.5 mi), and 115 (2.3 mi).

Marine Shipping

The Port of Grays Harbor operates four deep-water cargo terminals in Aberdeen and Hoquiam as well as the Westport Marina. The Port is currently working on several projects to address the impacts of growing rail traffic: PGH Marine Terminal Rail, Hoquiam River Rail Bridge, and Wishkah River Rail Bridge.[3] Sierra Pacific Industries is also a major marine shipping point within Grays Harbor Estuary.

Airports

There are four public airfields in Grays Harbor County. Bowerman Field in Hoquiam is the largest with a 5,000-foot runway serving around 19,600 operations in 2003. Other major airfields in the county include Elma, Ocean Shores, and Westport Municipal airports. Smaller airfields are located throughout the county.

Rail

The Puget Sound and Pacific Railroad is headquartered in Elma, Washington. The PSAP interchanges with the BNSF and UP Class I railroads. The PSAP runs through the rich forest lands of Washington State and serves major lumber customers with transportation services. Freight moves over 108 miles of track in Northwest Washington. Major commodities shipped include lumber, logs, and chemicals for the pulp and paper mills. The PSAP provides an integral service to national account lumber companies moving their products to the Class I roads for further movement throughout North America. Located on the PSAP is the Port of Grays Harbor that is the only deep-draft shipping port on Washington's coast, only 2 hours from open sea, and centrally located between the Seattle and Portland markets. Unburdened by daily traffic jams of urban areas, companies gain efficient and cost-effective highway access via the four-lane highway from Interstate 5 or rail service provided by Puget Sound & Pacific with connections to Burlington Northern Santa Fe and Union Pacific. A continuous rail loop throughout the marine terminal complex allows the free flow of cargo in and out of the facility. The rail loop is designed to handle and store unit-trains as well as smaller sets of rail cars (Grays Harbor HMP, 2011).

3.6 POPULATION

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.

Knowledge of the composition of the population, how it has or may change in the future is needed for informed planning decisions. 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.

As of April 1, 2017, Grays Harbor County had a population of 72,970 residents. Table 3-4 presents County population data as established by the Washington State Office of Financial Management (OFM).[3] Figure 3-7 illustrates population and the incorporated communities within Grays Harbor County illustrated by the Grays Harbor Council of Government.[4]

Table 3-4
2017 Population, Housing, Area, and Density Figures

			Density per square mile of land area***		
Geographic area	Population*	Housing units**	Land Area	Population	Pop Density Rank
Unincorporated Grays Harbor County	28,190	22,879	1,847	15.3	NA
Aberdeen	16,740	7,324	12.4	1,351.3	3
Cosmopolis	1,660	724	1.6	1,062.7	4
Elma	3,145	1,332	1.7	1,847.1	1
Hoquiam	8,560	3,872	13.3	645	7
McCleary	1,695	781	2.1	804.3	5
Montesano	4,120	1,732	10.9	379	9
Oakville	690	296	.05	1,376.8	2
Ocean Shores	6,055	5,227	9.3	651.1	6
Westport	2,115	1,591	3.6	586.2	8
Total	**72,970**	**36,120**	**1,902**		

*2017 Washington State Office of Financial Management Data

**2017 Grays Harbor Council of Governments http://www.ghcog.org/housing.html

*** April 1 2017 Land Area and Population Estimates – Grays Harbor Council of Governments http://www.ghcog.org/DemoTables/Population%20Tables/P9_Pop_LandArea_2017.pdf

[3] Office of Financial Management http://www.ofm.wa.gov/pop/april1/
[4] http://www.ghcog.org/mapfiles/GraysHarborCountyMap_2017PopEst.pdf

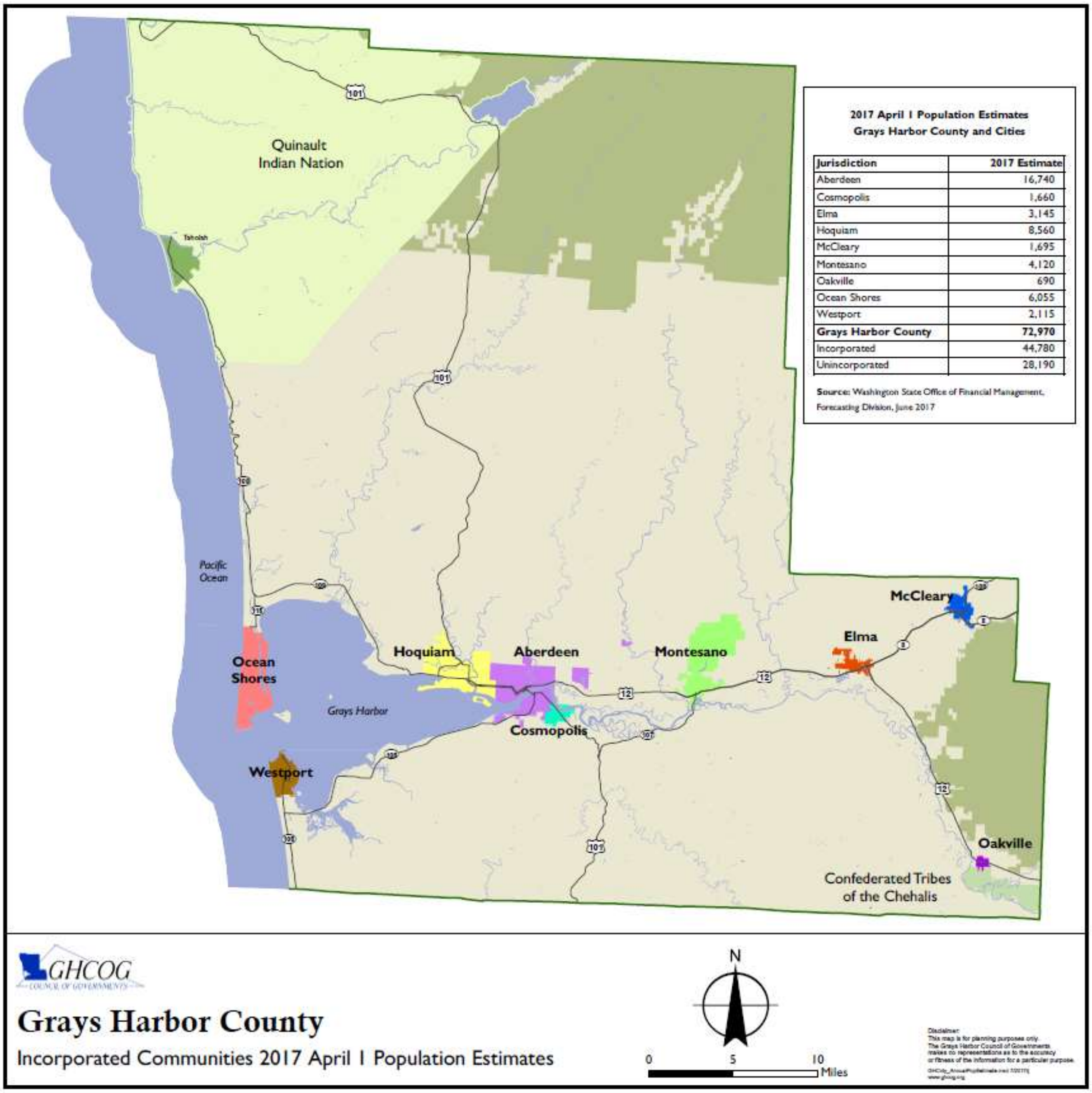


Figure 3-7 Grays Harbor Council of Governments 2017 Communities and Population Estimates

For all other demographic data, the U.S. Census Bureau data was utilized; however, it should be noted that U.S. Census data has a lower population rate (71,628 as of July 2016) as it does not adjust as frequently as OFM data. For planning purposes, however, the Census data provides greater variations of relevant data which has been utilized throughout this document. As such, numerical values may not coincide.

3.6.1 Population Trends

Population changes are useful socio-economic indicators. A growing population generally indicates a growing economy, while a decreasing population signifies economic decline. Population from the 2000

Census data for Grays Harbor County was 67,194. Each year until 2010 the county has shown an increase in population size. However, between 2010 to 2017, population trends for some jurisdictions in the county decreased, such as in Aberdeen and Hoquiam. Table 3-5 illustrates the population trends from 2010-2017.

Table 3-5
Countywide Population Changes by Jurisdiction 2010-2017

City or Town	Census 2010	Estimate 2011	Estimate 2012	Estimate 2013	Estimate 2014	Estimate 2015	Estimate 2016	Estimate 2017
Unincorporated Grays Harbor	28,438	28,555	28,610	28,615	28,635	28,475	28,110	28,190
Aberdeen	16,896	16,870	16,890	16,860	16,850	16,780	16,780	16,740
Cosmopolis	1,649	1,645	1,640	1,650	1,645	1,640	1,650	1,660
Elma	3,107	3,115	3,110	3,115	3,130	3,135	3,145	3,145
Hoquiam	8,726	8,650	8,655	8,620	8,625	8,575	8,580	8,560
McCleary	1,653	1,655	1,655	1,655	1,660	1,680	1,685	1,695
Montesano	3,976	4,010	4,050	4,070	4,075	4,095	4,105	4,120
Oakville	684	685	690	690	690	685	695	690
Ocean Shores	5,569	5,615	5,745	5,815	5,880	5,935	5,955	6,055
Westport	2,099	2,100	2,105	2,110	2,110	2,110	2,115	2,115
TOTAL	**72,797**	**72,900**	**73,150**	**73,200**	**73,300**	**73,110**	**72,820**	**72,970**
Source: http://www.ofm.wa.gov/pop/april1/poptrends.pdf								

The Office of Financial Management updates county and state long-range population forecasts every five years to support Growth Management Act planning (discussed in Section 18.1.2). The most recent forecasts, which project out to 2040, were issued in May 2012 and are shown in Table 3-6. OFM considers the medium projection the most likely (RCW 43.62.035) because it is based on assumptions that have been validated with past and current information. The high and low projections represent the range of uncertainty that should be considered when using these projections for planning.

During the 10-year time period of 2007-2017, population changed 3.06 percent from 70,800 to 72,970, which represents an increase of 2,170. Based on 2012 projections by OFM for 2015, when compared to current population, the county is below OFM projected levels. This is further confirmed in OFM's 2016 Annual Report, which indicates that Grays Harbor County is one of seven counties statewide having lost population over the course of the 2015-2016 time period, with the state, in general, increasing in population size by 1.73 percent, up from 1.34 percent in 2015 (OFM Annual Report, 2016) (see Figure 3-8 and Figure 3-9).

Table 3-6
County and State Population Projections

	Census	Projections					
	2010	2015	2020	2025	2030	2035	2040
Washington	6,724,540	7,022,200	7,411,977	7,793,173	8,154,193	8,483,628	8,790,981
Adams	18,728	20,257	21,640	22,964	24,289	25,690	27,205
Asotin	21,623	21,818	22,033	22,196	22,313	22,358	22,356
Benton	175,177	184,882	197,806	210,803	223,689	236,007	247,856
Chelan	72,453	75,180	78,586	81,885	84,778	87,168	89,246
Clallam	71,404	71,868	73,616	75,022	76,112	76,786	77,224
Clark	425,363	447,201	477,884	508,124	536,717	562,207	585,137
Columbia	4,078	4,047	4,013	3,968	3,895	3,800	3,700
Cowlitz	102,410	105,130	108,588	111,706	114,158	115,798	116,897
Douglas	38,431	40,603	43,619	46,662	49,583	52,256	54,762
Ferry	7,551	7,619	7,706	7,751	7,754	7,740	7,692
Franklin	78,163	87,755	100,926	115,142	130,284	146,103	162,900
Garfield	2,266	2,238	2,220	2,210	2,202	2,175	2,143
Grant	89,120	95,822	104,078	112,525	121,204	129,779	138,337
Grays Harbor	72,797	73,575	74,408	75,529	76,428	76,905	77,070
Island	78,506	80,337	82,735	85,073	87,621	90,239	93,205
Jefferson	29,872	30,469	32,017	33,678	35,657	37,914	40,093
King	1,931,249	2,012,782	2,108,814	2,196,202	2,277,160	2,350,576	2,418,850
Kitsap	251,133	262,032	275,546	289,265	301,642	311,737	320,475
Kittitas	40,915	42,592	45,255	47,949	50,567	53,032	55,436
Klickitat	20,318	20,606	20,943	21,225	21,430	21,492	21,439
Lewis	75,455	77,621	80,385	82,924	85,165	87,092	88,967
Lincoln	10,570	10,616	10,707	10,800	10,865	10,862	10,817
Mason	60,699	63,203	67,545	71,929	76,401	80,784	84,919
Okanogan	41,120	42,230	43,163	43,978	44,619	45,127	45,707
Pacific	20,920	20,860	20,990	21,261	21,495	21,736	22,042
Pend Oreille	13,001	13,289	13,692	13,977	14,129	14,149	14,116
Pierce	795,225	831,944	876,565	923,912	967,601	1,006,614	1,042,341
San Juan	15,769	15,907	16,256	16,606	16,939	17,216	17,443
Skagit	116,901	121,624	128,249	136,410	144,953	153,632	162,738
Skamania	11,066	11,282	11,548	12,014	12,447	12,816	13,082
Snohomish	713,335	750,358	805,015	857,939	908,807	955,281	997,634
Spokane	471,221	489,491	513,910	537,428	558,614	576,763	592,969
Stevens	43,531	44,262	45,212	46,447	47,834	49,340	50,929
Thurston	252,264	266,224	288,265	307,930	326,426	343,019	358,031
Wahkiakum	3,978	3,931	3,877	3,830	3,772	3,716	3,669
Walla Walla	58,781	60,015	61,685	63,368	64,978	66,378	67,655
Whatcom	201,140	210,050	225,307	241,138	256,643	271,142	284,901
Whitman	44,776	46,139	47,826	49,346	50,577	51,563	52,504
Yakima	243,231	256,341	269,347	282,057	294,445	306,636	318,494

Note: OFM Forecasting – May 2012 Differences in 2010 figures compared to other tables due to Census corrections. Data may not add due to rounding; unrounded figures are not meant to imply precision.

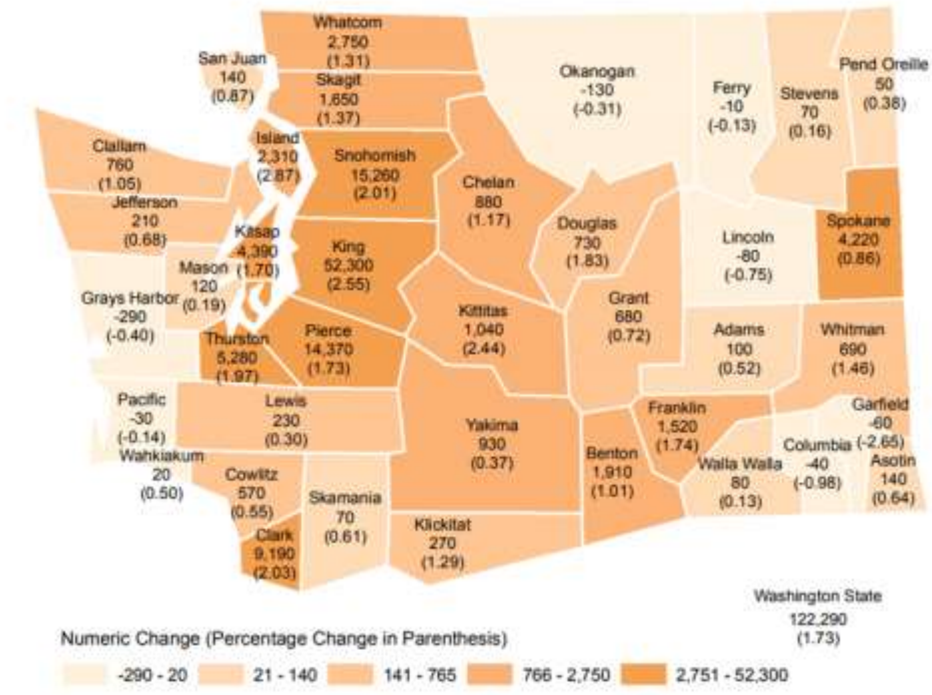


Figure 3-8 Statewide Distribution of 2015-2016 Population Change by County
Source: Office of Financial Management 2016 Population Trends

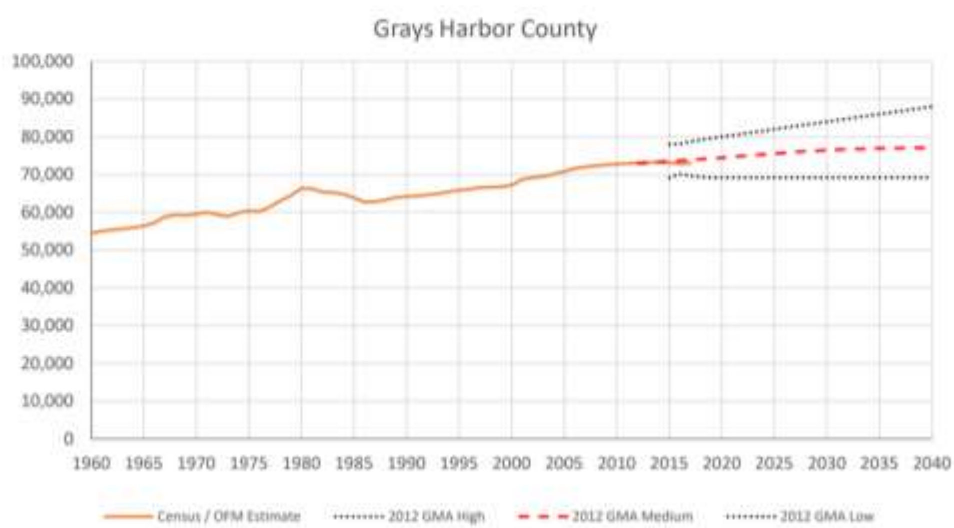
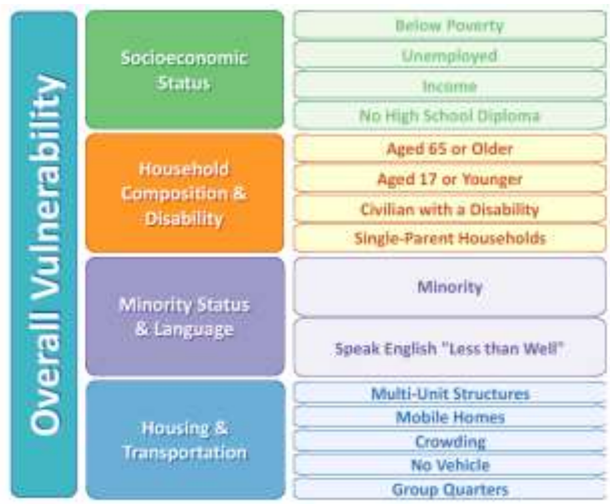


Figure 3-9 Grays Harbor County Population Trends and Projects - 1960-2040

3.6.2 Social Vulnerability

Some populations are at greater risk from hazard events because of decreased resources or physical abilities. Elderly people may be more likely to require additional assistance during a disaster incident, or might be less able to provide such care during a crisis, finding the magnitude of the task of providing that care beyond their capability. Research has shown that people living near or below the poverty line, the elderly, 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 help to extend focused public outreach and education to these most vulnerable citizens.



During emergencies, real-time evacuation information may not be provided to people with limited English proficiency, the hearing and visually impaired, and other special needs group. Many low-income people may be stranded because they have no personal transportation, and no mass transit (especially during emergencies) is available. For the poor, they are less likely to have the income, or assets needed to prepare for a possible disaster, or to recover after a disaster. Although the monetary value of their property may be less than that of other households, it likely represents a larger portion of the total household assets. As such, lost property is proportionately more expensive to replace, especially without insurance. Additionally, unemployed persons do not have employee benefits that provide health cost assistance. High-income populations who suffer higher household losses (absolute terms) find their overall position mitigated by insurance policies and other financial investments not available to lower income households.

3.6.3 Age Distribution

As a group, the elderly are more apt to lack the physical and economic resources necessary for response to hazard events and 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 require extra notice to implement evacuation.

Elderly residents 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.

Grays Harbor County is an older community compared to both the State of Washington and the United States. Median age is 43.9 years. As of 2016, an estimated ~20 percent of county residents were older than 65 (Fact Finder Census).[5] This is higher than the State average. This is also higher than Grays Harbor County's 2010 Census data, which documented 16.3 percent of the population 65 years and over.

Table 3-7
Population Age 65 Years and Over

	Census			Estimate	Percent of 2016
Area	1990	2000	2010	2016	Population
Washington	571,403	662,142	827,677	1,072,637	14.93
Grays Harbor	10,146	10,321	11,849	14,421	19.8

Source: Office of Financial Management (2016)[6]

Children under 5 are particularly vulnerable to disasters because of their dependence on others for basic necessities. Very young children are additionally 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. The U.S. Census QuickFacts identifies 5.5 percent of the County's population under the age of 5 years, which is 0.4 percent lower than 2010.

Figure 3-10 and Figure 3-11 illustrate density of age populations 5 and under, and 65 and over throughout Grays Harbor County.

[5] https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_16_1YR_S0101&prodType=table
[6] http://www.ghcog.org/DemoTables/Population%20Characteristics%20Tables/PC11_GHC_Pop65_over_2016.pdf

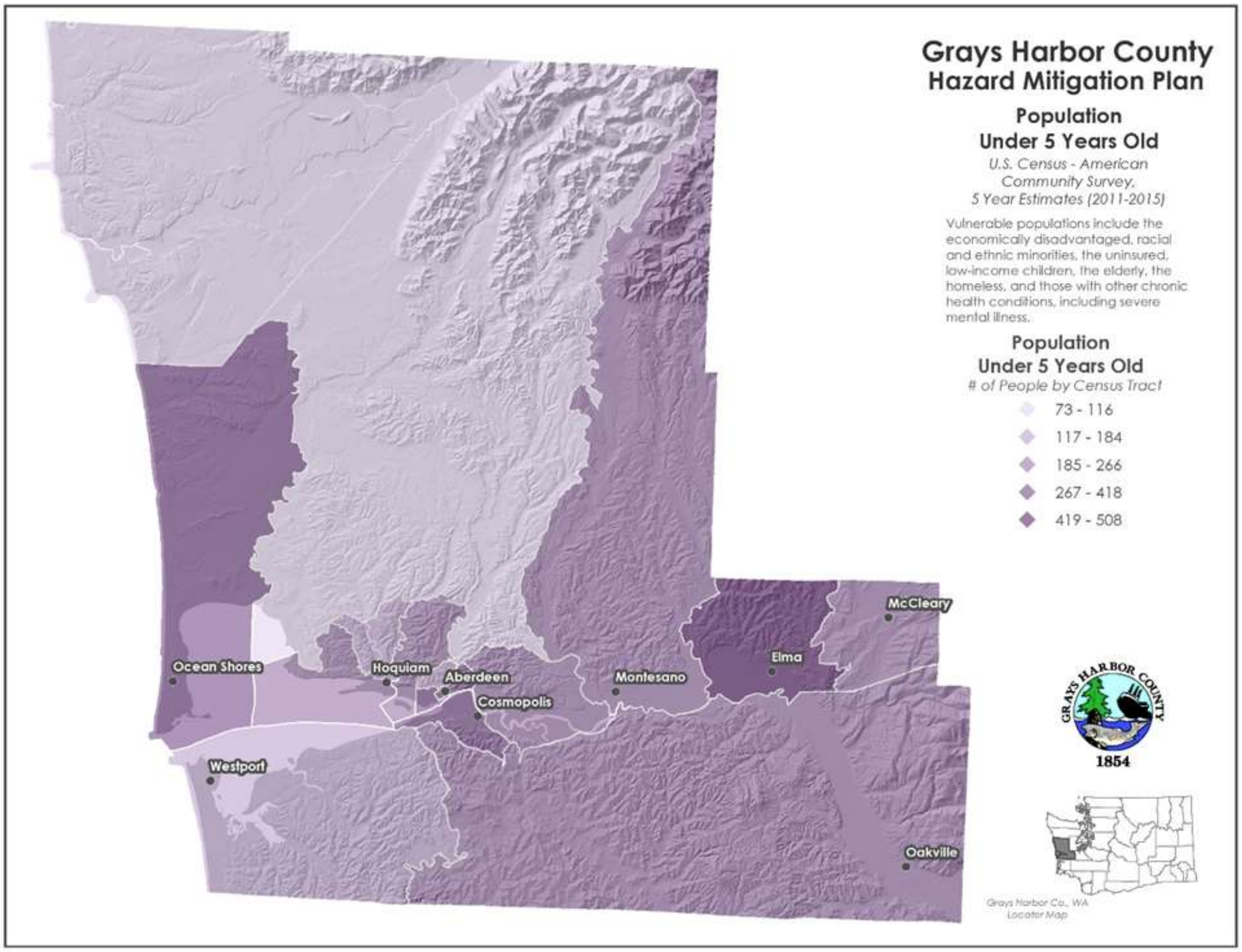


Figure 3-10 Distribution of Population Under 5 Years of Age

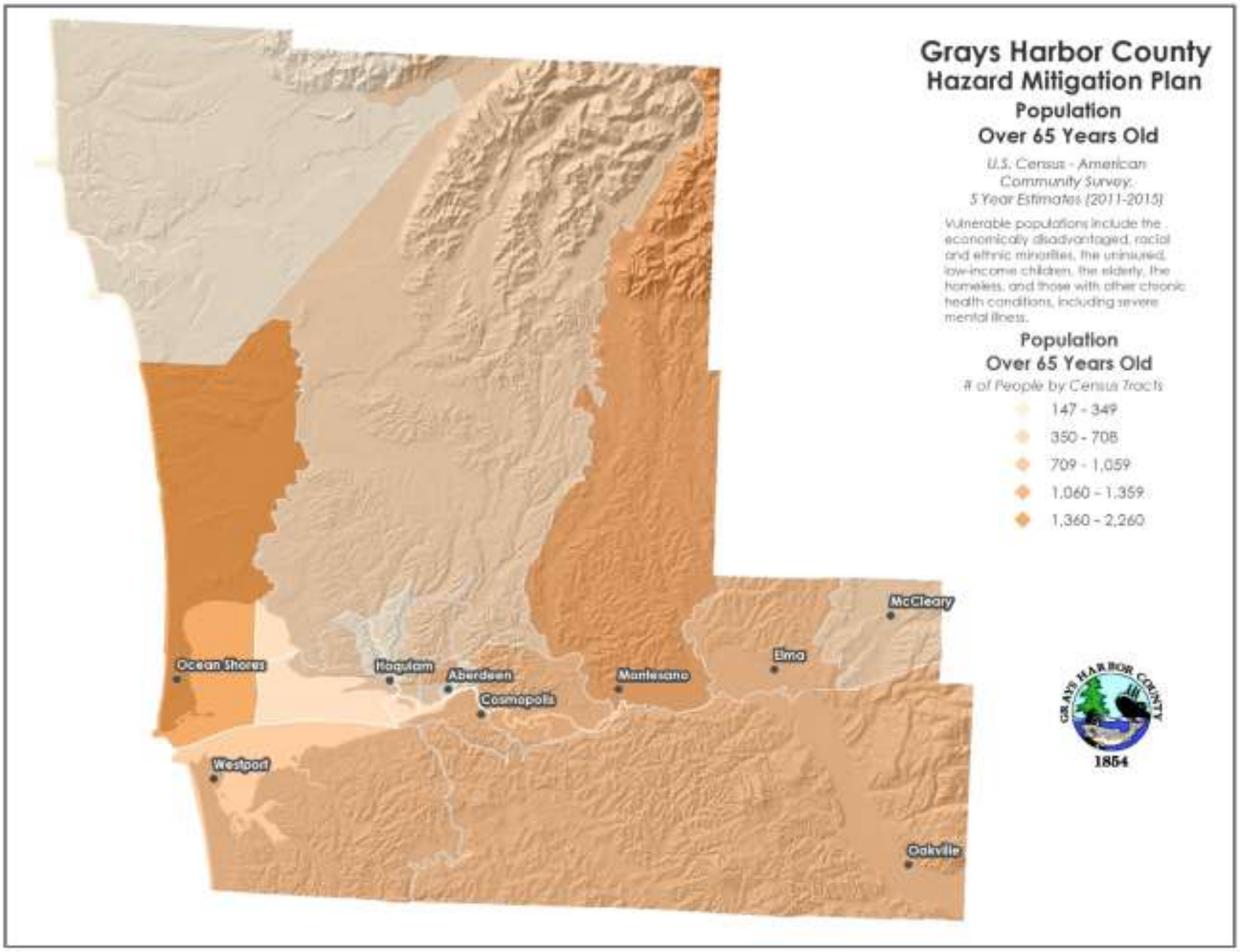


Figure 3-11 Distribution of Population Over 65 Years of Age

3.6.4 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 U.S. Census Bureau's QuickFacts, racial makeup of the county is: 87.4% white; 5.5% American Indian; 1.5% Asian; 1.4% black or African American; 0.3% Pacific Islander; and 3.9% from two or more races. Those of Hispanic or Latino origin made up 9.9% of the population. The County also had a Veteran population base during the time period of 2011-2015 of 7,451.[7]

[7] https://www.census.gov/quickfacts/fact/table/graysharborcountywashington/PST045216

Census data also indicates that 9.0 percent of the Grays Harbor population spoke a language other than English at home.

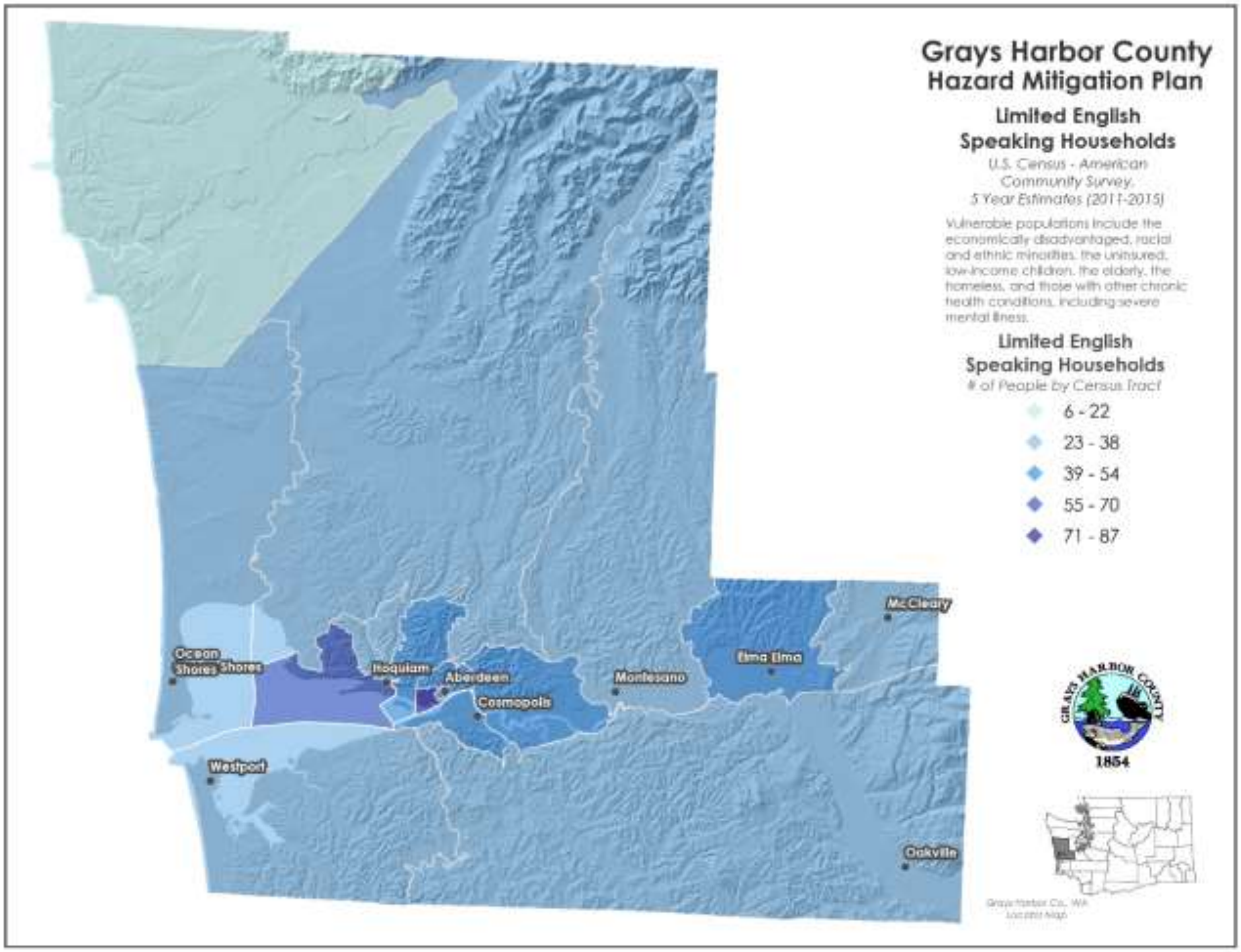


Figure 3-12 Limited English Speaking Households

3.6.5 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. Census data identifies 14.6 percent of Grays Harbor's population under age 65 living with a disability during the time period 2011-2015. This represents a higher rate than statewide, which is 8.9 percent for the same time period.

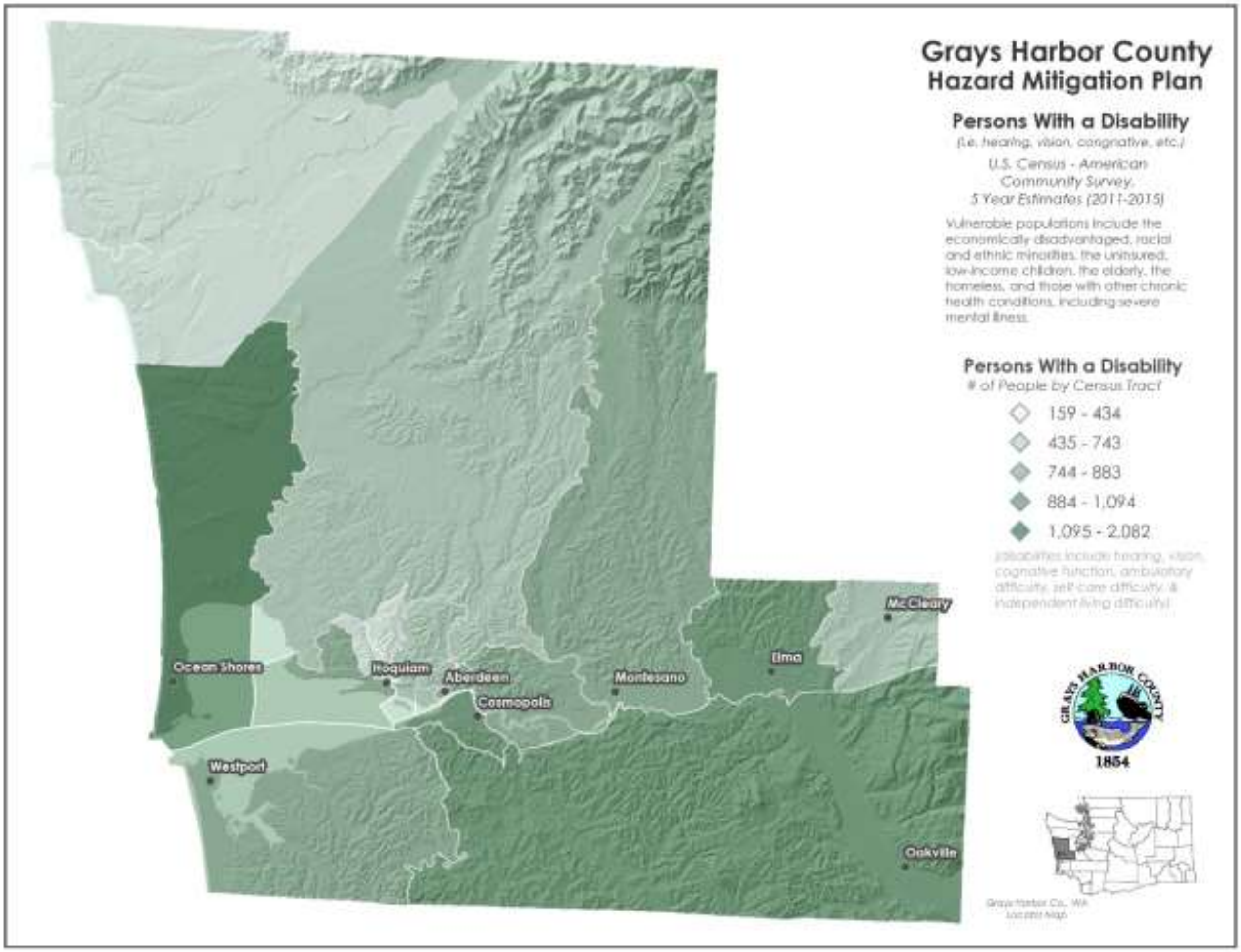


Figure 3-13 Persons with Disability

Table 3-8 further expands disability categories for Census purposes to identify individuals with hearing, vision, cognitive, ambulatory, physical, self-care, and independent living difficulties.

Table 3-8
2016 Population Totals with Disability

	Number of Individuals with Disability	Percent of Total Age Group with Disability
Total population with reported disability	11,705	17.1%
Under 18 years of age with a disability	500	4.6%
Between the ages of 18-64 with a disability	5,794	25.1%
65 years and over with a disability	5,456	82.6%

Source: American Fact Finder
https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_16_1YR_S1810&prodType=table

3.6.6 Homeless Population

In emergency planning, the needs of homeless people are usually categorized within the needs of all "special populations." People who are homeless have limited resources to evacuate, stockpile food, store medications, and shelter in place. In addition, people who are homeless have limited access to Internet and television, and are often the last to know about emergencies. Most do not own vehicles for evacuation purposes, and do not know safe locations to which to evacuate. For these reasons, communities often struggle in their approach to prepare homeless people for disasters. While informational leaflets, coupled with personal trainings, have been effective in helping homeless people prepare for disasters, most jurisdictions are unaware of the number of homeless in their community, and even where they are located.

According to the January 2017 Point in Time Count data captured by the Washington State Department of Commerce, Grays Harbor County has a total of 201.[8] Table 3-9 provides additional data from the Commerce Department.

Table 3-9
2017 Countywide Homeless Population Totals

County	Sheltered				Unsheltered				Total
	HH w/ adults & children	HH w/out children	HH w/ only children	Sheltered Total	HH w/ adults & children	HH w/out children	HH w/ only children	Unsheltered Total	
Grays Harbor	25	83	2	110	4	87	-	91	201
State Totals	5,518	6,626	107	12,251	543	7,834	214	8,591	21,112
HH = Households									

3.7 ECONOMY

Knowing the economic characteristics of a community can assist in the analysis of the community's ability to prepare, respond, and rebuild safer after a natural hazard. Categorizing economic vulnerability can encompass many factors, including median household income, poverty rates, employment and unemployment rates, housing tenure, and community building inventory.

Grays Harbor County has experienced intrinsic changes in its economy since the mid-1970s when national economic recessions and rising interest rates decimated the timber industry. Masking this trend for a short time was the upsurge in construction employment for the Washington Public Power Supply System plant at Satsop beginning in 1976. However, with the early 1980s came the termination of Satsop and another national recession, causing the civilian labor force to decline sharply. From 1981 to 1986, the labor force declined by 9,480 workers in county, dropping it to the same level 10 years earlier.

Intrinsic changes in the timber industry also began in the 1980s. One notable transformation was how the timber industry began to restructure and modernize its plants and operations, reducing its workforce needs. Another hit on the economy came in the late 1980s and early 1990s when endangered species listings and

[8] http://www.commerce.wa.gov/wp-content/uploads/2017/08/CSHD-HAU-2017-County-Summary-August-2017v2.pdf

timber-set asides cost more jobs by reducing raw log supplies, particularly on federal lands. The lumber and wood products manufacturing sector alone lost over 4,160 jobs from 1979 through the late 1990s.

Once again, in 2009, the economic downturn brought the county into shrinking payrolls and skyrocketing unemployment rates. The manufacturing sector that was helping provide materials for the residential building boom both in the state and nationally, became a victim to the housing crisis. With unemployment in 2009 averaging nearly double what it was in 2008, the local economy became more depressed with the recession. In late 2008, plant closures were the rule, as lumber mills and similar industries closed their doors, victim first of the national and then the state economy. With the closures came the loss of hundreds of high-wage jobs and their benefits. Over time, the economy in the area has rebound.

Within Grays Harbor County, regional job concentration for wood products manufacturing is 11.04 times the state job concentration. In other words, there are 1,004% more jobs within this sector in Grays Harbor County than the typical county in Washington (Grays Harbor Chamber of Commerce, 2017) Currently, there are 27 wood products companies in Grays Harbor County employing 850 workers generating an annual payroll of $38,108,000 per year (Census: 2014). In addition to wood products manufacturing, regional jobs for ship and boat building concentration is 6.99 times the state job concentration, meaning that there are 599% more jobs in ship and boat building in the region than the typical county in Washington (Chamber, 2017).

Currently, government is the County's second largest employer, with service-providing industries remaining the top industry in the County.[9] Principal economic activities in the county are: wood and paper products, seafood processing, food processing, and manufacturing. Ten of the top 15 industrial companies in the county are wood-product related; and sustained-yield forestry, reforestation, plywood, paper, pulp and food processing remain the county's industrial base.

Tourism is also of significance countywide, with tourism resulting in more than $260 million of revenue and over 5,000 jobs for Grays Harbor County.[10] On average, the county receives in excess of 4 million visitors per year.[11] Daily average figures fluctuate based on season, but does significantly impact response capabilities of first responders.

3.7.1 Income and Employment

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

[9] Washington State Employment Security Labor Market and Performance Analysis https://fortress.wa.gov/esd/employmentdata/reports-publications/regional-reports/labor-area-summaries
[10] http://www.prweb.com/releases/2017/09/prweb14741311.htm Accessed 15 Dec 2017.
[11] Personal communication with Grays Harbor Tourism and Planning Team Members.

Median income for a household in the county is based on OFM data, and presented in Table 3-10 (2015 dollars). Per capita income for the county is identified in Table 3-11. Based on Census data, approximately 12.7 percent of the population were below the poverty line; state level was approximately 13 percent of population base.[12] The poverty rate for the county was lower than the national rate (15.5 percent in 2015), and 0.6 percent lower than the state rate (13.3 percent in 2015).

Table 3-10
Median Household Income Levels 2005-2015

Median Family Income	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
U.S.	$66,284	$67,672	$69,004	$69,361	$66,904	$65,307	$64,631	$64,537	$65,221	$66,141	$68,260
State	$71,323	$73,660	$75,173	$77,168	$74,876	$72,547	$72,175	$72,185	$72,698	$74,453	$76,954
Grays Harbor	$55,072	$48,283	$53,252	$59,500	$51,166	$55,006	$52,624	$54,731	$58,785	$50,052	$60,245

Table 3-11
Per Capita Income Levels 2005-2015

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
US	$35,904	$38,144	$39,821	$41,082	$39,376	$40,277	$42,453	$44,267	$44,462	$46,414	$48,112
State	$37,759	$40,357	$43,192	$44,794	$41,844	$42,195	$44,197	$47,324	$47,778	$50,357	$51,898
Grays Harbor	$26,559	$27,529	$28,698	$30,374	$29,794	$30,265	$31,235	$32,496	$32,756	$34,832	$35,625
Rank among Washington Counties	25	27	31	34	35	37	37	35	35	33	35

Economic sustainability is encouraged through employment and job security. The higher the employment rate, the more financial stability is accomplished on an individual level. In addition, a healthy job market brings economic growth to communities. In August 2017, the employment rate in Grays Harbor County was 6.2 percent, higher than most other counties in the state (see Figure 3-14, Table 3-12, and Figure 3-15).

[12] Census Quick Facts https://www.census.gov/quickfacts/fact/table/US/IPE120216#viewtop

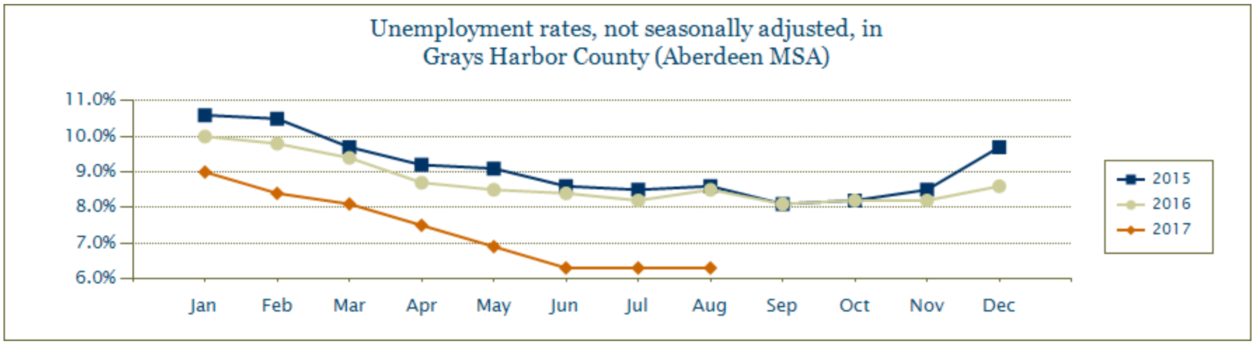


Figure 3-14 Grays Harbor County Unemployment Statistics 2015-2017

Table 3-12
Grays Harbor County Unemployment Rates 2015-2016

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015	10.6%	10.5%	9.7%	9.2%	9.1%	8.6%	8.5%	8.6%	8.1%	8.2%	8.5%	9.7%
2016	10.0%	9.8%	9.4%	8.7%	8.5%	8.4%	8.2%	8.5%	8.1%	8.2%	8.2%	8.6%
2017	9.0%	8.4%	8.1%	7.5%	6.9%	6.3%	6.3%	6.3%				

Source: https://fortress.wa.gov/esd/employmentdata/reports-publications/regional-reports/labor-area-summaries

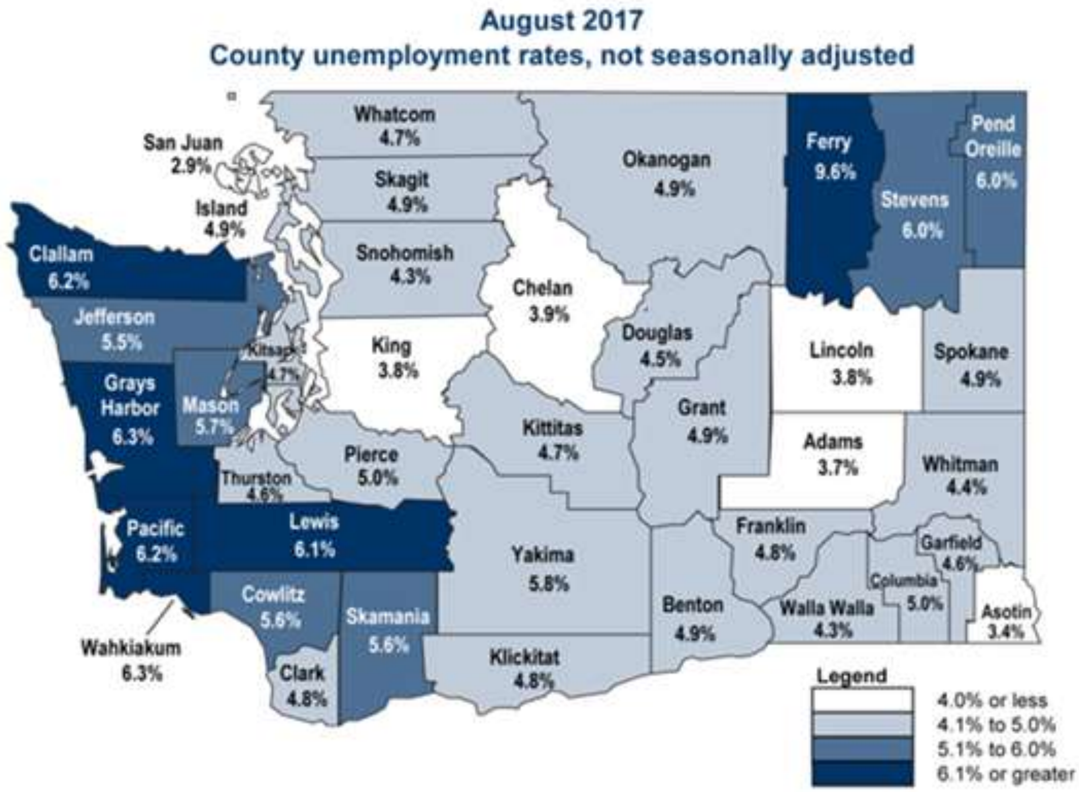


Figure 3-15 Statewide Unemployment Rates August 2017

3.8 LAND USE PLANNING AND FUTURE DEVELOPMENT TRENDS

According to the Washington State Department of Revenue, as of 2014 (most current data available) Grays Harbor County had 619,107 acres of Designated Forest Land. This ranks the County third in the state with respect to acres with such designation, with Lewis and Stevens Counties ranking first and second, respectively (Washington DOR, 2016).[13] Population density in the area is 38.36 people per square mile.

The County Comprehensive Plan includes components that help to guide the vision for the County: Planning Policies, Future Land Use Analysis, Critical Areas, and Capital Facilities. Within Washington State, the State Growth Management Act (GMA) requires state and local governments to manage Washington's growth by identifying and protecting critical areas and natural resource lands, designating urban growth areas, preparing comprehensive plans and implementing them through capital investments and development regulations.

Washington's Growth Management Act (GMA) requires that jurisdictions select a population projection to use for planning projections. Section 3.5 details the population projects for Grays Harbor County. The Office of Financial Management considers the medium projection the most likely (RCW 43.62.035) because it is based on assumptions that have been validated with past and current information. The high and low projections represent the range of uncertainty that are considered when using these projections for

[13] Washington State Department of Revenue. https://dor.wa.gov/about-us/statistics-reports/property-tax-current-use-designated-forest-land

planning purposes. Counties must select a population projection that falls within these ranges to determine their GMA planning projection. Grays Harbor County does not fully participate under the GMA (OFM 2016 Annual Report).

Critical areas are environmentally sensitive natural resources that have been designated for protection and management in accordance with the requirements of the GMA. Protection and management of these areas is important to the preservation of ecological functions of our natural environment, as well as the protection of the public health, safety and welfare of our community. The County recently updated its Critical Area Protection Ordinance in September 2017. Information from this mitigation plan will help identify the critical areas throughout the county and its incorporated jurisdictions in future updates as appropriate.

The County has adopted a comprehensive plan that governs its land use decision- and policy-making process in accordance with GMA guidelines. 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 Grays Harbor County.

The County's Planning Department is responsible for updating the Comprehensive Land Use Plan and for overseeing and regulating land use and development in unincorporated Grays Harbor County to protect the health, safety, and welfare of County residents. The department is also responsible for floodplain management in the County, having previously developed a Comprehensive Flood Management Plan in 2001. The Planning Department works with other government departments (including emergency management); various agencies and municipalities (including special purpose districts); the general public; land-owners; special interest groups; and businesses to oversee development in unincorporated Grays Harbor County, ensuring land use remains consistent with federal, state and county regulations.

Utilzing estimated population growth statistics, the county has estimated how the future growth in population will be distributed among the different districts created in the Comprehensive Plan. Table 3-13 identifies current land use classifications, acres in such classification, and the percent of total land area within the County. Figure 3-16 and Figure 3-17 are illustrations of the County's land use distribution. Figure 3-18 illustrates zoning throughout the county.

Table 3-13
Present Land Use in Planning Area

Present Use Classification	Area (acres)	% of total
Commercial	2,527	0.22
Services		0.18
Governmental	491.39	
All Other Services	1,743.61	
Parks		
Resources		53.24
Agriculture	18,614	
Fishing	47.66	
Forest	624,264	
Mining	94.33	
Gravel Pits	105.11	
Not presently assigned	82.05	
Residential	40,099	3.32

Table 3-13
Present Land Use in Planning Area

Present Use Classification	Area (acres)	% of total
Recreational*	3,558	0.29
Trade	538	0.04
Transportation	2,611	0.22
Uncategorized	246,503	20.40
Undeveloped		22.09
Land	262,888	
Water Areas	198.68	
Open Space	3,787.04	
Total	**1,208,152**	**100.00**

*Recreational includes Parks, Campgrounds/resorts, and other Recreational sites

Figure 3-16 Grays Harbor County Land Use Map (2017)

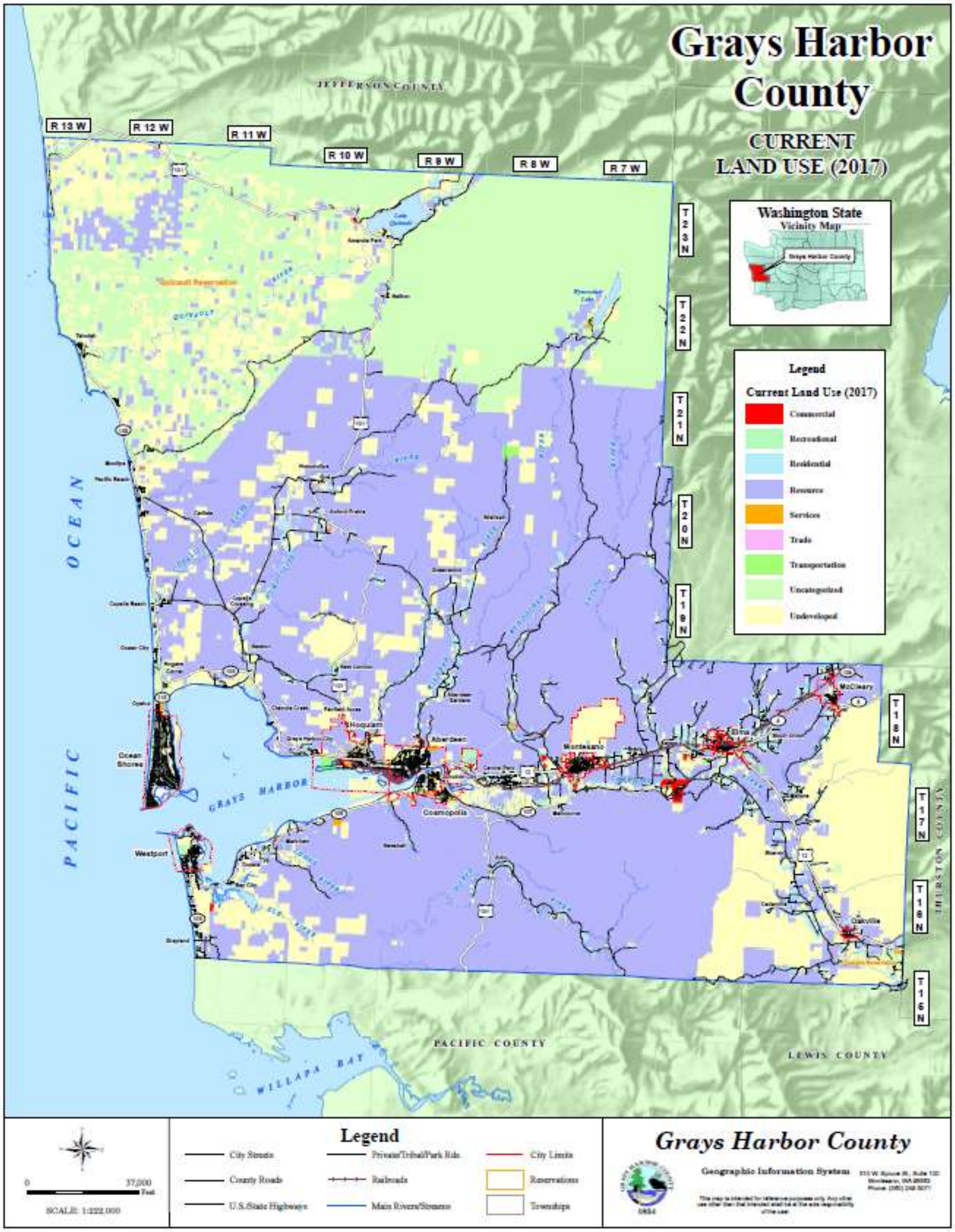


Figure 3-17 2017 Land Use Designation

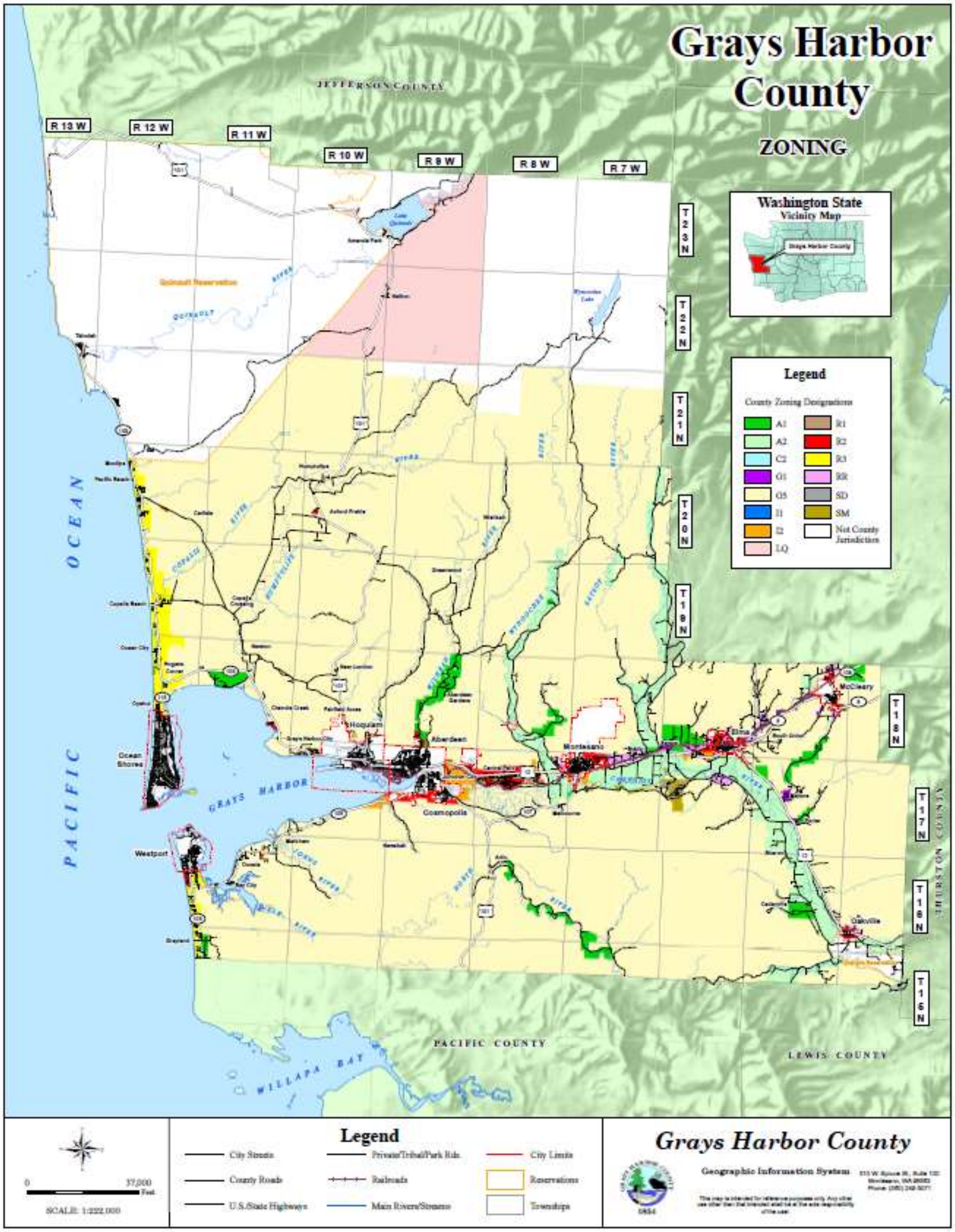


Figure 3-18 Grays Harbor County Zoning Map (2017)

Research in the area of growth management has demonstrated that communities experiencing economic growth who are able to invest in new development, including mitigation efforts, increase the resilience of both existing and new buildings and infrastructure. Newly constructed buildings and infrastructure are more resilient to hazards of concern and the associated impact by those hazards (e.g., ground shaking) as they are built to higher building code standards. The use of data within plans such as these play a significant role in education with respect to identifying those areas of concern addressed within Growth Management. According to U.S. Census QuickFacts, a total of 207 building permits were issued within the County in 2016.

All municipal planning partners will seek to incorporate by reference the Grays Harbor County Multi-Jurisdiction Hazard Mitigation Plan in their comprehensive plans. This will assure that all future development can be established with the benefits of the information on risk and vulnerability to natural hazards identified in this plan. On next update of its Comprehensive Land Use Plan, this hazard mitigation plan will provide information that will be utilized to support that effort.

Each planning partner's specific annex to this plan (see Volume 2) includes an assessment of 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. In addition, Chapter 18 of this plan provides a general overview of the municipalities' regulatory authority.

3.8.1 Housing Stock

According to *A Social Vulnerability Index for Disaster Management* (Journal of Homeland Security and Emergency Management, 2011), housing quality is an important factor in assessing disaster vulnerability. It is closely tied to personal wealth: people in lower income brackets often live in more poorly constructed homes that are especially vulnerable to strong storms or earthquakes. Mobile homes are not designed to withstand severe weather or flooding, and typically do not have basements. They are frequently found outside of metropolitan areas and, therefore, may not be readily accessible by interstate highways or public transportation. Also, because mobile homes are often clustered in communities, their overall vulnerability is increased.

Office of Financial Management's Forecasting Division provides data on Housing Units by Structure Type for Grays Harbor County and its cities. Table 3-14 identifies structure types by jurisdiction.

Table 3-14
Grays Harbor County Housing Units By Structure Type

Jurisdiction	Total	One Unit	Two or More Units	Mobile Home/Special
Unincorporated County	13,241	9,136	297	3,808
Aberdeen	7,324	4,893	2,073	358
Cosmopolis	724	615	42	67
Elma	1,332	876	316	140
Hoquiam	3,872	2,842	882	148
McCleary	781	663	98	22
Montesano	1,732	1,307	339	86
Oakville	296	216	0	80
Ocean Shores	5,227	4,195	436	596
Westport	1,591	1,038	386	167
TOTAL	**36,120**	**25,781**	**4,867**	**5,427**

Source: Office of Financial Management Forecasting Division, June 2017. Data compiled by Grays Harbor Council of Governments. Data accessible at: http://www.ghcog.org/DemoTables/Housing%20Tables/H1_2017HU_April1OFM.pdf

3.8.2 Building Stock Age

The age of a building in determining vulnerability is a significant factor, as it helps identify the building code to which a structure was built. Homes built prior to 1975 are considered pre-code since there was no statewide requirement to include specific standards to address the various hazards of concern (e.g., there were no seismic provisions contained within the building code). Structures built after 1975 are considered of moderate code. It was at that point in time in which all Washington jurisdictions were required to adhere to the provision of the most recently adopted version of the Uniform Building Code (UBC) (Noson et al., 1988).

Data from 2010 (most recent Census data addressing housing) Grays Harbor County reported that a high percentage of its buildings had been built before 1959 (see Figure 3-19).[14] The median year that a house in Grays Harbor County was built is 1972, which is older than the median year for a house built in the state of Washington, which is 1980. This is also older than the median year for a house built in the USA which is 1976.

[14] http://www.usa.com/grays-harbor-county-wa-housing.htm

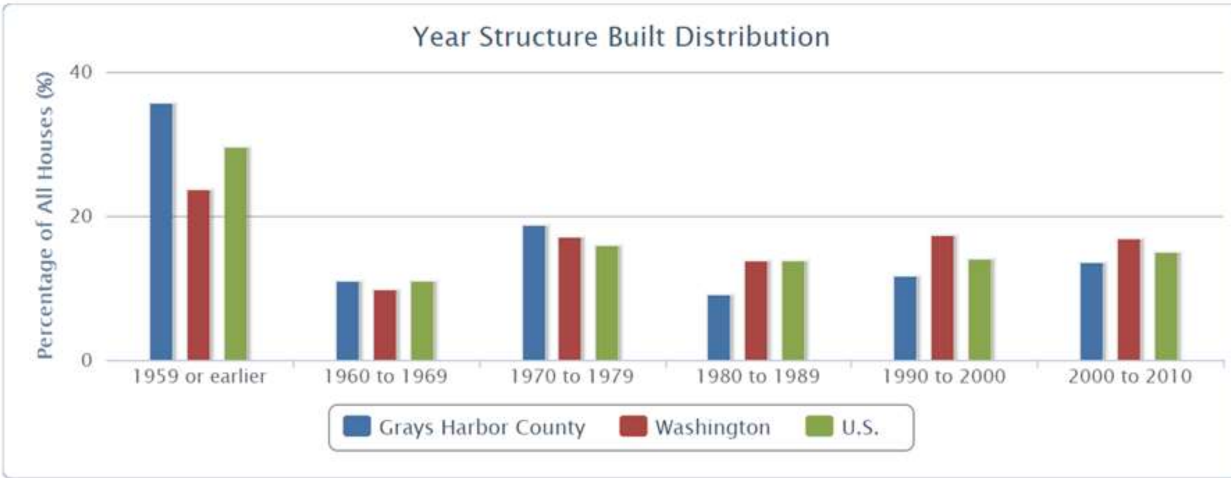


Figure 3-19 Grays Harbor County Year Structures Built

During FEMA's Risk Map project, an analysis was also completed to identify how many buildings were built to a specific building code. As FEMA utilized its Hazus program to conduct much of its risk assessment, Hazus criteria was also utilized. Hazus identifies key changes in earthquake building codes based on year. Homes built prior to 1941 are considered pre-code; they were constructed before earthquake building codes were put in place. Homes constructed after 1941 are considered moderate code and may include some earthquake building components (see Table 3-15).

Table 3-15
Grays Harbor County Housing Units Pre- and Moderate-Code

Community	Number of Pre-Code	Number of Moderate Code	Total
Unincorporated County	1,848	11,053	12,901
Aberdeen	3,507	2,824	6,331
Cosmopolis	244	496	740
Elma	368	860	1,228
Hoquiam	2,257	1,200	3,457
McCleary	222	450	672
Montesano	531	1,023	1,554
Oakville	113	218	331
Ocean Shores	3	4,597	4,600
Westport	149	1,142	1,291
Total	9,242	23,863	33,105

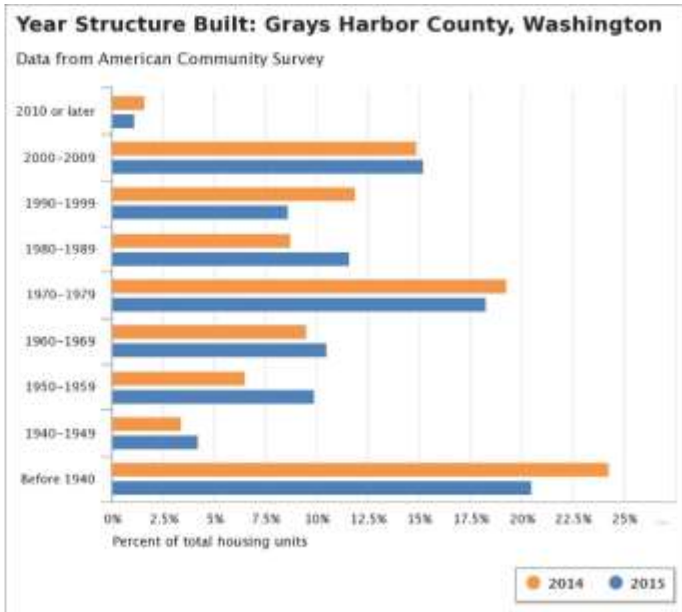


Figure 3-20 Year Structure Built

Figure 3-20 illustrates American Census Survey data, which very closely mirrors FEMA's data. It should be noted, however, that the data may be slightly skewed due to the fact that actual building code adoption dates may vary slightly by jurisdiction. Also, the FEMA data provided is captured from the Assessor's data. Structures may have undergone remodel, or improvements which changed the building code classification, increasing the level of code applied. That data may not have been captured or applied in a manner which would reflect a change in the year of construction. Additionally, while building codes may not have been in place, houses may have been constructed to higher standards. Therefore, this data should be used for planning purposes only. Questions concerning actual structural integrity should be determined by appropriate subject matter experts in the field. FEMA's pre- and moderate-code building data was utilized for the risk assessment analysis associated with this plan update.

CHAPTER 4.
RISK ASSESSMENT METHODOLOGY

4.1 OVERVIEW

The DMA requires measuring potential losses to critical facilities and property resulting from natural hazards. A hazard is an act or phenomenon that has the potential to produce harm or other undesirable consequences to a person or thing. Natural hazards can exist with or without the presence of people and land development. However, hazards can be exacerbated by societal behavior and practice, such as building in a floodplain, along a sea cliff, or on an earthquake fault. Natural disasters are inevitable, but the impacts of natural hazards can, at a minimum, be mitigated or, in some instances, prevented entirely.

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

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

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

> The first phase, hazard identification, involves the identification of the geographic extent of a hazard, its intensity, and its probability of occurrence (discussed below). This level of assessment typically involves producing a map. The outputs from this phase can be used for land use planning, management, and development of regulatory authority; public awareness and education; identifying areas which require further study; and identifying properties or structures appropriate for mitigation efforts, such as acquisition or relocation.
>
> The second phase, the vulnerability assessment, combines the information from the hazard identification with an inventory of the existing (or planned) property and population exposed to the hazard. It then attempts to predict how different types of property and population groups will be impacted or affected by the hazard of concern. This step assists in justifying changes to building codes or regulatory authority, property acquisition programs, such as those available through various granting opportunities; developing or modifying policies concerning critical or essential facilities, and public awareness and education.
>
> The third phase, the risk analysis, involves estimating the damage, injuries, and costs likely to be incurred in the geographic area of concern over a period of time. Risk has two measurable components:
>
> 1. The magnitude of the harm that may result, defined through the vulnerability assessment; and
> 2. The likelihood or probability of harm occurring.

Utilizing those three phases of assessment, information was developed which identifies the hazards that affect the planning area, the likely location of natural hazard impact, the severity of the impact, previous occurrences, and the probability of future hazard events. That data, once complete, is utilized to complete the Risk Ranking process described in Chapter 14, which applies all of the data capture to the Calculated Priority Risk Index (CPRI). Each planning partner completes this process for their own community, as well as conducting the analysis on a countywide level.

The following is provided as the foundation for the standardized risk terminology:

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

4.2 METHODOLOGY

The risk assessment for this hazard mitigation plan evaluates the risk of natural hazards prevalent in Grays Harbor County and meets requirements of the DMA (44 CFR Section 201.6(c)(2)). The methodology used to complete the risk assessment is described below.

4.2.1 Hazard Identification and Profiles

For this plan, the planning partners and stakeholders considered the full range of natural hazards that could impact the planning area 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.

The Planning Team reviewed the hazards considered during the 2011 plan. Based on the review, the Planning Team, at its kick-off meeting, identified the following natural hazards that this plan addresses as the hazards of concern (2018 changes to the hazards of concern are indicated in italics):

- Climate Change (*New* with qualitative assessment)
- Earthquake (*Expanded* to include the Cascadia scenario)

- Flood (*Expanded* to include FEMA's new 2017 *coastal flood analysis* and identification of dams)
- Hazardous Materials (Exposure analysis to hazards of concern where applicable utilizing WDOE's FY2017 reports)
- Landslide (*Expanded* to include updated DNR data and updated erosion data)
- Severe Weather (*Expanded* to include additional related hazard types)
- Tsunami
- Volcano
- Wildfire (*Expanded* with a different type of risk assessment)

The hazard profiles describe the risks associated with identified hazards of concern. Each chapter describes the hazard, the planning area's vulnerabilities, and, when possible, probable event scenarios. For those municipal planning partners with defined geographic boundaries, this data is identified within the associated tables in the base plan in which the risk at the county level is also identified. The following steps were used to define the risk of each hazard:

Identify and profile the following information for each hazard:

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

4.2.2 Risk Assessment Process and Tools

The hazard profiles and risk assessments contained in the hazard chapters describe the risks associated with each identified hazard of concern. Each chapter describes the hazard, the planning area's vulnerabilities, and probable event scenarios.

Once the profiles identified above were completed, the following steps were used by each planning partner to define the risk of each hazard:

- Determine exposure to each hazard—Exposure was determined by overlaying hazard maps with an inventory of structures, facilities, and systems to determine which of them would be exposed to each hazard.
- Assess the vulnerability of exposed facilities—Vulnerability of exposed structures and infrastructure was determined by interpreting the probability of occurrence of each event and assessing structures, facilities, and systems that are exposed to each hazard. Tools such as GIS and Hazus (discussed below) were used in this assessment.
- Where specific quantitative assessments could not be completed, vulnerability was measured in general, qualitative term, summarizing the potential impact based on past occurrences,

spatial extent, and subjective damage and casualty potential. Those items were categorized utilizing the criteria established in the CPRI index.

- The final step in the process was to determine the cumulative results of vulnerability based on the risk assessment and Calculated Priority Risk Index (discussed below) scoring, assigning a final qualitative assessment based on the following classifications:
  - Extremely Low—The occurrence and potential cost of damage to life and property is very minimal to nonexistent.
  - Low—Minimal potential impact. The occurrence and potential cost of damage to life and property is minimal.
  - Medium—Moderate potential impact. This ranking carries a moderate threat level to the general population and/or built environment. Here the potential damage is more isolated and less costly than a more widespread disaster.
  - High—Widespread potential impact. This ranking carries a high threat to the general population and/or built environment. The potential for damage is widespread. Hazards in this category may have occurred in the past.
  - Extremely High—Very widespread with catastrophic impact.

4.2.3 Risk Map Project

In February 2017, FEMA's RiskMap Program finalized Grays Harbor County's new NFIP Flood Maps, as well as completing additional analysis on earthquake and landslide. The process utilized by FEMA is the same process normally followed for risk analysis for hazard mitigation plans; therefore, the County elected to utilize information developed during that process to support applicable hazards of concern in this plan update. As information was utilized throughout the plan, it is noted as such. Specific processes followed should be gained from review of FEMA Region X's 2015 Risk Report for Grays Harbor County, available from Grays Harbor County Department of Emergency Management, or FEMA Region X. In addition to the 2015 study for the updated NFIP maps, FEMA also completed a study on the Chehalis Watershed. That data has also been utilized and identified in this planning effort; however, because the maps have not yet been adopted by the County and the project will not be completed until 2019, the information has been broken out separately, and is subject to change. Therefore, viewers should seek out the final map products from FEMA's or the County's website to determine the final NFIP map products and risk assessment, as the data may change.

4.2.4 Hazus and GIS Applications

Earthquake and Flood Modeling Overview

In 1997, FEMA developed the standardized Hazards U.S., or Hazus, model to estimate losses caused by earthquakes and identify areas that face the highest risk and potential for loss. Hazus was later expanded into a multi-hazard methodology, Hazus-MH, with new models for estimating potential losses from hurricanes and floods. The most recent model, Hazus 4.0, now allows for Tsunami modeling. At the time of this update, FEMA was in the process of developing a tsunami scenario and conducting Hazus 4.0 analysis for Grays Harbor County. As such, the resulting data was utilized in this update process when presenting impact data for the Tsunami hazard. As this planning process also utilized to a great extent the risk assessment from the Risk Map report completed by FEMA, Hazus 3.0 was utilized for all other Hazus analysis to ensure consistency in data and analysis.

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.

Levels of Detail for Evaluation

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

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

Building Inventory

During FEMA's Risk Map process, a User Defined Facilities (UDFs) approach was used to model exposure and vulnerability. Countywide GIS building data utilizing detailed structure information for facilities was loaded into the GIS and Hazus model. Building information was developed using best available Assessor's data, including building address points, aerial imagery, and staff resources. Building and content replacement values were estimated using values from the Assessor's data base, data from within the previous hazard mitigation plan, insurance policy data, and national replacement cost estimating guides as appropriate. Emphasis was put on developing the most accurate representation of buildings using best available resources. Building inventory included in excess of 33,727 structures, inclusive of general building stock and critical infrastructure.

In addition to the building inventory, the planning process also included identification of the critical facilities within each jurisdiction. On completion of the analysis, each planning partner was provided the critical facilities list, on which impact from each hazard is identified for each critical facility. That data was then utilized by each planning partner to determine dollar impact (e.g., magnitude and severity within the Calculated Priority Risk Index discussed below). The critical facilities list as a whole is considered privileged in nature from public disclosure; however, each planning partner was left to make the determination as to how they wished to identify specific structures based on their policies in place. In addition, specific critical facility structure impact data is further identified within the various Critical Facilities tables contained in each hazard profile, identified by critical facility type, e.g., power, water, wastewater, etc.

Building impact was further identified in a Loss Matrix, which provides the breakdown to each of the jurisdictional planning partners for use in completing their risk assessment. That Loss Matrix further identifies the number of structures impacted and the population impacted (where possible) based on the specific hazard of concern. The Loss Matrix is also identified within the various public outreach documents and posters developed for the public outreach efforts. That document supports the various tables completed throughout the plan.

Hazus Application for this Plan

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

- **Flood**—A Hazus Level 2 analysis was performed. Analysis was based on current FEMA regulatory 100- and 500-year flood hazard data based on the 2017 Flood Study.
- **Earthquake**—A Hazus Level 2 Hazus analysis was performed to assess earthquake risk and exposure. Earthquake shake maps and probabilistic data prepared by the U.S. Geological Survey (USGS) were used for the analysis of this hazard. A modified version of the National Earthquake Hazard Reduction Program (NEHRP) soils inventory was used. The one scenario-based shake map event utilized was the Cascadia Subduction Zone event.

  In addition, FEMA's Risk Report also identifies the Earthquake Design Code. Based on that, the following codes were used in the UDF database and Hazus earthquake analysis. Pre-code is any building built prior to 1941. Moderate code is any building built post-1941. These values are the Hazus defaults. The dates differ for the building code analysis since additional research was done to understand the building codes in Washington. An additional Hazus analysis will have to be completed to incorporate updated pre-code for structures prior to 1975 and moderate code for structures after 1975, which will result in higher damages for those buildings that are between 1941 and 1975.

GIS Application for this Plan

Dam, Hazardous Materials, Landslide, Severe Weather, Volcano, and Wildfire - For these hazards, historical data is not adequate to model future losses as no specific damage functions have been developed. However, GIS is able to map hazard areas and calculate exposure if geographic information is available with respect to the location of the hazard and inventory data. Areas and inventory susceptible to some of the hazards of concern were mapped and exposure was evaluated. For other hazards, a qualitative analysis was conducted using the best available data and professional judgment. Locally relevant information was gathered from a variety of sources. Frequency and severity indicators include past events and the expert opinions of geologists, staff, emergency management personnel, and others. The primary data source was Grays Harbor County GIS data, augmented with state and federal data sets, including FEMA's RiskMap data. Additional data sources for specific hazards are identified within the various profiles. In general analysis was completed as follows:

- **Climate Change** – Existing information was utilized to present future impact of climate change on the planning area. No specific analysis was conducted; however, existing data which illustrates potential impact was incorporated to the greatest extent possible in a qualitative manner. In addition, FEMA RiskMap data also developed potential sea level rise data, which was also included.

- **Dam Failure**—Inundation data was unavailable for all of the high- or medium-hazard dams in the County. Therefore, available dam data was used to identify the location and hazard classification of dams located within the planning area, and where dam safety plans were available, specific numbers of impact were included based on existing data.
- **Hazardous Materials** – Hazardous materials data was utilized, captured from the Department of Ecology's FY2017 Tier II reporting data, which requires updates by March of each year within the State of Washington. No plume modeling was conducted; rather, proximity was demonstrated for high-hazard sites which fall within a 100' buffer to critical facilities and infrastructure. Rail lines were also illustrated, as they many times transport chemicals into the area.
- **Erosion** – Washington State Department of Ecology conducted an erosion study within Grays Harbor County over the course of the last two years. FEMA further funded Washington DOE to assist in developing the erosion profile for this HMP update.
- **Landslide**—Historic landslide hazard data was used to assess exposure to landslides using Washington DNR 2016 Landslide Susceptibility data. This data depicts landslide susceptibility at a 10 meter resolution, across the state of Washington. Landslide damages are illustrated based on the number of parcels intersecting the landslide zone.
- **Severe Weather**—Severe weather data was downloaded from the Natural Resources Conservation Service and the National Climatic Data Center, as well as PRISM Precipitation, Average Low, and Average High data. Tornado Project data was utilized to identify events which have occurred in the planning area.
- **Tsunami** – Information for Tsunami was captured through FEMA's Risk Map project as a pilot project for the new Hazus 4.0 model.
- **Wildfire**—Information on wildfire analysis was captured from various sources, including Washington DNR Wildfire History data, Wildfire Protection data, US Forest Service data, LAND FIRE data, and Wildland Urban Interface Zone data, among other sources.

4.2.5 Calculated Priority Risk Index Scoring Criteria

The Planning Team utilized a Calculated Priority Risk Index Score for each hazard of concern, addressing impact both at the county level, and at the Planning Partner level. The same process was followed for both the County and by each Planning Partner. While the base plan defines the process followed, each jurisdictional annex provides only the outputs rather than re-describing the entire process.

Vulnerabilities are described in terms of critical facilities, structures, population, economic values, and functionality of government which can be affected by the hazard event as identified in the below tables. Hazard impact areas describe the geographic extent a hazard can impact a jurisdiction and are uniquely defined on a hazard-by-hazard basis. Mapping of the hazards, where spatial differences exist, allows for hazard analysis by geographic location. Some hazards can have varying levels of risk based on location. Other hazards cover larger geographic areas and affect the area uniformly. Therefore, a system must be established which addresses all elements (people, property, economy, continuity of government) in order to rate each hazard consistently, and in a manner which addresses the functionality of each Planning Partner involved (e.g., municipality, fire district, public utility district, etc.). The use of the Calculated Priority Risk Index allows such application, based on established criteria of application to determine the risk factor. For identification purposes, the six criteria on which the CPRI is based are probability, magnitude, geographic extent and location, warning time/speed of onset, and duration of the event. Those elements are further defined as follows:

Probability

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

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

Magnitude

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

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

Extent and Location

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

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

Warning Time/Speed of Onset

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

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

Duration

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

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

Chapter 16 summarizes all of the analysis conducted by way of completion of the Calculated Priority Risk Index (CPRI) for hazard ranking. It should again be emphasized that each planning partner utilized the outputs from the risk assessment to compute their CPRI for their own respective jurisdiction, following the process identified.

4.3 PROBABILITY OF OCCURRENCE AND RETURN INTERVALS

Natural hazard events with relatively long return periods, such as a 100-year flood or a 500- or 1,000-year earthquake, are often thought to be very unlikely. In reality, the probability that such events occur over the next 30 or 50 years is relatively high, having significant probabilities of occurring during the lifetime of a building:

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

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

4.4 COMMUNITY VARIATIONS TO THE RISK ASSESSMENT

Each planning partner within their respective annex describes where or how their risk varies from what is described in the hazard profiles and risk ranking. Variations are documented in the risk assessment section in their annex to the plan, if appropriate. In some instances, declared disaster events may not have impacted a specific jurisdiction or entity. Similarly, there may have been incidents of significance which did not rise to a level of a disaster declaration, but were nonetheless significant to the jurisdiction or entity. As such, those differences are noted where applicable.

4.5 LIMITATIONS

The models and information presented in this document does not replace or supersede any official document or product generated to meet the requirements of any state, federal, or local program, which may be much more detailed and encompassing beyond the scope of this project. This document is intended for planning purposes only. This document and its contents have been prepared and are intended solely for Grays Harbor County and its planning partners' information and use with respect to hazard mitigation planning, incorporating other relevant data into other planning mechanisms as appropriate. While this process utilized best available science and scientific data, the Planning Team, consultant, nor any of the planning partners conducted any scientific analysis within this document, and none should be construed. Our process only reproduced existing data in different ways to meet the guidelines and requirements of 44 CFR 201.6. All data layers utilized are identified within the various sections of this document should reviewers wish greater clarification and information.

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, Grays Harbor County and its planning partners will continue to collect additional data to assist in better estimating potential losses associated with other hazards as science increases the validity of data.

Some assumptions were made by the planning partnership in an effort to capture as much data as necessary to supplant any significant data gaps. One example of this is the valuation for structures within the assessed data, most commonly as it relates to the general building stock. For structures for which data was not provided, the missing information was determined using averages of similar types of structures, determining square footage and applying a multiplier. This process is identified in the Hazus User’s Guide.

Some hazards, such as earthquake, are pre-loaded with scientifically determined scenarios which are used during the modeling process. This does not allow for manipulation of the data as with other hazards, such as flood. In the case of earthquake, greater reliance existed on the use of the Hazus default data, which is known to be less accurate, most often causing higher loss values. Therefore, while loss estimates are provided, they should be viewed with this flaw in mind. A much more in-depth scientific analysis is necessary to rely on this type of data with a high degree of accuracy. Readers should view this document as a baseline or starting point, and information should be further studied and analyzed by scientists and other subject matter experts in specific hazard fields.

CHAPTER 5.
CLIMATE CHANGE

5.1 WHAT IS CLIMATE CHANGE?

Climate, consisting of patterns of temperature, precipitation, humidity, wind and seasons, 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. Worldwide, average temperatures have increased more than 1.4ºF over the last 100 years (NRC, 2010). Although this change may seem small, it can lead to large changes in climate and weather.

The warming trend and its related impacts are caused by increasing concentrations of carbon dioxide and other greenhouse gases in the earth’s atmosphere. Greenhouse gases are gases that trap heat in the atmosphere, resulting in a warming effect. Carbon dioxide is the most commonly known greenhouse gas; however, methane, nitrous oxide and fluorinated gases also contribute to warming. Emissions of these gases come from a variety of sources, such as the combustion of fossil fuels, agricultural production, and changes in land use. According to the U.S. Environmental Protection Agency (EPA), carbon dioxide concentrations measured about 280 parts per million (ppm) before the industrial era began in the late 1700s and have risen 41 percent since then, reaching 394 ppm in 2012 (see Figure 5-1). The EPA attributes almost all of this increase to human activities (U.S. EPA, 2013f).

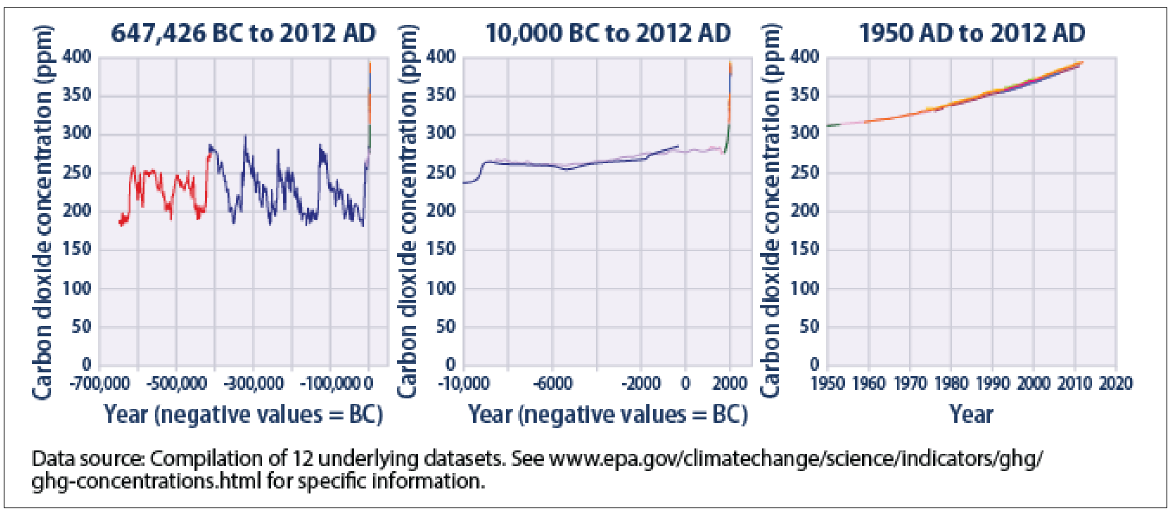


Figure 5-1. Global Carbon Dioxide Concentrations Over Time

Climate change will affect the people, property, economy, and ecosystems of Grays Harbor County in a variety of ways. Some impacts will have negative consequences for the region and others may present opportunities. The most important effect for the development of this plan is that climate change will have a measurable impact on the occurrence and severity of natural hazards.

5.2 HOW CLIMATE CHANGE AFFECTS HAZARD MITIGATION

An essential aspect of hazard mitigation is predicting the likelihood of hazard events in a planning area. Typically, predictions are based on statistical projections from records of past events. This approach assumes that the likelihood of hazard events remains essentially unchanged over time. Thus, averages based on the past frequencies of, for example, floods are used to estimate future frequencies: if a river has flooded an average of once every five years for the past 100 years, then it can be expected to continue to flood an average of once every five years.

For hazards that are affected by climate conditions, the assumption that future behavior will be equivalent to past behavior is not valid if climate conditions are changing. As flooding is generally associated with precipitation frequency and quantity, for example, the frequency of flooding will not remain constant if broad precipitation patterns change over time. The risks of avalanche, landslide, severe weather, severe winter weather and wildfire are all affected by climate patterns as well.

For this reason, an understanding of climate change is pertinent to efforts to mitigate natural hazards. Information about how climate patterns are changing provides insight on the reliability of future hazard projections used in mitigation analysis. This chapter summarizes current understandings about climate change to provide a context for the recommendation and implementation of hazard mitigation measures.

Table 5-1 identifies the relationship between climate change risk and its influence on the various hazards of concern within the planning region. When reviewing the Table, the downward leftmost column identifies the climate risks. Column headings across the table identify the natural hazards identified in the County's Plan. Cells with an X or P show which climate risks will affect the frequency, intensity, magnitude, or duration of each natural hazards. The "P" identifies the primary relationship between the risk and the identified hazard. The "X" identifies a secondary relationship. The blue cells in the body of the table show where climate change risk and a natural hazard are essentially the same thing. The first two highlighted risks rows—increased temperatures and changes in hydrology—are two of the primary climate drivers for many of the natural hazards. The other climate risks represent known environmental or ecosystem responses to one or both of the primary drivers. With respect to Volcanic activity, the impact from climate change on a volcano is unknown; however, volcanic activity itself can influence climate change with respect to absorption of terrestrial radiation by volcanic clouds, lowering temperatures in the lower atmosphere and changing atmospheric circulation patterns.

Table 5-1
Relationship Between Climate Change and Identified County Hazards

CLIMATE RISKS	Coastal Erosion	Drought	Earthquake	Flood	Landslide	Severe Weather			Wildfire	Tsunami	Volcano*
						Cold	Heat	Winter storms			
Increased temperatures	X	P		X	X	X	X	X	P		
Changes in Hydrology	X	P	X	P	P			X	X	X	
Increased Wildfires		X		X	X				P		
Increase in ocean temperatures and changes in ocean chemistry	P			X				P			
Increased Drought		P									
Increased Costal Erosion	P									X	
Changes in habitat	X	X		X	X				X		
Increase in Invasive Species and Pests		X		X	X		X		P		
Decrease in natural vegetation	X	X		P	P	X		X	P		
Loss of Wetland ecosystems and services	X	P		P	X				X		
Increased frequency of extreme precipitation events and flooding				P	P			X			
Increased Landslides	X	X		X	P			X	X		

5.3 CURRENT INDICATIONS OF CLIMATE CHANGE

5.3.1 Global Indicators

The major scientific agencies of the United States—including the National Aeronautics and Space Administration (NASA) and the National Oceanic and Atmospheric Administration (NOAA)—agree that climate change is occurring (NOAA Technical Report, 2012; U.S. EPA, 2013). Multiple temperature records from all over the world have shown a warming trend (U.S. EPA, 2011). According to NOAA, the decade from 2000 to 2010 was the warmest on record, and 2010 was tied with 2005 as the warmest year on record (NOAA, 2011). Worldwide, average temperatures have increased more than 1.4ºF over the last 100 years (NRC, 2010). Many of the extreme precipitation and heat events of recent years are consistent with projections based on that amount of warming (USGCRP, 2009).

Rising global temperatures have been accompanied by other changes in weather and climate. Many places have experienced changes in rainfall resulting in more intense rain, as well as more frequent and severe heat waves. The planet's oceans and glaciers have also experienced changes: oceans are warming and becoming more acidic, ice caps are melting, and sea levels are rising (U.S. EPA, 2010). Global sea level has risen approximately nine (9) inches, on average, in the last 140 years (U.S. EPA, 2010). This has already put some coastal homes, beaches, roads, bridges, and wildlife at risk (USGCRP, 2009).

For our coastal communities, this has, and will continue, to exacerbate erosion issues to levels not previously seen.

5.4 PROJECTED FUTURE IMPACTS

5.4.1 Global Projections

Scientists project that Earth's average temperatures will rise between 2ºF and 12ºF by 2100 (NRC, 2011a). Some research has concluded that every increase of 2ºF in average global average temperature can have the following impacts (NRC, 2011b):

- 3 to 10 percent increases in the amount of rain falling during the heaviest precipitation events, which can increase flooding risks
- 200 to 400 percent increases in the area burned by wildfire in parts of the western United States
- 5 to 10 percent decreases in stream flow in some river basins
- 5 to 15 percent reductions in the yields of crops as currently grown.

The amount of sea level rise (SLR) expected to occur as a result of climate change will increase the risk of coastal flooding for millions to hundreds of millions of people around the world, many of whom would have to permanently leave their homes (IPCC, 2007). While no widely accepted method is currently available for producing probabilistic projects of sea level rise at actionable scales (i.e. regional and local), a 2012 NOAA study identified advancements in satellite measurements indicating ice sheet loss as a greater contributor to global SLR than thermal expansion over the period of 1993-2008 (NOAA, 2012).

According to the 2012 report, review of historical SLR rate derived from tide gauge records beginning in 1900, global sea level has risen 0.2 meters (8 inches). By 2100, sea level is expected to rise another 1.5 to 3 feet (NRC, 2011b). There is a highly significant correlation between observations of global mean SLR and increasing global mean temperature, and the IPCC and more recent studies anticipate that global mean sea level will continue to rise even if warming ceases. As such, continually rising seas will make coastal storms and the associated storm surges more frequent and destructive. What is currently termed a once-in-a-century coastal flooding event could occur as frequently as once per decade (USGCRP, 2009).

5.4.2 Projections for Washington State

The Climate Impacts Group (CIG, 2009) at the University of Washington used multiple climate models to evaluate potential climate change in Washington State and the Pacific Northwest region. Likewise, NOAA (2012) also completed various studies and technical reports. The following are key findings of those studies that are relevant for hazard mitigation planning:

- Climate models project increases in annual temperature (compared to 1970 – 1999 and averaged across all models) of 2.0°F by the 2020s, 3.2°F by the 2040s, and 5.3°F by the 2080s.
- Projected changes in annual precipitation, averaged over all models, are small (+1 to +2 percent), but some models project an enhanced seasonal precipitation cycle with changes toward wetter autumns and winters and drier summers.
- Regional climate models generally predict increases in extreme high precipitation over the next half-century, particularly around Puget Sound. Sea level risk by the year 2100 is projected to be in the range of 5-33cm (2-13 inches) under the moderate models for Washington state (2009 Climate Impact Group).
- April 1 snowpack is projected to decrease (compared with the 1916 – 2006 historical average) by 28 percent across the state by the 2020s, 40 percent by the 2040s, and 59 percent by the 2080s (Littell et al., 2009). However, the increased snowfall could "more than make up for" the shorter snow season and yield increased snow accumulations in some regions (Christensen, et al 2007, as cited in Sandell, 2013).
- Due to increased summer temperature and decreased summer precipitation, the area burned by fire in the U.S. portion of the Columbia River basin is projected to double by the 2040s and triple by the 2080s. The probability that more than 2 million acres in that area will burn in a given year is projected to increase from 5 percent today to 33 percent by the 2080s.
- Projected warming would likely result in 101 additional deaths during heat events in the greater Seattle area among persons 45 and older in 2025 and 156 additional deaths in 2045.
- A 2013 published report by Wild Fish Conservancy indicates that more recent predictions are not evenly distributed on a global scale. According to the study, the "Pacific Ocean is characterized by warming, but recent cooling also occurred in some regions of the Eastern Pacific," including Grays Harbor County (Wild Fish, 2013, p. 3). The report goes on to indicate that the "cooling may be the result of a reversal in the Pacific Decadal Oscillation" (Bindoff et al. 2007). Regional differences are also apparent in the sea level data, where sea level has declined in the short term, but is [sic] has still risen in comparison with historical levels (Wild Fish, 2013, p. 4).
- Most recently in Washington, the summer of 2017 was one of the driest on record, dating back over 30 years. Area weather records were set for two 90 degree days, tying 1967 and 1988 with the highest number of 90 degree days in September on record.
- Averaged over Washington State, the June through August average temperatures ranked as the 4th warmest in the historical record with temperatures 2.6°F above the 1981-2010 normal. Total June through August precipitation also ranked in the top 10, coming in as the 7th driest for Washington State with over a 2" rainfall deficit compared to normal.

5.5 RESPONSES TO CLIMATE CHANGE

5.5.1 Mitigation and Adaptation

Communities and governments worldwide are working to address, evaluate, and prepare for climate changes that are likely to impact communities in coming decades. Generally, climate change discussions encompass two separate but inter-related considerations: mitigation and adaptation. The term "mitigation" can be confusing, because its meaning changes across disciplines:

- Mitigation in restoration ecology and related fields generally refers to policies, programs or actions that are intended to reduce or to offset the negative impacts of human activities on natural systems. Generally, mitigation can be understood as avoiding, minimizing, rectifying, reducing, or eliminating, or compensating for known impacts (CEQ, 1978).
- Mitigation in climate change discussions is defined as "a human intervention to reduce the impact on the climate system." It includes strategies to reduce greenhouse gas sources and emissions and enhance greenhouse gas sinks (U.S. EPA, 2013g).
- Mitigation in emergency management is typically defined as the effort to reduce loss of life and property by lessening the impact of disasters (FEMA, 2013).

In this chapter, mitigation is used as defined by the climate change community. In the other chapters of this plan, mitigation is primarily used in an emergency management context.

Adaptation refers to adjustments in natural or human systems in response to the actual or anticipated effects of climate change and associated impacts. These adjustments may moderate harm or exploit beneficial opportunities (U.S. EPA, 2013g).

Mitigation and adaptation are related, as the world's ability to reduce greenhouse gas emissions will affect the degree of adaptation that will be necessary. Some initiatives and actions can both reduce greenhouse gas emissions and support adaptation to likely future conditions. Likewise, assessing mitigation efforts to include impact from climate change is a logical approach to enhance resilience of a community.

Societies across the world are facing the need to adapt to changing conditions associated with natural disasters and climate change. Farmers are altering crops and agricultural methods to deal with changing rainfall and rising temperature; architects and engineers are redesigning buildings; planners are looking at managing water supplies to deal with droughts or flooding.

Most ecosystems show a remarkable ability to adapt to change and to buffer surrounding areas from the impacts of change. Forests can bind soils and hold large volumes of water during times of plenty, releasing it through the year; floodplains can absorb vast volumes of water during peak flows; coastal ecosystems can hold out against storms, attenuating waves, and reducing erosion. Other ecosystem services—such as food provision, timber, materials, medicines, and recreation—can provide a buffer to societies in the face of changing conditions.

Ecosystem-based adaptation is the use of biodiversity and ecosystem services as part of an overall strategy to help people adapt to the adverse effects of climate change. This includes the sustainable management, conservation and restoration of specific ecosystems that provide key services.

5.5.2 Response To Climate Change in the Northwest

The State of Washington has adopted greenhouse gas reduction requirements that aim to reduce emissions to 1990 levels by 2020, to 25 percent below 1990 levels by 2035 and to 50 percent below 1990 levels by 2050 (RCW 47.01.440). Scientists have known for more than a decade that carbon pollution is the primary cause of climate change. Recognizing the need to take action, in 2015 Gov. Jay Inslee directed Ecology to cap and reduce carbon pollution under Washington's Clean Air Act. Under the new rule, businesses that are responsible for 100,000 metric tons of carbon pollution annually will be required to cap and then gradually reduce their emissions. Natural gas distributors, petroleum fuel producers and importers, power plants, metal manufacturers, waste facilities, and state and federal facilities need to show their emissions are declining by an average of 1.7 percent a year starting in 2017.

5.6 POTENTIAL CLIMATE CHANGE IMPACT ON HAZARDS

An understanding of the basic features of climate change allows for a qualitative assessments of impacts on hazards of concern addressed in this hazard mitigation plan. This overview serves as a basis for evaluating how risk will change as a result of future climate change impacts. The vulnerabilities identified in this plan update will ultimately be used to inform other aspects of emergency management planning, such as the Comprehensive Emergency Management Plan.

5.6.1 Avalanche

Snow avalanches are rarely used as indicators of climate change. The effects of climate change on avalanche frequency and magnitude are uncertain and will likely be dependent on local climate change impacts, such as changes in snowfall events and temperature series. Some studies have indicated that the types of avalanche events (wet or dry) may shift as a result of changes in snow cover (Martin et al., 2001). Avalanches, however, are not influenced by snow cover alone, but by several interrelated factors including forest structure, surface energy balance, melt water routing, precipitation, air temperature and wind (Teich et al., 2012; Lazar and Williams, 2008).

Secondary and tertiary impacts of climate change may also alter avalanche events. For example, climate change may modify the distribution of tree species across mountain landscapes. Some case studies in the Swiss and French Alps indicate that climate change impacts may reduce the frequency or severity of such events, while other assessments indicate that events may occur more frequently in other mountain regions (Kohler, 2009; Teich et al. 2012). No studies assessing the relative frequency and severity of avalanches in the Cascade Range were located, but an analysis of wet avalanche hazards in an Aspen ski area indicated that such effects may occur more frequently under high-emission scenarios (Lazar and Williams, 2008). Feedback loops affecting snow cover, forest structure, meteorological averages, and land use planning decisions are all likely to influence the future frequency and severity of impacts from avalanche events.

5.6.2 Dam Failure

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

5.6.3 Earthquake

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

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

5.6.4 Flood

According to University of Washington scientists, global climate changes resulting in warmer, wetter winters are projected to increase flooding frequency in most Western Washington river basins. Future floods are expected to exceed the capacity and protective abilities of existing flood protection facilities, threatening lives, property, major transportation corridors, communities, and regional economic centers.

Changes in Hydrology

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

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

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

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

Sea Level Rise

Sea level and temperature are interrelated (U.S. EPA, 2013e). Warmer temperatures result in the melting of glaciers and ice sheets. This melting means that less water is stored on land and, thus, there is a greater volume of water in the oceans. Water also expands as it warms, and the heat content of the world's oceans has been increasing over the last several decades. According to the EPA, there is likely to be 13 inches of sea level rise in the Puget Sound basin by 2100. According to the Washington State Department of Ecology the impacts of sea level rise could include the following: increased coastal community flooding, coastal erosion and landslides, seawater well intrusion, acidification of waters, and lost wetlands and estuaries (see Figure 5-2).

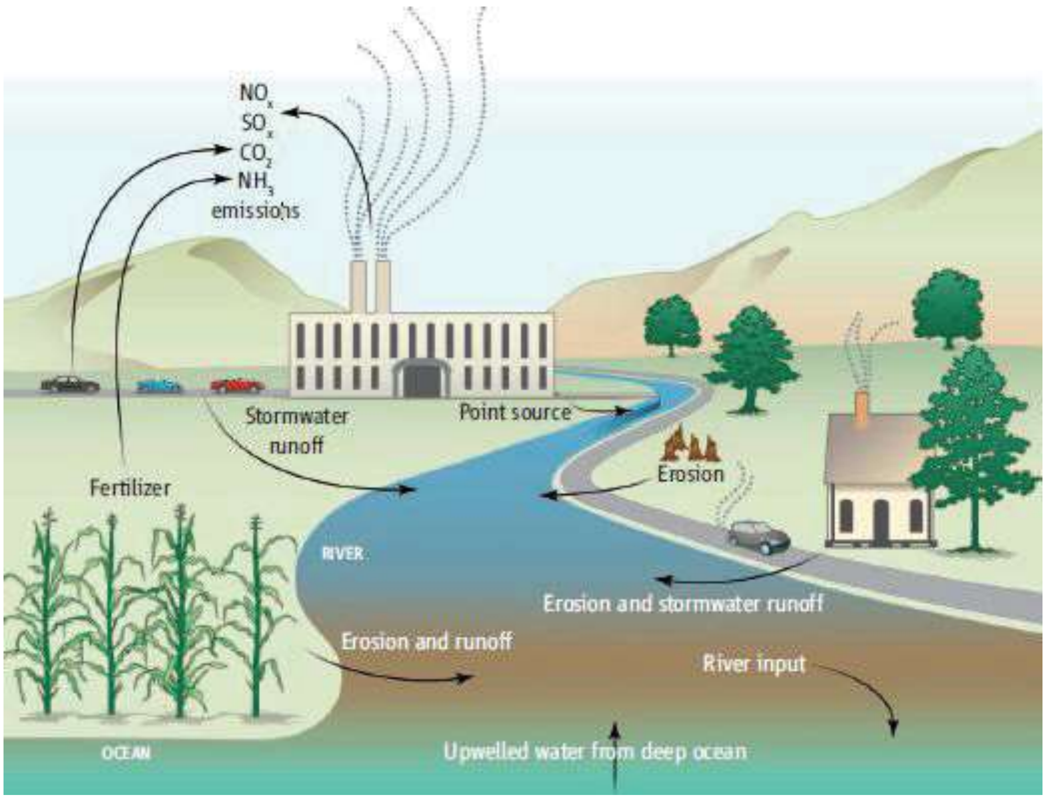


Figure 5-2 Contributors to acidification

In 2017, FEMA issued an update to the County's National Flood Insurance Maps (discussed in Chapter 7), which also included potential rise associated with increased sea level. Figure 5-3 represents the results of that study, illustrating potential impact from a 1, 2, and 3 foot increase to the County's Base Flood Elevation associated with its flood maps. While this illustration does not predict the amount of sea level which can occur, it does demonstrate potential impacts at those intervals.

In addition, sea level risk may also be impacted by vertical land deformation caused by tectonic movement, isostatic rebound, which is the rising of compressed earth after removal of a heavy load mass, such as glaciers, and seasonal ocean elevation changes due to atmospheric impact and effects.

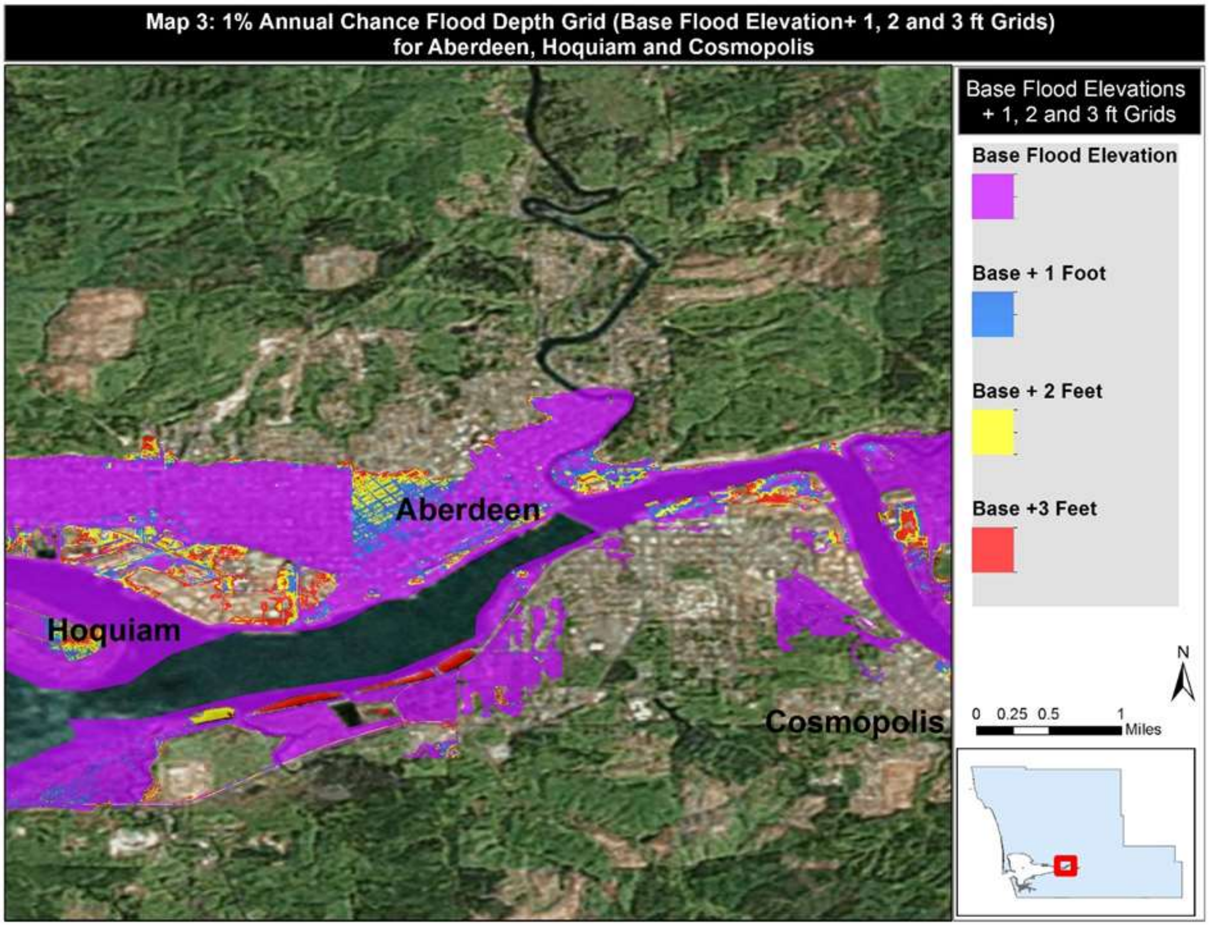


Figure 5-3 Potential Sea Level Rise Impact at +1, 2 and 3 ft. above Base Flood Elevation
Source: FEMA Risk Report, 2015

5.6.5 Landslide and Erosion

Climate change may impact storm patterns, increasing the probability of more frequent, intense storms with varying duration. Increase in global temperature could affect the snowpack and its ability to hold and store water. Warming temperatures also could increase the occurrence and duration of droughts, which would increase the probability of wildfire, reducing the vegetation that helps to support steep slopes. All of these factors would increase the probability for landslide occurrences. Likewise, although erosion on beaches and bluffs is a naturally occurring, on-going process, major episodes of erosion often occur during storm events, particularly when storms coincide with high tides. Such events will exacerbate episodic erosion events, accelerating bluff and beach erosion.

5.6.6 Severe Weather

Climate change presents a challenge for risk management associated with severe weather. The frequency of severe weather events has increased steadily over the last century. The number of weather-related disasters during the 1990s was four times that of the 1950s, and cost 14 times as much in economic losses. Historical data shows that the probability for severe weather events increases in a warmer climate (see Figure 5-4). According to the EPA, "Since 1901, the average surface temperature across the contiguous 48 states has risen at an average rate of 0.14°F per decade. Average temperatures have risen more quickly since the late 1970s (0.36 to 0.55°F per decade). Seven of the top 10 warmest years on record for the contiguous 48 states have occurred since 1998, and 2012 was the warmest year on record (U.S. EPA, 2013b)." This increase in average surface temperatures can also lead to more intense heat waves that can be exacerbated in urbanized areas by what is known as urban heat island effect. Additionally, the changing hydrograph caused by climate change could have a significant impact on the intensity, duration, and frequency of storm events. All of these impacts could have significant economic consequences.

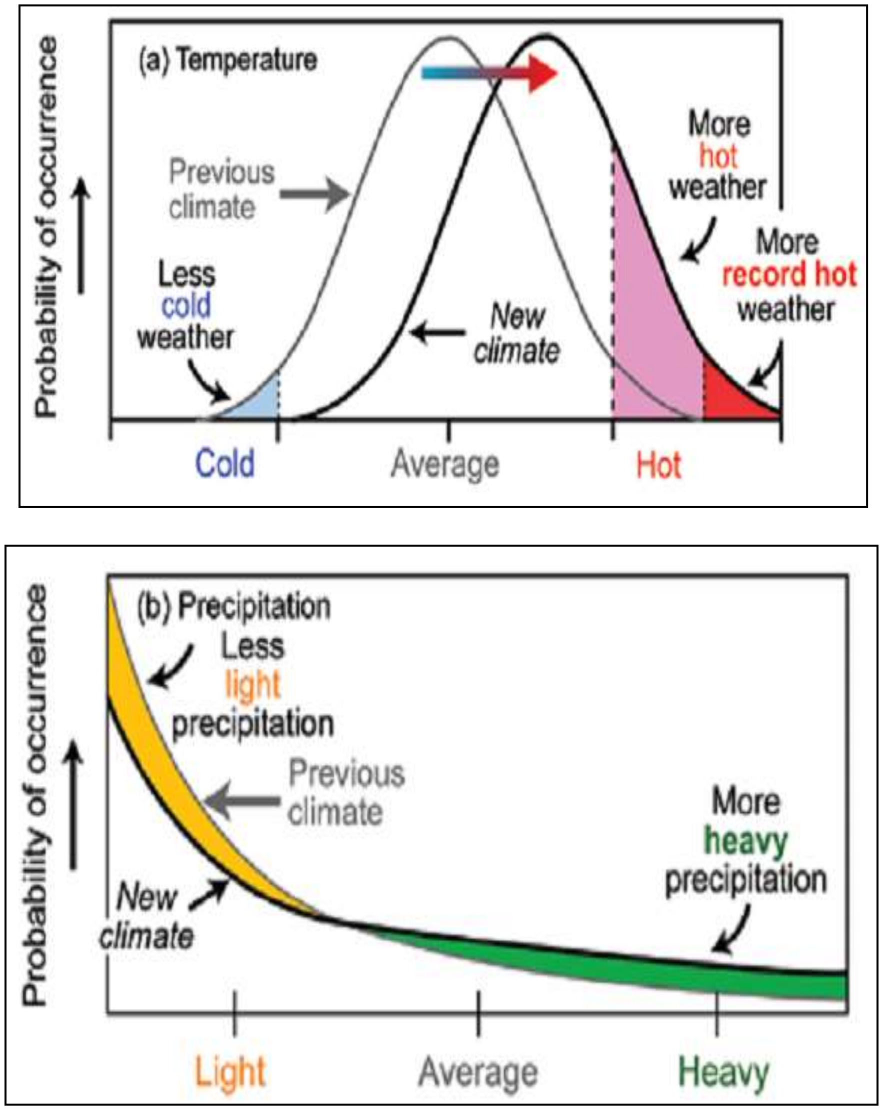


Figure 5-4 Severe Weather Probabilities in Warmer Climates

5.6.7 Severe Winter Weather

One impact of climate change is an increase in average ambient temperatures. Since the 1980s, unusually cold temperatures have become less common in the contiguous 48 states (U.S. EPA, 2013c). This trend is expected to continue and the frequency of winter cold spells will likely decrease.

As ambient temperatures increase, more water evaporates from land and water sources. The timing, frequency, duration, and type of precipitation events will be affected by these changes. In general, more precipitation will fall as rain rather than snow; however, the amount of snowfall may increase where temperatures remain below freezing (U.S. EPA, 2013d). Snowfall may also change if typical storm track patterns are altered. Snowfall is already changing in the United States. According to the EPA (see Figure 5-5; U.S. EPA, 2013d):

- Total snowfall has decreased in most parts of the country since widespread observations became available in 1930, with 57 percent of stations showing a decline.
- More than three-fourths of the stations across the contiguous 48 states have experienced a decrease in the proportion of precipitation falling as snow.
- Snowfall trends vary by region. The Pacific Northwest has seen a decline in both total snowfall and the proportion of precipitation falling as snow.[15]

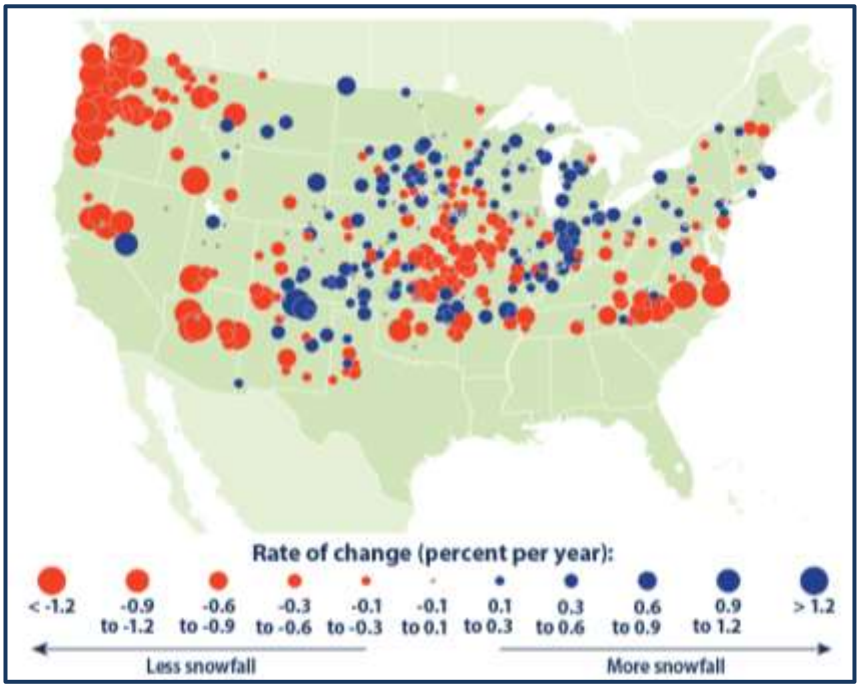


Figure 5-5 Change in Snowfall, 1930-2007

From 1950 to 2000, snowpack has declined in most of the western United States, compared to historical averages. Western Washington, western Oregon and northern California have seen the greatest declines (U.S. EPA, 2013d). These changes will impact ecosystems, recreation opportunities, the hydroelectric power supply, and drinking water systems. The timing and magnitude of flooding may also be impacted by changes in the region's hydrograph, due to a greater percentage of precipitation falling as rain and earlier spring melt times.[16]

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[15] https://www.epa.gov/climate-indicators/climate-change-indicators-snowfall
[16] https://www.epa.gov/climate-indicators

5.6.8 Tsunami

The impacts of climate change on the frequency and severity of tsunami events could be significant in regions with vulnerable coastline. Global sea-level rise will affect all coastal societies, especially densely populated low-lying coastal areas. Sea level rise has two effects on low-lying coastal regions: any structures located below the new level of the sea will be flooded; and the rise in sea level may lead to coastal erosion that can further threaten coastal structures.

5.6.9 Volcano

While there are no volcanoes in Grays Harbor County, the accumulation of ash from an eruption could occur; however, significant impact is limited in probability and severity due to the westerly winds flowing on-shore which would push ash in a more easterly direction. Climate change is not likely to affect the risk associated with volcanoes; however, volcanic activity can affect climate change. Volcanic clouds absorb terrestrial radiation and scatter a significant amount of incoming solar radiation. By reducing the amount of solar radiation reaching the Earth's surface, large-scale volcanic eruptions can lower temperatures in the lower atmosphere and change atmospheric circulation patterns. Such effects can last from two to three years following a volcanic eruption. The massive outpouring of gases and ash can influence climate patterns for years following a volcanic eruption as sulfuric gases convert to sub-micron droplets containing about 75 percent sulfuric acid. These particles can linger three to four years in the stratosphere.

5.6.10 Wildfire

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. Climate change also may increase winds that spread fires. Forest response to increased atmospheric carbon dioxide could contribute to more tree growth and thus more fuel for fires, although the effects of carbon dioxide on mature forests are still largely unknown. In turn, increased high-elevation wildfires could release stores of carbon and further contribute to the buildup of greenhouse gases.

The extent of area burned by wildfires each year appears to have increased since the 1980s. According to National Interagency Fire Center data, of the 10 years with the largest acreage burned, nine have occurred since 2000, including the peak year in 2015. This period coincides with many of the warmest years on record nationwide.[17]

Wildfire 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

[17] https://www.epa.gov/climate-indicators/climate-change-indicators-wildfires Accessed 30 May 2017.

conditions in the U.S. shift from region to region. El Niño years bring drier conditions to the Pacific Northwest and more fires.

Climate scenarios project summer temperature increases between 2ºC and 5°C and precipitation decreases of up to 15 percent. Such conditions would exacerbate summer drought and further promote high-elevation wildfires, releasing stores of carbon, and further contributing to the buildup of greenhouse gases. Forest response to increased atmospheric carbon dioxide 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.

5.7 GRAYS HARBOR COUNTY IMPACT

Climate change is likely to have an impact on future water resources in the County. Over the next decades, increased regional temperatures are anticipated to lead to a reduction in snowpack and receding glaciers in the Olympic Mountains. Since many of the tributary streams in County's WRIA areas (e.g., WRIA 22) depend upon snowmelt and glacier melt waters, these streams may be affected over time. Anticipated effects include decreased summer baseflows as snowpack and glaciers are reduced. Spring peak flows are also predicted to occur two to six weeks earlier than they do normally (CIG, 2009). Further, streams without snowmelt or headwaters in the mountains will also be affected, perhaps more strongly, as streams currently have low in-stream flows.

Within the Chehalis River Watershed, which represents a rain-dominated watershed, studies indicate that there will be an increase in the magnitude and frequency of extreme winter precipitation events, which will "increase winter stream flows and may increase flooding" (Sandell, 2013). Within transient watersheds (mixed rain and snow) or snowmelt-dominated watersheds, projected climate change influences could vary as those are snow-dependent (see Figures 5-8 below).

Additionally, the communities in Grays Harbor County that are low-lying could be affected by sea level rise (Mote, et al. 2009). Sea level rise will allow high tides to reach farther into low-lying coastal areas and rise higher on existing flood control structures such as dikes and bulkheads. Coastal flooding will persist longer and could lead to faster rates of erosion on beaches and coastal bluffs (Shipman, 2009). Sea level rise will exacerbate the conditions that contribute to episodic erosion events, and will accelerate bluff and beach erosion. Increased storm strength or frequency will further exacerbate the situation.

Coastal freshwater aquifers in the area will also be subject to increased intrusion by saltwater, while increased atmospheric temperatures will also increase ocean temperatures, leading to increased acidity. While acidity levels currently are not increasing because of melting glacial ice sheets, the potential for increased acidity does increase over time. Ecology has directed local governments to consider preparing for sea level rise during the Shoreline Master Program update process.

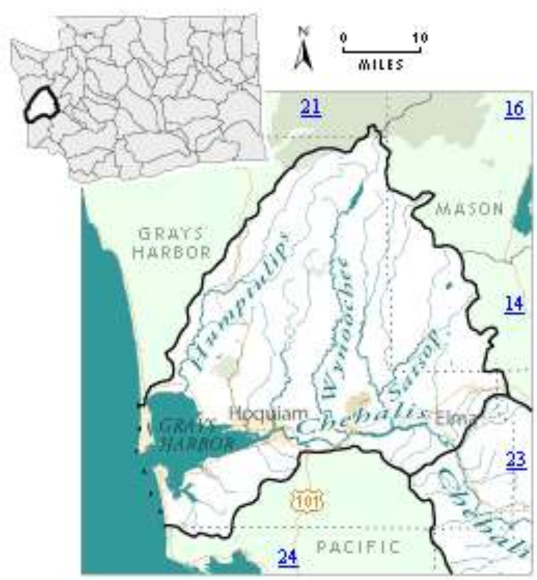

Figure 5-6 WRIA 22 Lower Chehalis Watershed

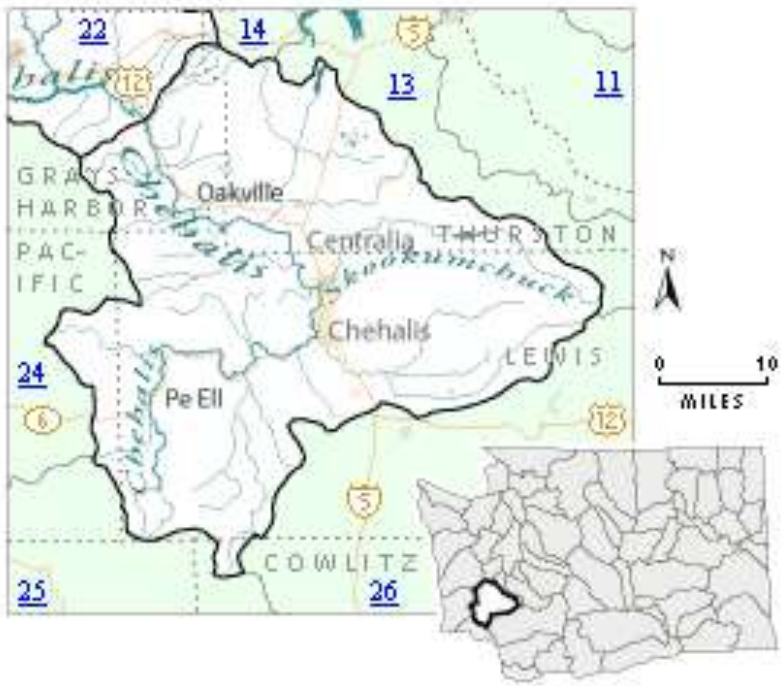

Figure 5-7 WRIA 23 Upper Chehalis Watershed

Figure 5-8 WRIA 24 Willapa Watershed

5.8 RESULTS

Based on review and analysis of the data, the Planning Team has determined that the probability for impact from Climate Change throughout the area is highly likely. While there are still many uncertainties associated with climate change, indicators of impact already exist. The area has previously experienced drought conditions, with a drought incident occurring only a short period ago (2015). During the summer of 2017, the State experienced one of its driest summers on record. With anticipated increase in temperatures as a result of climate change, drought situations will only intensify. The impact of Climate Change on Earthquake, while relatively unknown, could be exacerbated as a result of increased liquefaction, due to increased flooding issues. Anticipated sea level rise would impact the coastal areas of the County, increasing storm surge which exacerbate landslide and erosion incident, as well as increasing the potential for flooding in areas which customarily experienced no or limited flooding. Historical hydrologic patterns of weather events would become increasingly inaccurate, increasing potential vulnerability due to uncertainty for water supplies, flood management, and ecological functions. Increased temperatures would also impact snow levels, decreasing water supplies in the various watersheds, even those outside of the planning area. Higher temperatures anticipated with climate change would increase vulnerability of the population due to excessive heat. Based on the potential impact, the Planning Team determined the CPRI score to be 2.35, with overall vulnerability determined to be a low level.

CHAPTER 6.
DROUGHT

6.1 GENERAL BACKGROUND

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

Droughts originate from a deficiency of precipitation resulting from an unusual weather pattern. If the weather pattern lasts a short time (a few weeks or a couple of months), the drought is considered short-term. If the weather pattern becomes entrenched and the precipitation deficits last for several months or years, the drought is considered 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.

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

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

6.2 HAZARD PROFILE

6.2.1 Extent and Location

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

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

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

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

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

Much of the area depends on well water, which currently supplies a large portion of Grays Harbor County residents with their drinking water. Drought conditions within the planning area increase pressure on local aquifers, with increased pumping potentially resulting in saltwater intrusion into freshwater aquifers. This, in turn, could cause restrictions on economic growth and development.

A 2015 Department of Ecology report completed, in part, as a result of the lower-than-normal water levels experienced in 2015 stated that on "the west side of the mountains, only two Ecology monitored wells (near Sequim) exhibited 2015 water levels that consistently fell below the wells normal water level range" (WA DOE, 2016). The report went on to state that "both wells have experienced significant on-going water level declines in recent years however, which suggests their lower than normal water levels this past year [2015] may not be drought related.

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 also harm recreational companies that use water (e.g., swimming pools, water parks, and river rafting companies) as well as landscape and nursery businesses because people will not invest in new plants if water is not available to sustain them. With much of Washington's energy coming from hydroelectric plants, a drought means less inexpensive electricity coming from dams and probably higher electric bills. All people would pay more for water if utilities increase their rates. This has become an issue within Washington State as a whole previously, when a lack of snow pack has decreased hydroelectric generating capacity, and raised the electric prices, impacting residents.

6.2.2 Previous Occurrences

In the past century, Washington has experienced a number of drought episodes, including several that lasted for more than a single season—1928 to 1932, 1992 to 1994, and 1996 to 1997. Table 6-1 identifies additional drought occurrences in the state. The 1977 drought was the worst on record, but the 2001 drought came close to surpassing it in some respects. Table 6-2 has data on how the two droughts affected Washington by late September of their respective years.

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[18] Washington State Department of Ecology 2014-2015 Drought: Groundwater Level/Storage Response. http://waecy.maps.arcgis.com/apps/MapSeries/index.html?appid=b64d6f24e4894b878e47a209020b73a9

Table 6-1
Drought Occurrences

July-August 1902	No measurable rainfall in Western Washington
August 1919	Drought and hot weather occurred in Western Washington
July – August 1921	Drought in all agricultural sections.
June-August 1922	The statewide precipitation averaged 0.10 inches.
March – August 1924	Lack of soil moisture retarded germination of spring wheat.
July 1925	Drought occurred in Washington
July 21-August 25, 1926	Little or no rainfall was reported.
June 1928-March 1929	Most stations averaged less than 20 percent of normal rainfall for August and September and less than 60 percent for nine months.
July – August 1930	Drought affected the entire state. Most weather stations averaged 10 percent or less of normal precipitation.
April 1934-March 1937	The longest drought in the region's history – the driest periods were April-August 1934, September-December 1935, and July-January 1936-1937.
May – September 1938	Driest growing season in Western Washington.
1952	Every month was below normal precipitation except June. The hardest hit areas were Puget Sound and the central Cascades.
January – May 1964	Drought covered the southwestern part of the state. Precipitation was less than 40 percent of normal.
Spring 1966	Drought throughout Washington
June – August 1967	Drought throughout Washington
January – August 1973	Dry in the Cascades.
October 1976 – September 1977	Worst drought in Pacific Northwest history. Below normal precipitation in Olympia, Seattle, and Yakima. Crop yields were below normal and ski resorts closed for much of the 1976-77 season.
2001	Governor declared statewide Stage 2 drought in response to severe dry spell.
June – September 2003	Federal disaster number 1499 assigned to 15 counties. The original disaster was for flooding, but several jurisdictions were included because of previous drought conditions.
March 10, 2005 Governor Declared Drought	Precipitation levels was below or much below the average from November through February, with extremely warm fall and winter months, adversely affecting the state's mountain snow pack. A warm mid-January removed much of the remaining snow pack, with March projections at 66 percent of normal, indicating that Washington might be facing a drought as bad as, or worse, than the 1977 drought. Late March rains filled reservoirs to about 95 percent. State legislature approved $12 million supplemental budget that provided funds to buy water, improve wells, and implement other emergency water supply projects. Wildfires numbers was about 75 percent of previous five years, but acreage burned was three times greater.

Table 6-1 **Drought Occurrences**	
2015	2015 was the year of the "snowpack drought." Washington State had normal or near-normal precipitation over the 2014-2015 winter season. However, October through March the average statewide temperature was 40.5 degrees Fahrenheit, 4.7 degrees above the 20th century long-term average and ranking as the warmest October through March on record. Washington experienced record low snowpack because mountain precipitation that normally fell as snow instead fell as rain. The snowpack deficit then was compounded as precipitation began to lag behind normal levels in early spring and into the summer. With record spring and summer temperatures, and little to no precipitation over many parts of the state, the snowpack drought morphed into a traditional precipitation drought, causing injury to crops and aquatic species. Many rivers and streams experienced record low flows. (See Figure 6-1.)

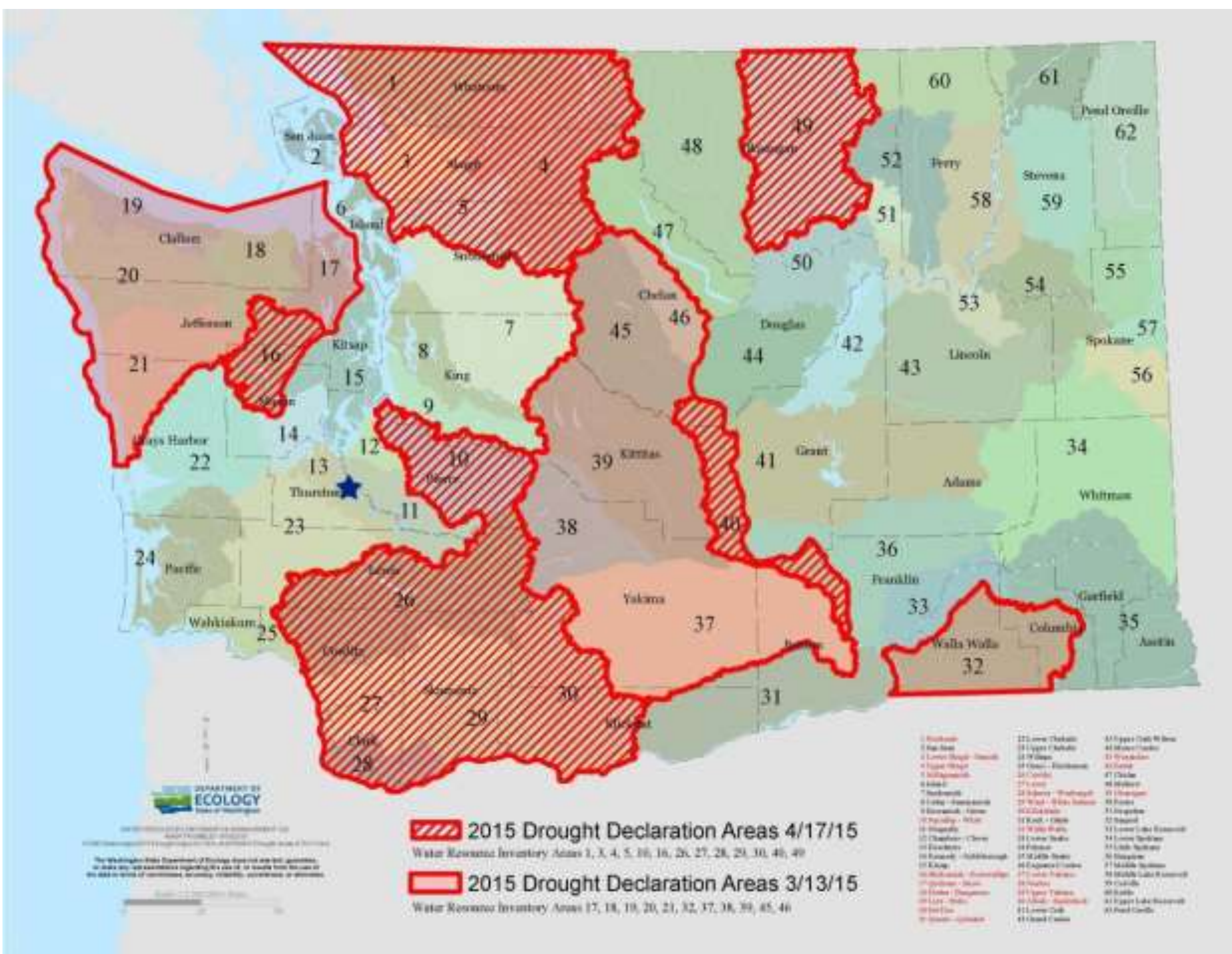


Figure 6-1 Washington State Department of Ecology 2015 Drought Map

Table 6-2
Comparison of Impacts of 1977 Drought to 2001 Drought

Impact	1977 Drought	2001 Drought
Precipitation	Precipitation at most locations ranged from 50 to 75% of normal levels, and in parts of Eastern Washington as low as 42 to 45% of normal.	Precipitation was 56 to 74% of normal. U.S. Bureau of Reclamation – Yakima Project irrigators received only 37% of their normal entitlements. At the end of the irrigation season, the Bureau of Reclamation's five reservoirs stored only 50,000 acre-feet of water compared with 300,000 acre-feet typically in storage.
Wildland Fire	1,319 wildland fires burned 10,800 acres. State fire-fighting activities involved more than 7,000 man-hours and cost more than $1.5 million.	1,162 wildland fires burned 223,857 acres. Firefighting efforts cost the state $38 million and various local, regional, and federal agencies another $100 million.
Fish	In August and September 1977, water levels at the Goldendale and Spokane trout hatcheries were down. Fish had difficulties passing through Kendall Creek, a tributary to the north fork of the Nooksack River in Whatcom County.	A dozen state hatcheries took a series of drought-related measures, including installing equipment at North Toutle and Puyallup hatcheries to address low water flow problems.
Emergency Water Permits	Department of Ecology issued 517 temporary groundwater permits to help farmers and communities drill more wells.	Department of Ecology issued 172 temporary emergency water-right permits and changes to existing water rights.
Economic Impacts	The state's economy lost an estimated $410 million over a two-year period. The drought hit the aluminum industry hardest. Major losses in agriculture and service industries included a $5 million loss in the ski industry. 13,000 jobs were lost because of layoffs in the aluminum industry and in agriculture.	The Bonneville Power Administration paid more than $400 million to electricity-intensive industries to shut down and remain closed for the duration of the drought. Thousands lost their jobs for months, including 2,000-3,000 workers at the Kaiser and Vanalco plants. Federal agencies provided more than $10.1 million in disaster aid to growers. More than $7.9 million in state funds paid for drought-related projects; these projects enabled the state to provide irrigation water to farmers with junior water rights and to increase water in fish-bearing streams.

The following information relates to the drought issue within Grays Harbor County, including years of low precipitation and snow pack, as well as sources of power, drinking water, and the fishing/tourism industry:

- Three energy curtailments resulted from drought periods prior to 1977, which caused temporary unemployment within various industry sectors.
- In the summer of 2001, the governor declared a statewide Stage 2 drought in response to the worst dry spell since records began in 1929.
- In 2003, the state and county were in another drought when the county went for over 60 days without substantial rain. The Office of the State Climatologist stated that the summer of 2003 was the driest summer (at that time) since records were officially kept.

- In March 2005, Washington Department of Ecology declared a statewide drought. The state legislature approved a $12 million supplemental budget request for buying water, improving wells, implementing other emergency water-supply projects, and hiring temporary state staff to respond to the drought emergency, conduct public workshops and undertake drought-related studies. In March, the water supply forecast was 66 percent of normal, signaling an extremely poor water year and a possible reduction in electricity production. By late spring, due to record precipitation in March and April, water filled reservoirs to about 95 percent of capacity, more than enough to meet projected electricity demands. Despite projected drought impacts of up to $300 million, unexpected spring rains combined with reallocation of water and conservation measures by farmers largely mitigated the drought's impacts. Harvest of most crops was near normal levels. While statewide harvests were near normal, local farmers who did not receive the spotty rains experienced poor harvests. Statewide, the number of wildfires was about 75 percent of average for the previous five years, but the acreage burned was three times greater. The largest – the School fire – burned 52,000 acres of state-protected lands, 109 homes and 106 other buildings in central Columbia and Garfield Counties, and cost more than $15 million to extinguish. The fire also destroyed half of the elk and bighorn sheep and a third of the deer in the Tucannon Game Management Unit. The fire's origin was traced to a dead pine tree falling over power lines, causing the lines to arc and send sparks to the ground, which ignited dry grass.
- Unlike classic droughts, characterized by extended precipitation deficits, 2015 was the year of the "snowpack drought." Washington State had normal or near-normal precipitation over the 2014-2015 winter season. However, October through March the average statewide temperature was 40.5 degrees Fahrenheit, 4.7 degrees above the 20th century long-term average and ranking as the warmest October through March on record. Washington experienced record low snowpack because mountain precipitation that normally fell as snow instead fell as rain. The snowpack deficit then was compounded as precipitation began to lag behind normal levels in early spring and into the summer. With record spring and summer temperatures, and little to no precipitation over many parts of the state, the snowpack drought morphed into a traditional precipitation drought, causing injury to crops and aquatic species. Many rivers and streams experienced record low flows. The Governor declared drought on March 13, 2015, for three regions of the state—the Olympic Peninsula, the east slopes of the central Cascades and the Walla Walla Basin. The state-level drought declaration was extended on April 17, 2015, to include more watersheds, and then was extended statewide on May 15, 2015. In May, the Water Supply Availability and Emergency Water Executive committees determined that 48 of the 62 watersheds had water supply conditions below 75 percent of normal, an area representing 85 percent of the state's geographic area (see Figure 6-1).

6.2.3 Severity

Droughts impact individuals (farm owners, tenants, and farm laborers), the agricultural industry, and other agriculture-related sectors. Lack of snow pack has forced ski resorts into bankruptcy. There is increased danger of forest and wildland fires. Millions of board feet of timber have been lost. Loss of forests and trees increases erosion, causing serious damage to aquatic life, irrigation, and power development by heavy silting of streams, reservoirs, and rivers.

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

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

- The ***Palmer Crop Moisture Index*** measures short-term drought on a weekly scale and is used to quantify drought's impacts on agriculture during the growing season.
- The ***Palmer Z Index*** measures short-term drought on a monthly scale.
-
- Figure *6-2* shows this index for July 2017.
- The ***Palmer Drought Index*** measures the duration and intensity of long-term drought-inducing circulation patterns. Long-term drought is cumulative, so the intensity of drought during a given month is dependent on the current weather patterns plus the cumulative patterns of previous months. Weather patterns can change quickly from a long-term drought pattern to a long-term wet pattern, and this index can respond fairly rapidly. Figure 6-3 shows this index for July 2017.

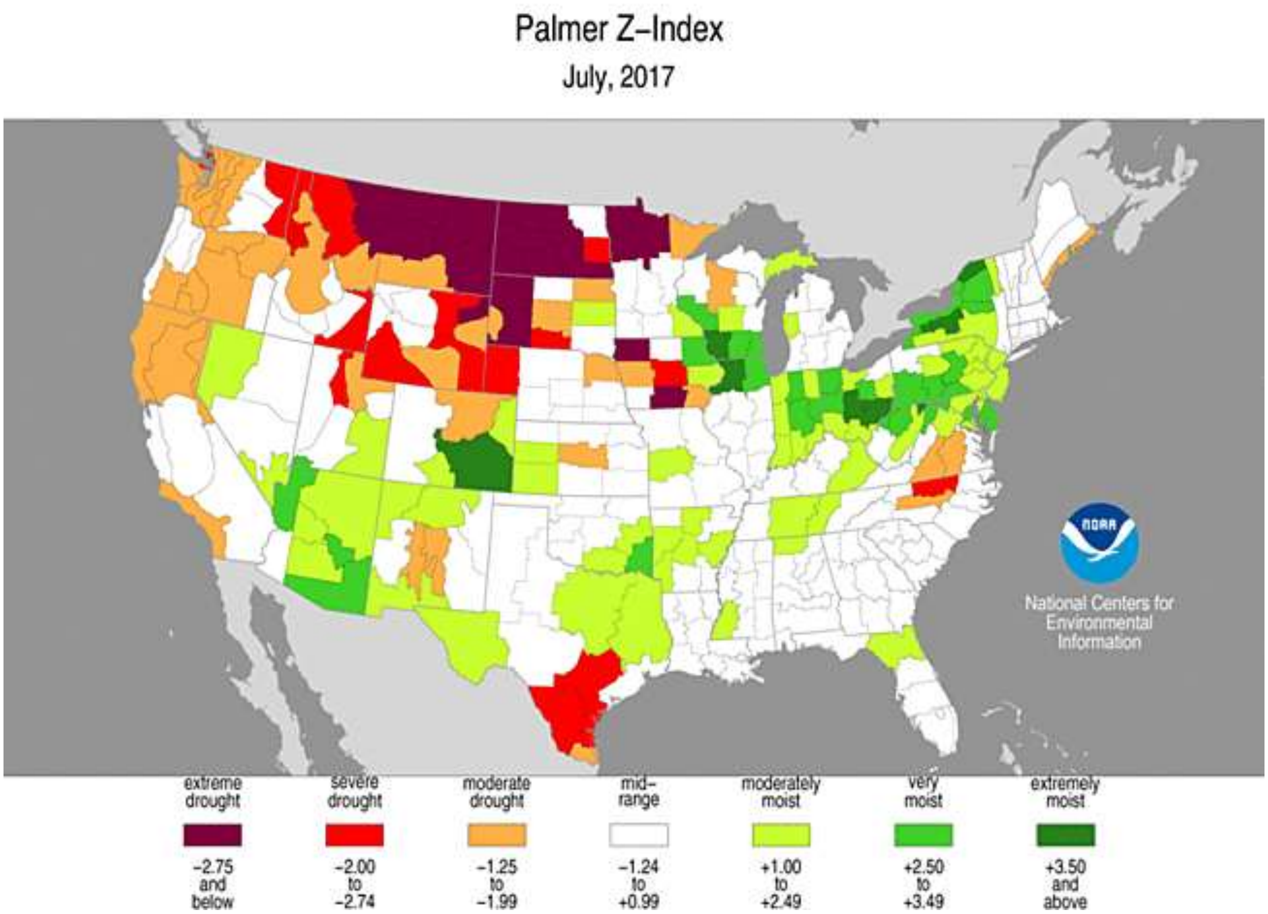


Figure 6-2 Palmer Z Index Short-Term Drought Conditions (July 2017)

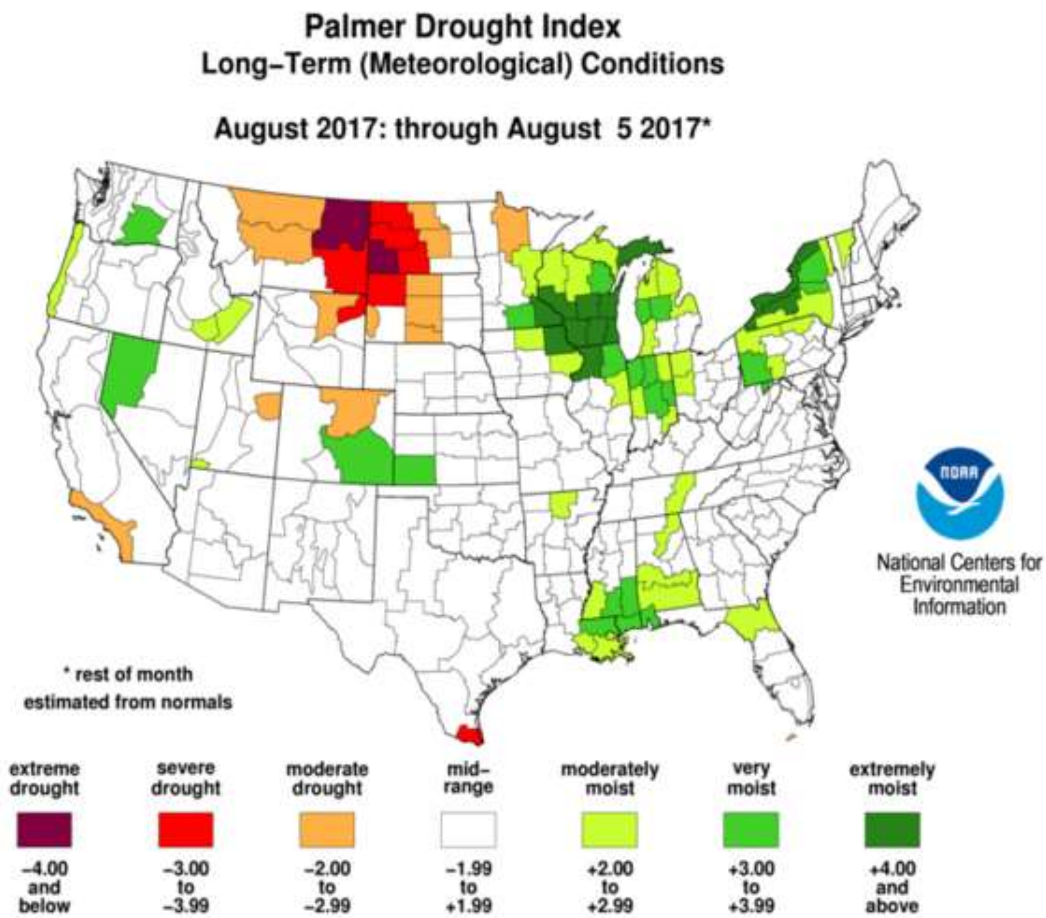


Figure 6-3 Palmer Drought Index Long-Term Drought Conditions

- The hydrological impacts of drought (e.g., reservoir levels, groundwater levels, etc.) take longer to develop and it takes longer to recover from them. The ***Palmer Hydrological Drought Index***, another long-term index, was developed to quantify hydrological effects. This index responds more slowly to changing conditions than the Palmer Drought Index.
- While the Palmer indices consider precipitation, evapotranspiration and runoff, the ***Standardized Precipitation Index*** considers only precipitation. In this index, a value of zero indicates the median precipitation amount; the index is negative for drought and positive for wet conditions. The Standardized Precipitation Index is computed for time scales ranging from one month to 24 months.

Additional information and current monthly data are available from the NOAA website: http://www.ncdc.noaa.gov/oa/climate/research/prelim/drought/palmer.html

6.2.4 Frequency

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

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

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

According to the Washington State Hazard Mitigation Plan data (2012) "At this time, reliable forecasts of drought are not attainable for temperate regions of the world more than a season in advance. However, based on a 100-year history with drought, the state as a whole can expect severe or extreme drought at least 5 percent of the time in the future, with most of eastern Washington experiencing severe or extreme drought about 10 to 15 percent of the time." (EMD, 2012)

The potential for improved drought predictions in the near future differs by region, season, and climatic regime. Based on Palmer Z Short-Term predictions (

Figure *6-2*), the planning area experienced a "moderate drought" situation within the area. Figure 6-3 demonstrates mid-range meteorological conditions for the two-year period encompassed within NOAA's long-term analysis.

6.3 VULNERABILITY ASSESSMENT

6.3.1 Overview

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

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

Methodology

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

- History of severe or extreme drought conditions:
  - The jurisdiction 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:
  - Acreage of irrigated cropland. The acreage of the jurisdiction's irrigated cropland must be in the top 20 in the state.
  - Percentage of harvested cropland that is irrigated. The percentage of the jurisdiction's harvested cropland that is irrigated must be in the top 20 in the state.
  - Value of agricultural products. The value of the jurisdiction's crops must be in the top 20 in the state.
  - Population growth greater than the state average. The 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:
  - The jurisdiction's median household income being less than 75 percent of the state median income of $51,749 in 2005.
  - The jurisdiction's 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.

Presently, Grays Harbor County is not among the nine counties referenced as vulnerable to drought in the Washington State Enhanced Hazard Mitigation Plan. The County does not meet at least five of the State's criteria to be considered vulnerable to drought.

Warning Time

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

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

Scientists do not know how to predict drought more than a month in advance for most locations. Predicting drought depends on the ability to forecast precipitation and temperature. Weather anomalies may last from several months to several decades. How long they last 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.

6.3.2 Impact on Life, Health, and Safety

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

The County and its jurisdictions have the ability to minimize impacts on residents and water consumers within the planning area should several consecutive dry years occur.

6.3.3 Impact on Property

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

6.3.4 Impact on Critical Facilities and Infrastructure

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

6.3.5 Impact on Economy

Economic impact from a drought is associated with different aspects, including potential loss of agri- and aqua-cultural production. Grays Harbor County agricultural producers are among the less than two percent of the population in the United States today that produce the food and fiber consumed by the remaining population and they do it more efficiently and at less cost to the consumer than any other industrialized country in the world. The following comparisons are from the 2012 Census of Agriculture released in May, 2014. The census also indicates that 61% of Grays Harbor County is in woodlands, 19% croplands, 8% pastureland, and 12% for other uses.[19] The county produces over 1,500 acres of vegetable crops including sweet corn and cannery peas. The county is also well known for the production of quality cut-flowers including daffodils, tulips, calla lilies, gladiolus, and dahlias. Other crops include Christmas trees, raspberries, blueberries, potatoes and beans. Cereal grain is also grown, with the majority of that in spring and winter wheat.

The County's economy ranks 28th in Washington based on the U.S. Department of Agriculture's 2012 County profile (most recent available).[20] The County also ranked 27th statewide with respect to nursery and greenhouse production. Combined, the impact from a drought situation on the County's agricultural markets for economic sustainability could be high. A drought situation such that has previously occurred statewide which impacted the fishing industry could have a negative impact on the agriculture production of the county (grains, oilseeds, dry beans and dry peas).

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

Problems of domestic and municipal water supplies have historically been corrected by building another reservoir, a larger pipeline, new well, or some other facility. With drought conditions increasing pressure on aquifers and increased pumping, which can result in saltwater intrusion into fresh water aquifers,

[19] http://extension.wsu.edu/graysharbor/wp-content/uploads/sites/18/2016/04/WSU-GH-2016-Final-2-14-17-PDF.pub_.pdf
[20] https://www.agcensus.usda.gov/Publications/2012/Online_Resources/County_Profiles/Washington/cp53027.pdf

resultant reductions or restrictions on economic growth and development could occur. Given potential political issues, a drought situation, if prolonged, could restrict building within specific areas due to lack of supporting infrastructure, thereby impacting the tax base and economy of the region by limiting growth. In addition, impact to or the lack of hydroelectric generating capacity associated with drought conditions as a result of reduced precipitation levels could raise electric prices throughout the region.

6.3.6 Impact on Environment

Environmental losses from drought are associated with aquatic life, plants, animals, wildlife habitat, air and water quality, forest fires, landscape quality, biodiversity, and soil erosion. Some effects are short-term and conditions quickly return to normal after the drought. Other effects linger or even become permanent. Wildlife habitat, for example, may be degraded through the loss of wetlands, lakes and vegetation, but many species will eventually recover from this effect. Degraded landscape quality, including soil erosion, may lead to a more permanent loss of biological productivity. Life-cycles for fish spawning in the area would have environmental impacts years into the future.

Public awareness and concern for environmental quality has led to greater attention to these effects. Drought conditions within the planning area could increase the demand for water supplies. Water shortages would have an adverse impact on the environment, relied upon by the planning partnership, causing social and political conflicts. If such conditions persisted for several years, the economy of Grays Harbor County could experience setbacks, especially in water dependent industries.

6.4 FUTURE DEVELOPMENT TRENDS

Grays Harbor County and its cities have a relatively high amount of land available (see Figure 6-4). The U.S. Department of Agriculture has indicated a 13% increase in the amount of farm lands within Grays Harbor County during the time period of 2007 to 2012 (USDA, 2012).

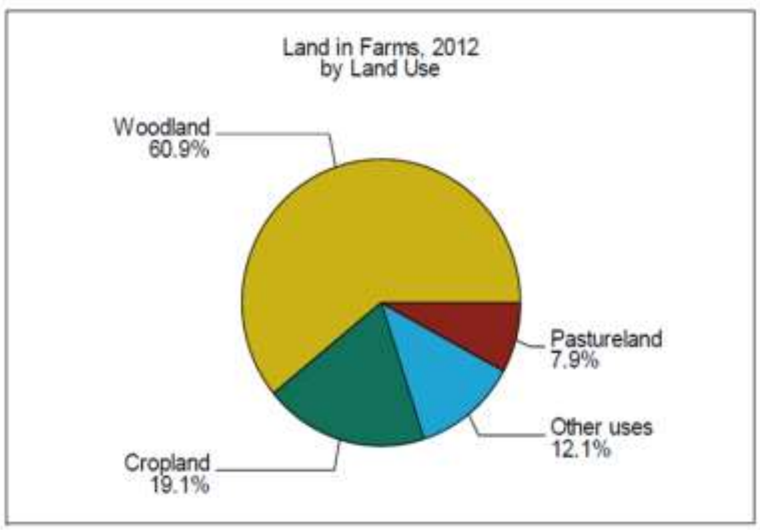


Figure 6-4 USDA Land in Farms by Land Use Type (2012)

With an increase in population, the rezoning of land from agricultural or woodland to residential would have the propensity to increase water demands, as well as increase demands on other infrastructure, and increase the potential for wildfires. The County and some of its cities have established comprehensive plans or water regulations that includes policies directing land use and dealing with issues of water supply and the protection of water resources, as well as fire regulations (e.g., Ocean Shores City Code Chapter 13.13 Water Conservation, 2005; City of Elma Comprehensive Plan, etc.). 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.

The planning area continues to move forward in developing policies directing land use and dealing with zoning, density and permitting for any new development. This will provide the capability to protect future development from the impacts of drought.

6.5 ISSUES

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

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

- The need for alternative water sources should a prolonged drought occur;
- Use of groundwater recharge 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;
- The potential impact on businesses in the area;
- The potential impact on the livelihood of those employed in industries that could be impacted by drought, such as agriculture, fishing, forestry, and tourism.

6.6 RESULTS

Based on review and analysis of the data, the Planning Team has determined that the probability for impact from Drought throughout the area is likely. The area has experienced drought conditions, with a drought incident occurring only a short period ago (2015). As of this 2017 update, the State experienced one of its driest summers on record for the last 30 years. With anticipated increase in temperatures as a result of climate change, drought situations will only intensify. With the planning area's dependence on agriculture, there is a significant potential economic loss in the region. In addition, higher temperatures anticipated with climate change would increase vulnerability of the population due to excessive heat, while also potentially impacting power supplies at the hydro-dam in the area. Based on the potential impact, the Planning Team determined the CPRI score to be 2.35, with overall vulnerability determined to be a low level.

CHAPTER 7.
EARTHQUAKE

An earthquake is the vibration of the earth's surface following a release of energy in the earth's crust. This energy can be generated by a sudden dislocation of the crust or by a volcanic eruption. Its epicenter is the point on the earth's surface directly above the hypocenter of an earthquake. The location of an earthquake is commonly described by the geographic position of its epicenter and by its focal depth. Earthquakes many times occur along a fault, which is a fracture in the earth's crust.

DEFINITIONS

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

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

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

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

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

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

7.1 GENERAL BACKGROUND

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

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

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

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

It is generally agreed that three source zones exist for Pacific Northwest quakes: a shallow (crustal) zone; the Cascadia Subduction Zone; and a deep, intraplate "Benioff" zone. These are shown in Figure 7-1. More than 90 percent of Pacific Northwest earthquakes occur along the boundary between the Juan de Fuca plate and the North American plate.

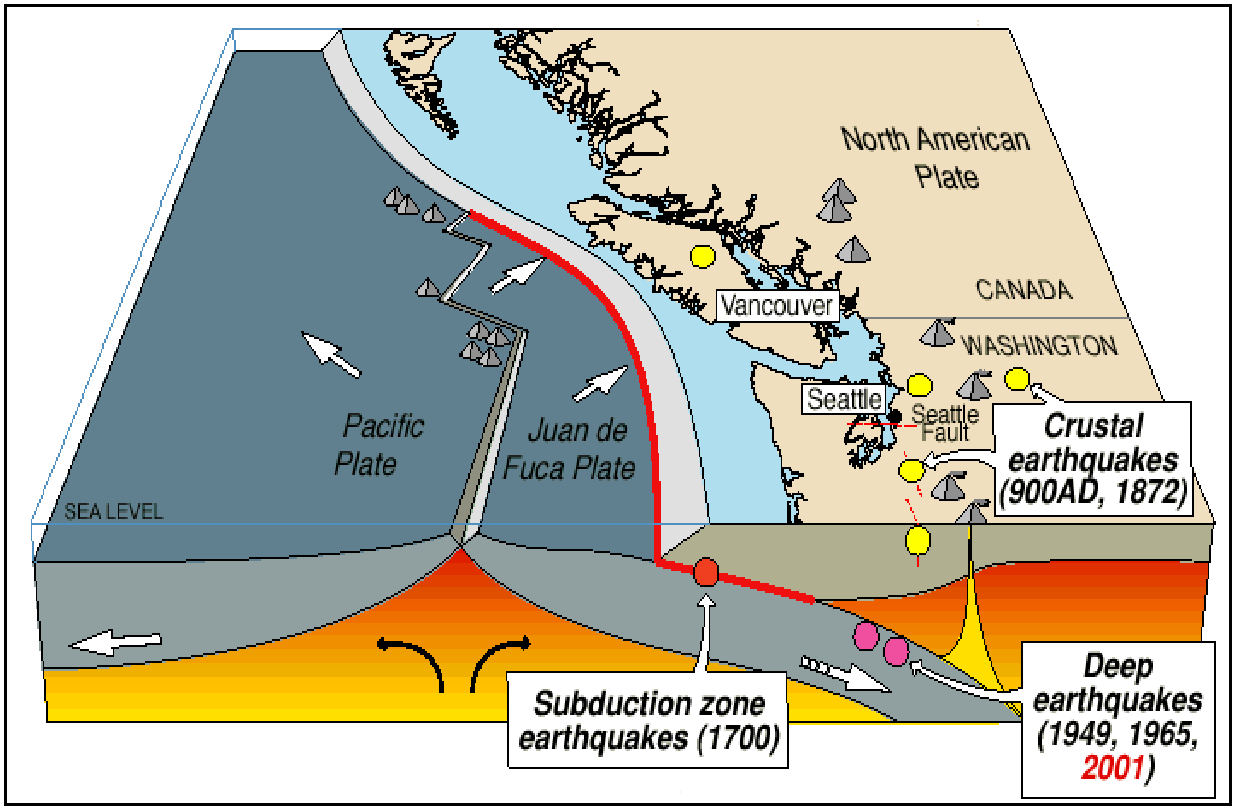


Figure 7-1 Earthquake Types in the Pacific Northwest

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

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

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

7.1.1 Earthquake Classifications

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

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

There are many measures of the severity or intensity of earthquake ground motions. The Modified Mercalli Intensity scale (MMI) (Table 7-1) was widely used beginning in the early 1900s. MMI is a descriptive, qualitative scale that relates severity of ground motions to the types of damage experienced. MMI values range from I to XII (USGS, 1989):

TABLE **7-1** MODIFIED MERCALLI INTENSITY (MMI) SCALE DESCRIPTIONS

MMI VALUE	**Description**
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.

TABLE **7-1** MODIFIED MERCALLI INTENSITY (MMI) SCALE DESCRIPTIONS

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.
X	Damage total. Lines of sight and level are distorted. Objects thrown into the air.

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

Ground Motion

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

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

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

PGA is the basis of seismic zone maps that are included in building codes such as the International Building Code. Grays Harbor County's Seismic Zone Map is figured right.[21] Building codes that include seismic provisions specify the horizontal force due to lateral acceleration that a building should be able to withstand during an earthquake. PGA values are directly related to these lateral forces that could damage "short period structures" (e.g. single-family dwellings). Longer period response components determine the lateral forces that damage larger structures with longer natural periods (apartment buildings, factories, high-rises, bridges). The amount of earthquake damage and the size of the geographic area affected generally increase with earthquake magnitude:

Figure 7-2 Grays Harbor County Seismic Zone Map

- Earthquakes below M5 are not likely to cause significant damage, even near the epicenter.
- Earthquakes between about M5 and M6 are likely to cause moderate damage near the epicenter.
- Earthquakes of about M6.5 or greater (e.g., the 2001 Nisqually earthquake in Washington) can cause major damage, with damage usually concentrated fairly near the epicenter.
- Larger earthquakes of M7+ cause damage over increasingly wider geographic areas with the potential for very high levels of damage near the epicenter.
- Great earthquakes with M8+ can cause major damage over wide geographic areas.

[21] http://www.co.grays-harbor.wa.us/docs/16ClimateGeographicDesignCriteria.pdf

- An M9 mega-quake on the Cascadia Subduction Zone could affect the entire Pacific Northwest from British Columbia, through Washington and Oregon, and as far south as Northern California, with the highest levels of damage nearest the coast.

Table 7-2 lists damage potential and perceived shaking by PGA factors, compared to the Mercalli scale.

Table 7-2
Comparison of Mercalli Scale and Peak Ground Acceleration

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

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

Sources: USGS, 2008; USGS, 2010

7.1.2 Effect of Soil Types

Liquefaction is a secondary effect of an earthquake in which soils lose their shear strength and flow or behave as liquid, thereby damaging structures that derive their support from the soil. Liquefaction generally occurs in soft, unconsolidated sedimentary soils. The National Earthquake Hazard Reduction Program (NEHRP) creates maps based on soil characteristics to help identify locations subject to liquefaction. Table 7-3 summarizes NEHRP soil classifications. NEHRP Soils B and C typically can sustain ground shaking without much effect, dependent on the earthquake magnitude. Areas that are commonly most affected by ground shaking and susceptible to liquefaction have NEHRP Soils D, E and F.

Table 7-3
NEHRP Soil Classification System

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

Table 7-4
Acres of NEHRP Soil Classification by Type Countywide

NEHRP Soil Type	Description	Mean Shear Velocity to 30 Meters (m/s)	# of Acres within Grays Harbor County	# of Acres w/in Aberdeen	# of Acres w/in Cosmopolis	# of Acres w/in Elma	# of Acres w/in Hoquiam	# of Acres w/in McCleary	# of Acres w/in Montesano	# of Acres w/in Oakville	# of Acres w/in Ocean Shores	# of Acres w/in Unincorporated Grays Harbor County
A	Hard Rock	1,500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B	Firm to Hard Rock	760-1,500	505,727.0	2,989.7	58.8	97.5	779.3	525.5	4,645.6	2.1	0.0	496,901.4
C	Dense Soil/Soft Rock	360-760	194,037.3	81.5	0.0	0.0	1,422.4	0.0	539.2	0.0	0.0	191,994.2
D	Stiff Soil	180-360	411,096.5	0.6	0.0	947.3	0.0	1,044.4	991.9	273.4	5,254.4	400,302.1
E	Soft Clays	< 180	122,701.2	3,986.1	846.6	195.3	4,022.2	30.6	507.5	51.3	391.0	112,642.0
F	Special Study Soils (liquefiable soils, sensitive clays, organic soils, soft clays >36 m thick)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

7.1.3 Fault Classification

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

- Class A—Geologic evidence demonstrates the existence of a Quaternary fault of tectonic origin, whether the fault is exposed by mapping or inferred from liquefaction or other deformational features.
- Class B—Geologic evidence demonstrates the existence of Quaternary deformation, but either (1) the fault might not extend deep enough to be a potential source of significant earthquakes, or (2) the currently available geologic evidence is too strong to confidently assign the feature to Class C but not strong enough to assign it to Class A.
- Class C—Geologic evidence is insufficient to demonstrate (1) the existence of tectonic faulting, or (2) Quaternary slip or deformation associated with the feature.

- Class D—Geologic evidence demonstrates that the feature is not a tectonic fault or feature; this category includes features such as joints, landslides, erosional or fluvial scarps, or other landforms resembling fault scarps but of demonstrable non-tectonic origin.

7.2 HAZARD PROFILE

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

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

7.2.1 Extent and Location

Washington State as a whole is one of the most seismically active states in United States. Figure 7-3 depicts the faults and seismogenic folds known or suspected to be active according to the 2013 Washington State Hazard Mitigation Plan.

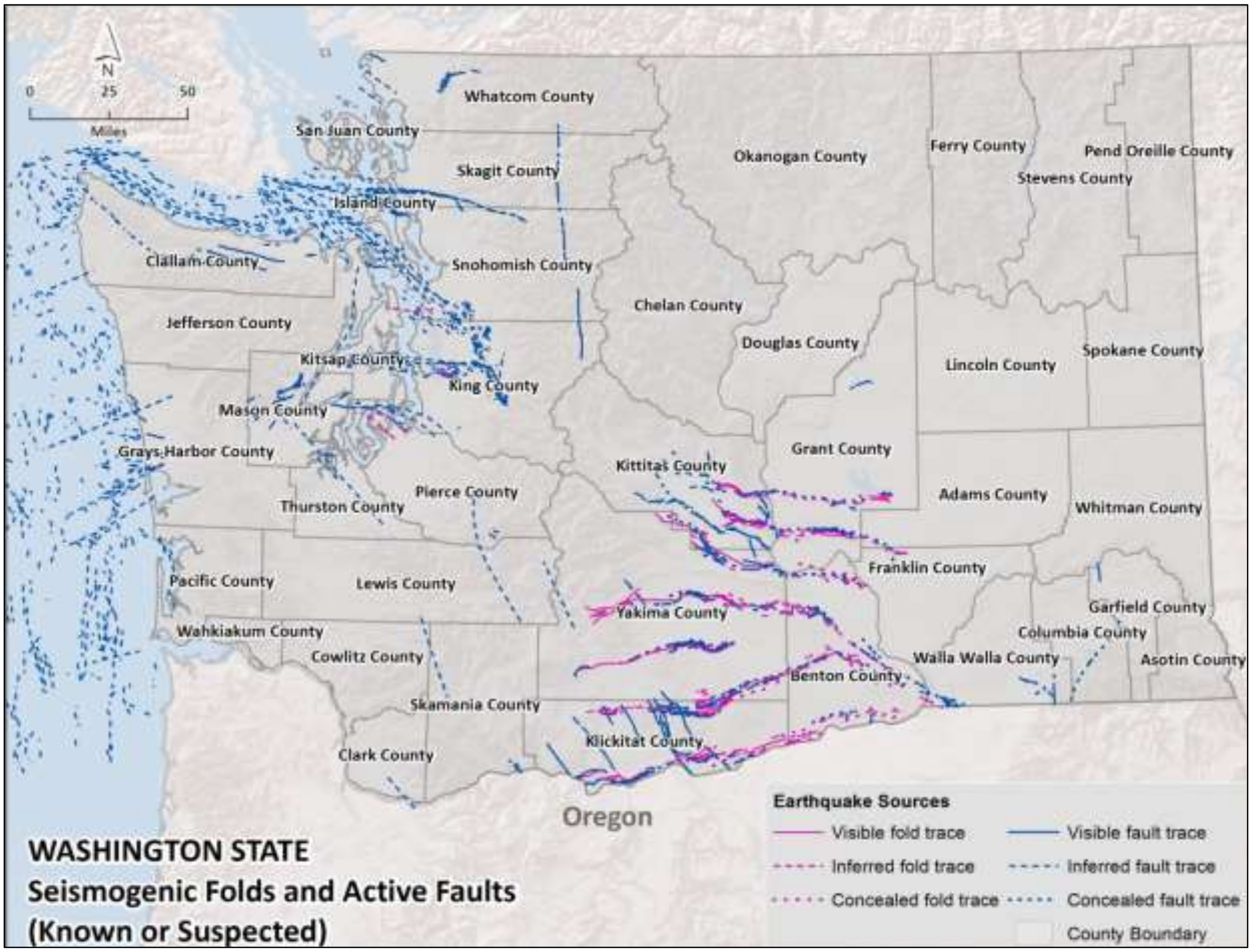


Figure 7-3 Washington State Seismogenic Folds and Active Faults

Local Faults

There are a number of faults running near or through Grays Harbor County (see

Figure 7-4), including the Grays Harbor Fault Zone, the Willapa Bay Fault Zone, Saddle Hills Fault Zone, Langley Hill fault, and Canyon Creek fault, which is located north and east in the County, bordering Mason County near the Olympic National Forest. The Saddle Mountain fault was first recognized in the early 1970's. Drowned trees and trench excavations demonstrate that the fault produced a MW 6.5-7.0 earthquake 1,000-1,300 years ago, likely occurring with the MW 7.5 Seattle fault earthquake 1,100 years ago. Additional earthquakes have been modeled on a hypothesized earthquake linking the Canyon River and Saddle Mountain faults, but further work is needed to demonstrate the feasibility of this source. Additionally, because the fault has only been demonstrated to be in the northeast corner of Grays Harbor County, far from the built environment, the scenario generates only minor estimated damage. Additional information is available from Washington State Department of Natural Resources Scenario catalogue, available at: https://fortress.wa.gov/dnr/seismicscenarios/index.html?config=canyonRiver.xml).

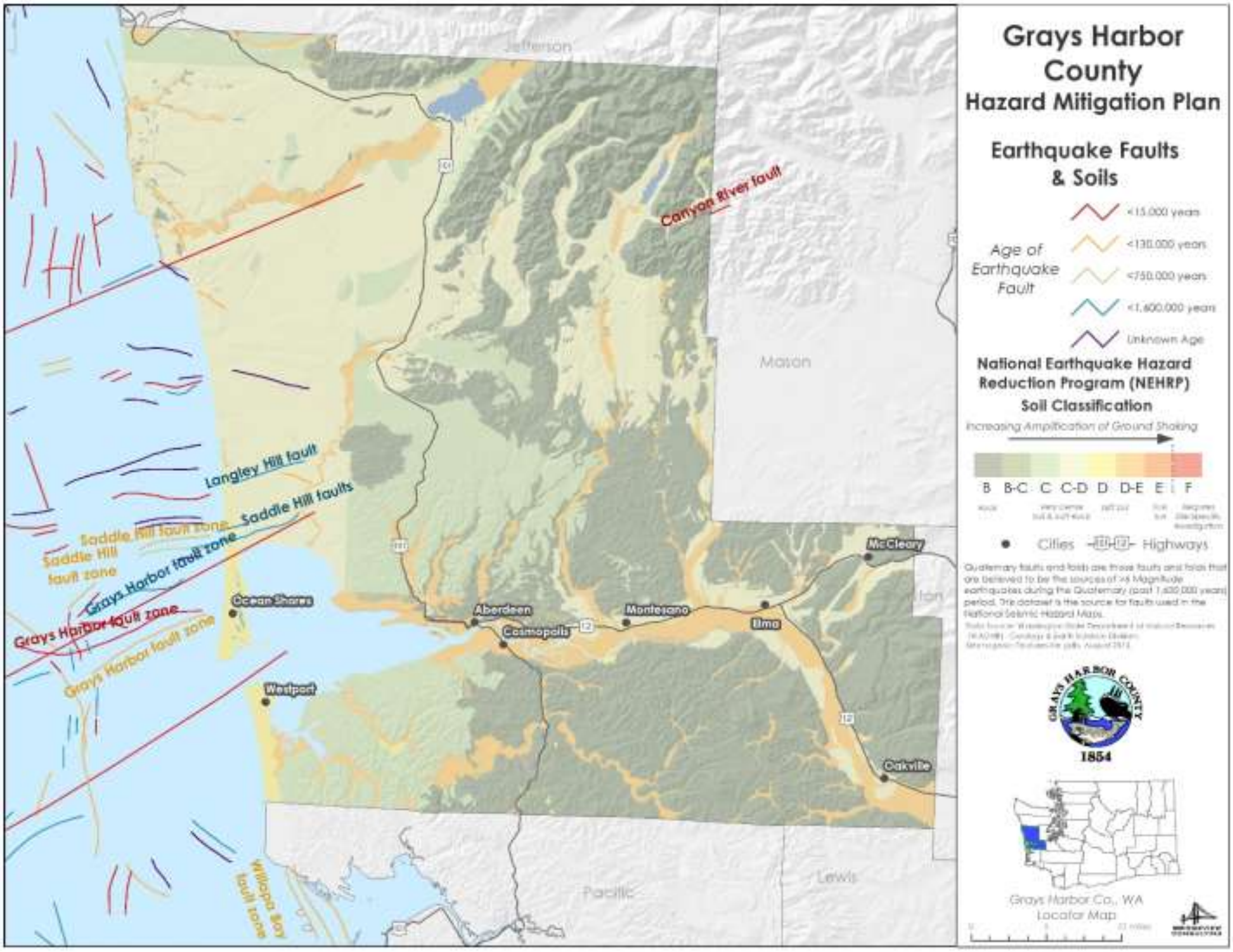


Figure 7-4 Grays Harbor County Faults and Soils Classifications
Source: USGS, 2015a

Hazard Mapping

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

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

Mapping that shows the impacts of these components was used to assess the risk of earthquakes within the planning area. While the impacts from each of these components can build upon each other during an earthquake event, the mapping looks at each component individually. The mapping used in this assessment is described below.

ShakeMaps

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

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

- A probabilistic seismic hazard map shows the hazard from earthquakes that geologists and seismologists agree could occur. The maps are expressed in terms of probability of exceeding a certain ground motion, such as the 10 percent probability of exceedance in 50 years. This level of ground shaking has been used for designing buildings in high seismic areas. Hazard maps for the 100-year and 500-year probabilistic earthquakes are shown on Figure 7-5 and Figure 7-6.
- Earthquake scenario maps describe the expected ground motions and effects of hypothetical large earthquakes for a region. Maps of these scenarios can be used to support all phases of emergency management. The Cascadia Subduction Zone Earthquake (Figure 7-7 and Figure 7-8) was chosen for this plan. Figure 7-8 is selected from FEMA's 2015 Risk Report.

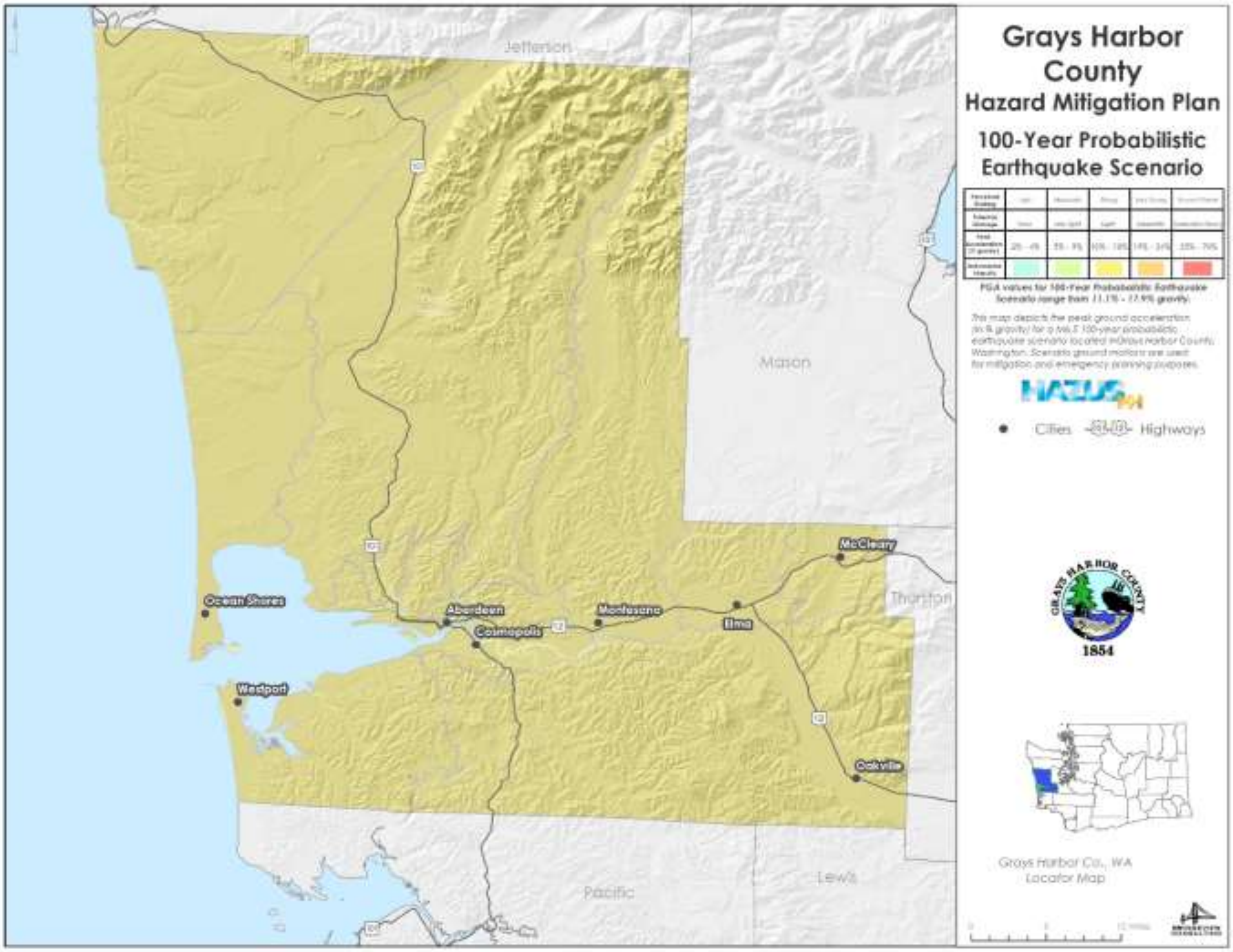


Figure 7-5 100-Year Probabilistic Earthquake Event

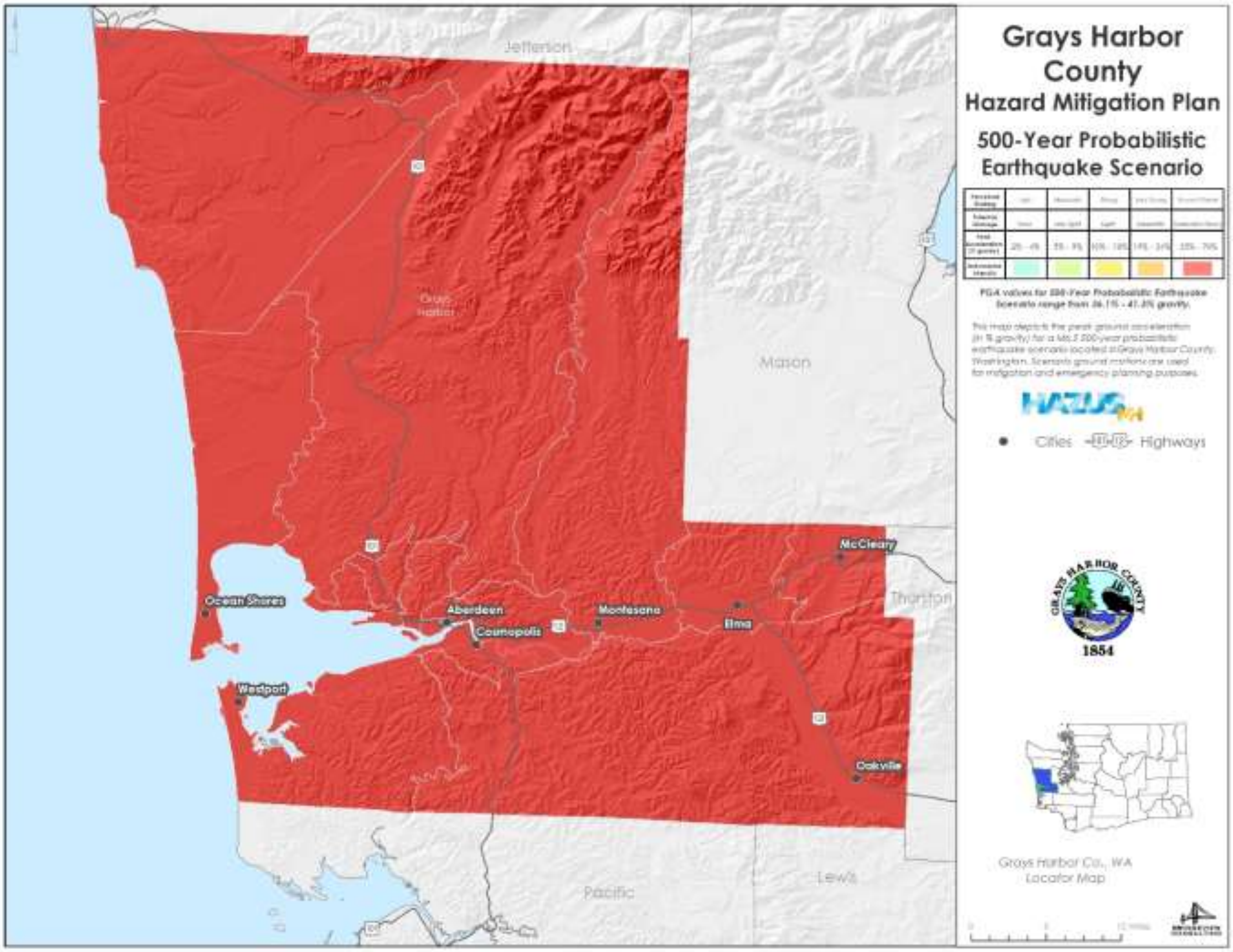


Figure 7-6 500-Year Probabilistic Earthquake Event

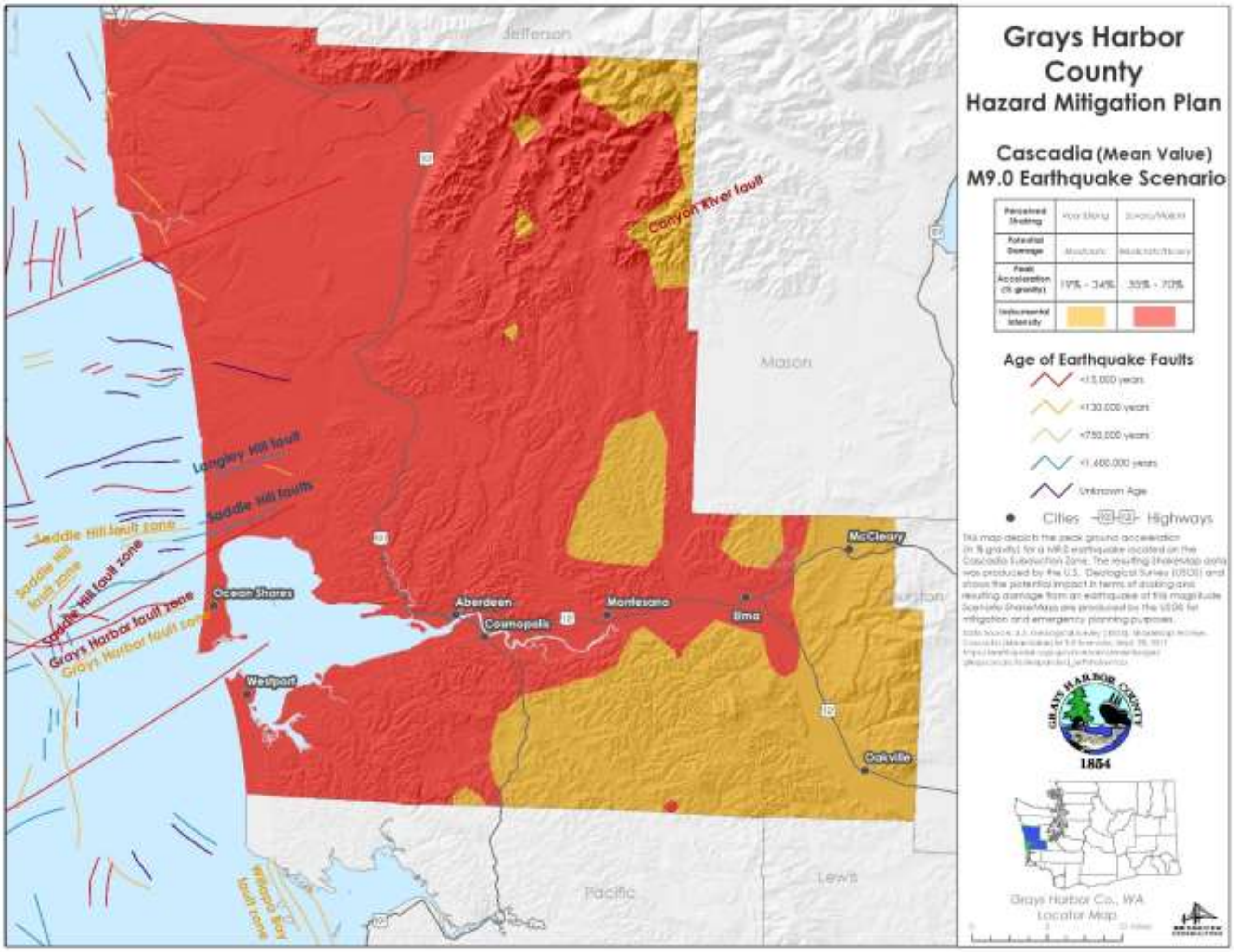


Figure 7-7 Cascadia M9.0 Fault Scenario

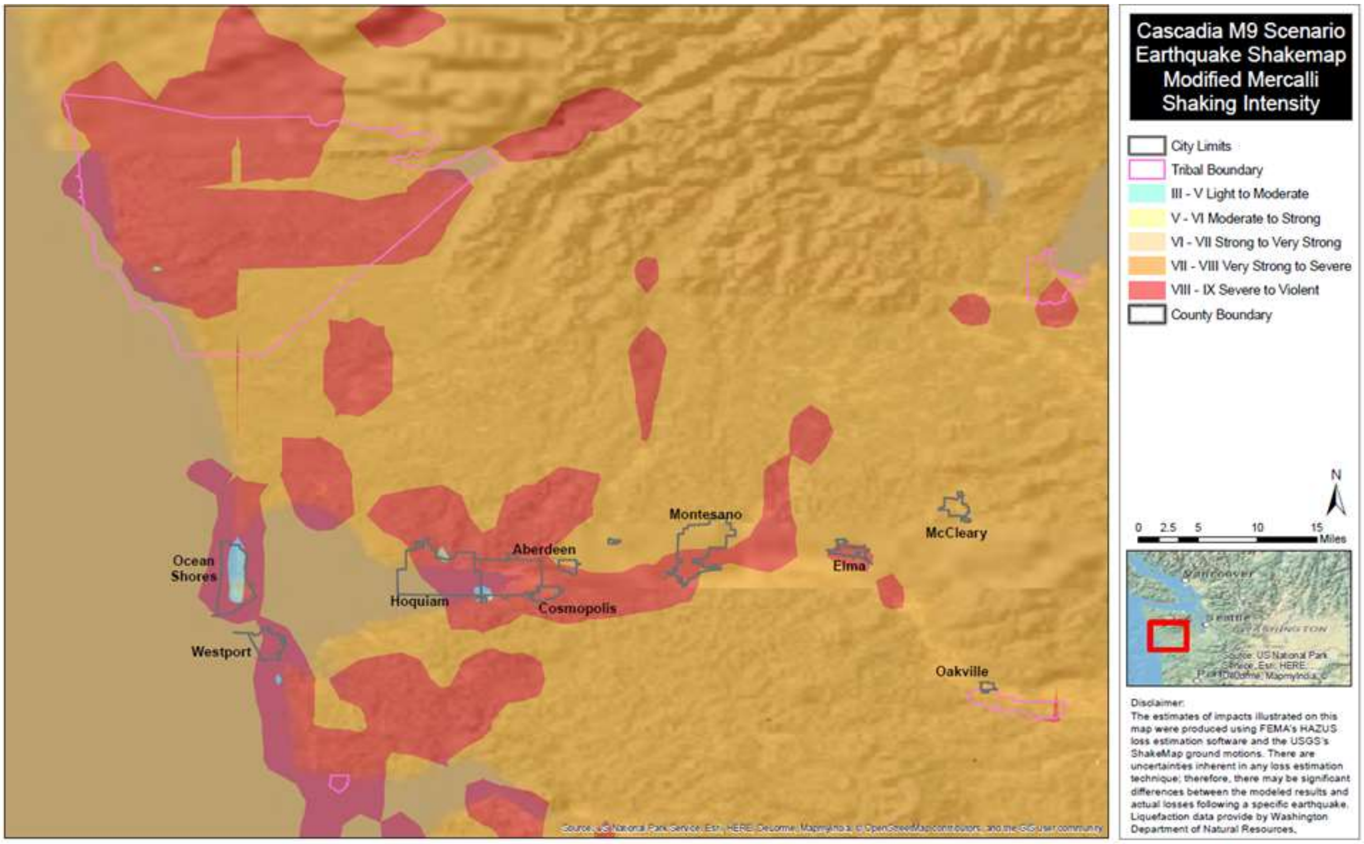


Figure 7-8 USGS ShakeMap Cascadia M9 Scenario Mercalli Scale Shaking Intensity

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 7-4 (above) identifies the various NEHRP soil classifications in Grays Harbor 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 susceptible to liquefaction. If there is a dry soil crust, excess water will sometimes come to the surface through cracks in the confining layer, bringing liquefied sand with it and creating sand boils. Figure 7-9 shows liquefaction susceptibility throughout the County.

Based on FEMA analysis completed in association with the Risk Map Project, FEMA identified potential structure losses associated with moderate-high liquefaction zones in Grays Harbor County as identified in Table 7-5 (FEMA Risk Report, 2015).

The earthquake risk assessment was completed using local parcel data from the County, as well as the Cascadia ShakeMap identified in Figures 7-7 and 7-8 above. For this study, individual building/parcel data from the county were incorporated into Hazus to report losses at the building level. (Please refer to FEMA's

2017 RiskMap Report for the detailed methodology on incorporating local data into Hazus.) The results of the analysis completed are summarized in Table 7-5.

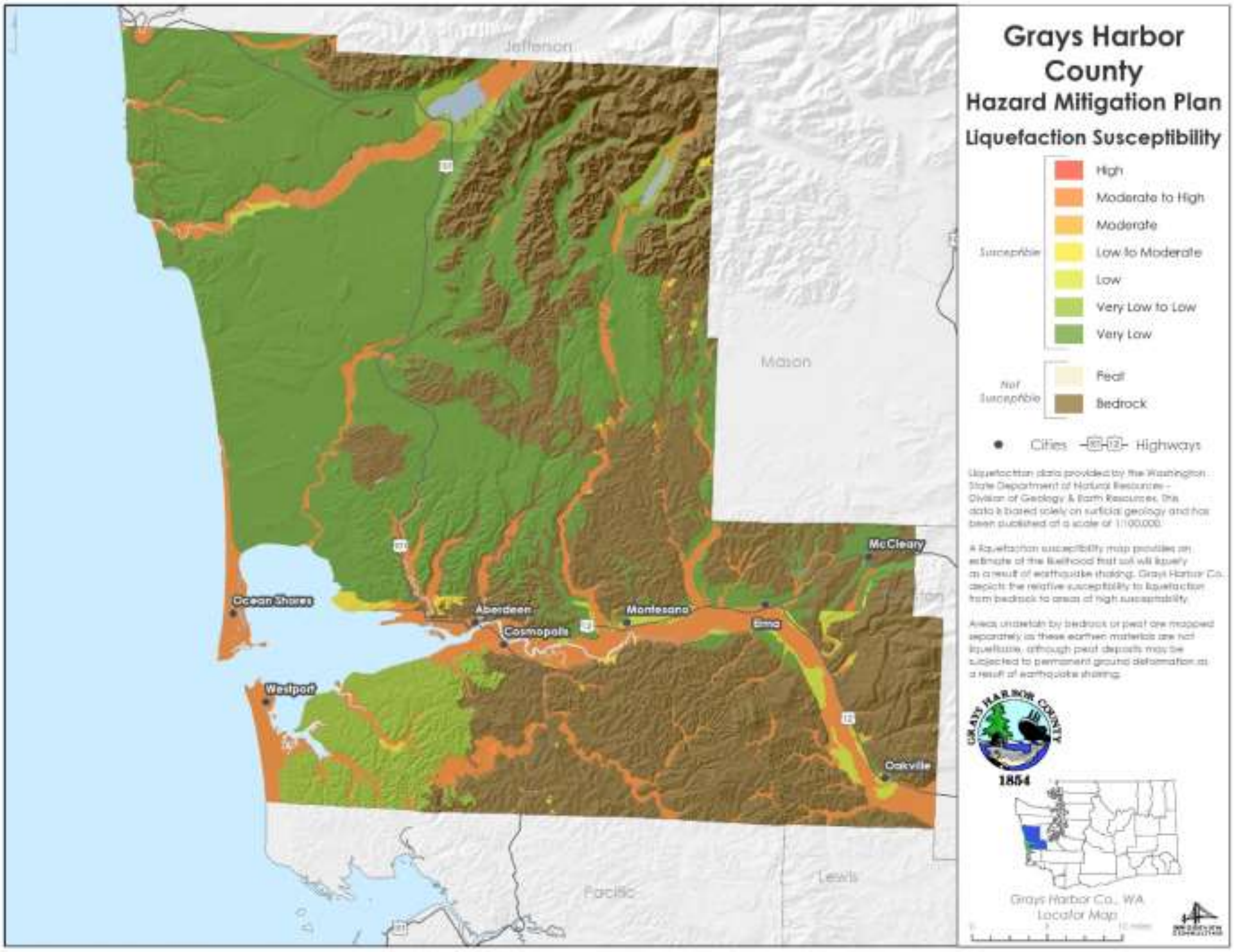


Figure 7-9 Liquefaction Susceptibility Zones

Table 7-5
Potential Building Impact From Liquefaction Zones In Grays Harbor County

Community	Total Estimated Building Value	Percent of Buildings in the Moderate-High Liquefaction Zone	Number of Buildings in the Moderate – High Liquefaction Zone	Loss Ratio (Dollar Losses/Total Building Value)
Unincorporated County	$1.8 Billion	12%	4,088	22%
Aberdeen	$872 Million	32%	4,664	32%
Cosmopolis	$119 Million	2%	714	24%
Elma	$189 Million	< 1%	45	24%

Table 7-5
Potential Building Impact From Liquefaction Zones In Grays Harbor County

Community	Total Estimated Building Value	Percent of Buildings in the Moderate-High Liquefaction Zone	Number of Buildings in the Moderate – High Liquefaction Zone	Loss Ratio (Dollar Losses/Total Building Value)
Hoquiam	$373 Million	83%	3,148	37%
McCleary	$80 Million	3%	0	14%
Montesano	$261 Million	< 1%	63	21%
Oakville	$38 Million	< 1%	20	16%
Ocean Shores	$722 Million	2%	4,543	23%
Westport	$181 Million	7%	1,281	21%
Total	**$4.1 Billion**		**18,566**	**25%**

Note: The above table shows the total estimate building value by community, and the percent and number of buildings in the high liquefaction zone. In addition, building losses are reported for a Cascadia 9.0 event as well as a loss ratio. A loss ratio is calculated by dividing the dollar loss by the total building value. The loss values are for building losses only; additional damages to infrastructure and building contents are not captured in this table. Figures are rounded up.

7.2.2 Previous Occurrences

Although earthquakes have been reported in Grays Harbor County from as early as the 1872 North Cascades quake, no earthquake creating major damage has been definitively identified within the county prior to the advent of the Puget Sound Seismic Network in 1969.

A 1944 earthquake did cause minor damage around Grays Harbor College, but it was presumably a local event.

The largest recorded earthquakes in Grays Harbor County were the July 3, 1999, M_w5.8 and the June 10, 2001, M_w5.0 Satsop quakes. These were located 5-10 miles north of Satsop, at depths of about 25 miles, which makes them Benioff Zone events, a type of earthquake that takes place in the subducting crust.

Figure 7-10 1999 Earthquake Courthouse Damage

There were no fatalities, but there was heavy damage to the Grays Harbor County Courthouse. The PUD Station in Aberdeen, which is the main connection between Grays Harbor and the Bonneville Power Administration, was also damaged, causing power outages in Aberdeen and Hoquiam. It was the deepest earthquake in the area in 20 years. Considering the magnitude and proximity to so many buildings and structures the total cost of damage was not very high. Costs included: County Road System, $12,500; Public Buildings & Equipment, $10,000,000 and damage to the private sector, $1,115,000 for a total of $1,457,500.

The Nisqually earthquake occurred February 2, 2001 with the epicenter about 11 miles northeast of the City of Olympia. It was a deep magnitude 6.8 event and due to extensive damage in several counties, was declared Federal Disaster #1361. Impacts included major traffic tie-ups in East County as cars were rerouted around damage in other counties, small power outages and temporary closure of state offices. Highway 12 near Porter was closed for a while and there were reports of minor buckling and cracks on local roads. Cracks in buildings and falling bricks also resulted from the shaking.

The largest earthquake threat to the county would likely be from a Cascadia subduction zone earthquake. Abundant physical evidence for an earthquake in AD 1700 includes evidence for abrupt tectonic subsidence along the Copalis River (cover photo) and subsequent drowning of a spruce and cedar forest. This event was probably about M9 and is the largest earthquake in Grays Harbor County in the historic or paleoseismic record. The evidence for this earthquake is documented in Atwater and others (2005) and Goldfinger and others (2012). This fault has an average recurrence interval of approximately 500 years for earthquakes of about M9.

Based on geologic evidence along the Washington coast, the Cascadia Subduction Zone has ruptured and created tsunamis at least seven times in the past 3,500 years and has a considerable range in recurrence intervals, from as little as 140 years between events to more than 1,000 years. The last Cascadia Subduction Zone-related earthquake is believed to have occurred on January 26, 1700, and researchers predict a 10 to 14 percent chance that another could occur in the next 50 years.

Table 7-6 lists past seismic events that have affected the areas in and around Grays Harbor County.[22] Those which directly impacted the county are highlighted. The county has received one disaster declaration as a result of earthquake damage – the Nisqually Earthquake, which occurred on February 28, 2001. Figure 7-11 is a newspaper article concerning the 1946 earthquake impacting the area, while Figure 7-12 (source unknown) illustrates impact from the April 29, 1965 earthquake.

Table 7-6
Historical Earthquakes Impacting The Planning Area

Year	Magnitude	Epicenter	Type
8/26/2004	3.5	Unknown*	Shallow Crustal
2/28/2001 (DR 1361)	6.8	Olympia (Nisqually)	Benioff
6/10/2001	5.0	Matlock	Benioff
7/3/1999	5.8	8.0 km N of Satsop	Benioff
8/1997	3.4	Unknown*	Unknown
6/23/1997	4.7	Bremerton	Shallow Crustal
5/3/1996	5.5	Duvall	Shallow Crustal
1/29/1995	5.1	Seattle-Tacoma	Shallow Crustal
10/25/1991	3.4	Unknown*	Unknown
8/23/1982	3.6	Unknown*	Unknown
2/14/1981	5.5	Mt. St. Helens (Ash)	Crustal
9/9/76	4.5	Union	Benioff Zone (28 miles deep)
12/13/1971	3.6	Unknown*	Unknown
5/11/1965 (DR 196)	6.6	18.3 KM N of Tacoma	Benioff
4/29/1965	6.5	12 miles North of Tacoma	Benioff
4/13/1949	7.1	Olympia*	Unknown
1/13/1949	7.0	12.3 KM ENE of Olympia	Benioff
6/23/1946	7.3	Strait of Georgia	Benioff

[22] PNSN, 2017

Table 7-6 **Historical Earthquakes Impacting The Planning Area**			
Year	**Magnitude**	**Epicenter**	**Type**
2/14/1946	6.3	Puget Sound	Benioff
4/1945	5.7	Northbend (8 miles south/southeast)	Unknown
11/13/1939	5.8	Puget Sound – Near Vashon Island	Unknown
1932	5.3	Central Cascades	Unknown
1/23/1920	5.5	Puget Sound	Unknown
12/6/1918	7.0	Vancouver Island	Unknown
8/18/1915	5.6	North Cascades	Unknown
1/11/1909	6.0	Puget Sound (Grays Harbor Earthquake)	Unknown
3/6/1904		Washington coastline Aberdeen to Hoquiam*	Unknown
11/30/1891		Slight earthquake felt in County*	Unknown
3/27/1884		Hoquiam*	Unknown
4/30/1882	5.8	Olympia area	Unknown
12/12/1880		2 shocks felt*	Unknown
12/15/1872	6.8	Pacific Coast	Unknown

*Earthquake Events identified in 2011; no further data available.
Source: Pacific Northwest Seismic Network


British, French Troops Violate Sovereignty of Levant, Say Russ
SECOND QUAKE WAKENS SLEEPERS!
GREEN RAPS NEW PRICE-WAGE PLAN
CLOUDY; COOLER
The Seattle Daily Times
SUNSET FINAL
LATEST CITY NEWS
WHERE BRICK WALL FELL IN QUAKE
MOST OF STATE BADLY SHAKEN; LOSSES HEAVY
Lebanon Asks Immediate Removal Of All Forces
Daily No-Stop L. A.-to-N. Y. Flights Begin
U. S. ASKS DATA
1 Dead, 17 Hurt As Police Rout
FLYER, BAILING
F. R., Handed Note, Dec. 6,
Asylum Aides Quit; Patients Roam Streets

Figure 7-11 Seattle Times Article - February 14, 1946 Earthquake

Figure 7-12 April 29, 1965 Earthquake

7.2.3 Severity

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

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

USGS ground motion maps based on current information about fault zones show the PGA that has a certain probability (2 or 10 percent) of being exceeded in a 50-year period. The PGA is measured in %g. Figure 7-13 shows the PGA with a 2 percent exceedance chance in 50 years in Washington.

Effects of a major earthquake in the Puget Sound basin area could be catastrophic, providing the worst-case disaster short of drought-induced wild fire sweeping through a suburban area. Hundreds of residents could be killed and a multitude of others left homeless.

Although recorded damage sustained to date in Grays Harbor County has been relatively minor and has been restricted to some incidence of cracked foundations, walls and chimneys, and damage to private wells, depending on the time of day and time of year, a catastrophic earthquake could cause hundreds of injuries, deaths and hundreds of thousands of dollars in property damage.

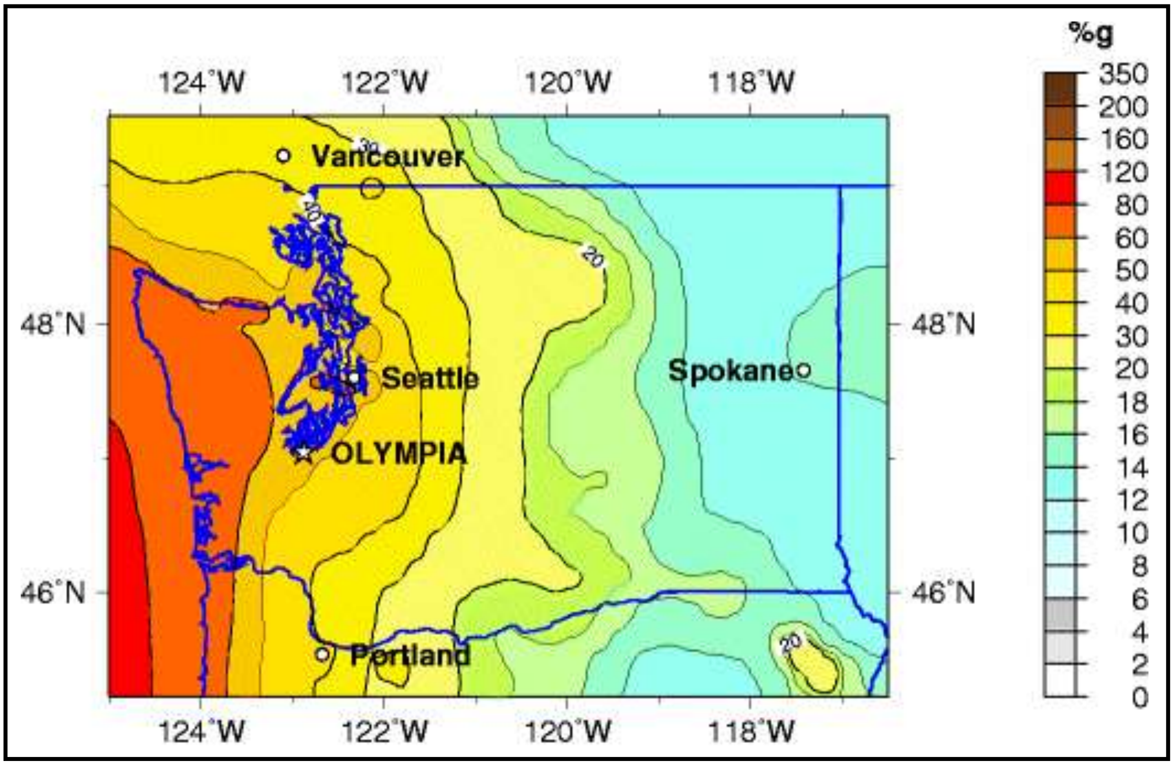


Figure 7-13 PGA with 2-Percent Probability of Exceedance in 50 Years, Northwest Region

7.2.4 Frequency

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

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

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

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

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

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

7.3 VULNERABILITY ASSESSMENT

7.3.1 Overview

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

Methodology

Earthquake vulnerability data was generated using a Level 2 Hazus analysis. Once the location and size of an 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.

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.

7.3.2 Impact on Life, Health, and Safety

The entire population of the planning area is potentially exposed to direct and indirect impacts from earthquakes. Two of the most vulnerable populations to a disaster incident such as this are the young and the elderly. Grays Harbor County has a fairly high population of retirees and individuals with disabilities, both higher than the state averages. The need for increased rescue efforts and/or to provide assistance to such a large population base could tax the first-responder resources in the area during an event. Although many injuries may not be life-threatening, people will require medical attention and, in many cases, hospitalization. Potential life-threatening injuries and fatalities are expected; these are likely to be at an increased level if an earthquake happens during the afternoon or early evening.

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

The number of people without power or water will be high, especially given the number of wells on which the County and its jurisdictions rely to supply water to individuals who most likely do not have generators to run pumps on the wells. This need will increase the number of individuals seeking shelter assistance.

7.3.3 Impact on Property

There are over 33,727 buildings in the planning area, with an estimated replacement value of $4.1 billion (structure only). Most of the buildings are residential, and most of the building stock is of considerable age and not supported by building codes which increase resilience to seismic events. Portions of these buildings are constructed out of unreinforced masonry; many have chimneys that may be in need of repair, and many, because of the age of the building stock, may contain some level of asbestos in building components such as the boiler room, ceiling tiles, carpeting, or glue. Since all structures in the planning area are susceptible to earthquake impacts to varying degrees (including liquefaction and landslides), these figures represent total numbers region-wide for property exposure to seismic events.

Property losses were estimated through the Level 2 Hazus analysis for the Cascadia earthquake scenario events (utilizing the USGS/Washington State Department of Natural Resources scenario catalog data and FEMA GIS datasets). A summary of the total potential building-related loss is identified below in Table 7-6 (above) and Table 7-7.[23] It should be noted that in some instances, such as with pump houses, no separate content value is associated with the structures, as the structure value is inclusive of the mechanisms affixed to the ground within those structures.

[23] FEMA 2015 Risk Report Data

Table 7-7 Hazus Results Cascadia M9.0 Earthquake Scenario Event

Jurisdiction	Estimated 2017 Population (1)	Estimated Building Count (2)	Total Building Value (Structure and Contents) (2)	Cascadia M9.0 Earthquake Event – Building Impact: Building Economic Impact from a 9.0 Cascadia Fault Earthquake Event (3)	% of Total Value	Average Building Functionality at Day 1 (%)	Average Building Functionality at Day 90 (%)
City of Aberdeen	16,740	6,331	$1,558,813,283	$277,885,569	17.83%	8.7	98.6
City of Cosmopolis	1,660	740	$219,110,855	$29,481,124	13.45%	15.0	98.7
City of Elma	3,145	1,225	$345,049,384	$45,501,729	13.19%	17.9	99.0
City of Hoquiam	8,560	3,457	$668,170,030	$138,333,238	20.70%	4.5	97.4
City of Mccleary	1,695	664	$138,539,384	$11,272,737	8.14%	29.2	99.9
City of Montesano	4,120	1,554	$433,872,272	$54,879,088	12.65%	21.4	99.5
City of Oakville	690	331	$66,998,060	$6,068,428	9.06%	27.8	99.8
City of Ocean Shores	6,055	4,600	$1,156,337,793	$167,877,311	14.52%	14.3	96.4
City of Westport	2,115	1,291	$310,030,743	$38,300,687	12.35%	20.5	98.2
Unincorporated Grays Harbor County	28,190	12,816	$3,122,630,417	$384,750,998	12.32%	17.8	98.3
Other(4)	N/A	718	$177,559,756	$17,123,158	9.64%	23.9	99.6
Grays Harbor County	**72,970**	**33,727**	**$8,197,111,976**	**$1,171,474,067**	**14.29%**	**18.3**	**98.7**

Source: (1) Population numbers based on Washington State Office of Financial Management April 2017 (http://www.ofm.wa.gov/pop/april1/)
(2) Exposure numbers estimated using FEMA Region X 2016 User Defined Facilities database
(3) USGS Cascadia M9.0 Earthquake Shakemap dataset
(4) "Other" includes Tribal, National Parks, and Military. Accurate population estimates for this classification are currently not available

Table 7-8 Building Impact from Moderate-High Liquefaction		
Community	**Percent of Buildings in the Moderate-High Liquefaction Zone**	**Number of Buildings in the Moderate – High Liquefaction Zone**
Unincorporated County	12%	4,088
Aberdeen	32%	4,664
Cosmopolis	2%	714
Elma	< 1%	45
Hoquiam	83%	3,148
McCleary	3%	0
Montesano	< 1%	63
Oakville	< 1%	20
Ocean Shores	2%	4,543
Westport	7%	1,281
Total		**18,566**
Source: FEMA Risk Report (2015)		

For the Cascadia M9.0 event, based on FEMA Hazus analysis, it is estimated that approximately 55 percent of buildings countywide fall within the moderate-high liquefaction zone, increasing their level of vulnerability. Figure 7-14 illustrates the damages as identified within the Hazus model for a Cascadia M9.0 event. The Cities of Aberdeen and Hoquiam have the largest percentage of buildings located in the moderate-high liquefaction zone. Many of the communities will be substantially impacted if a Cascadia quake were to occur.

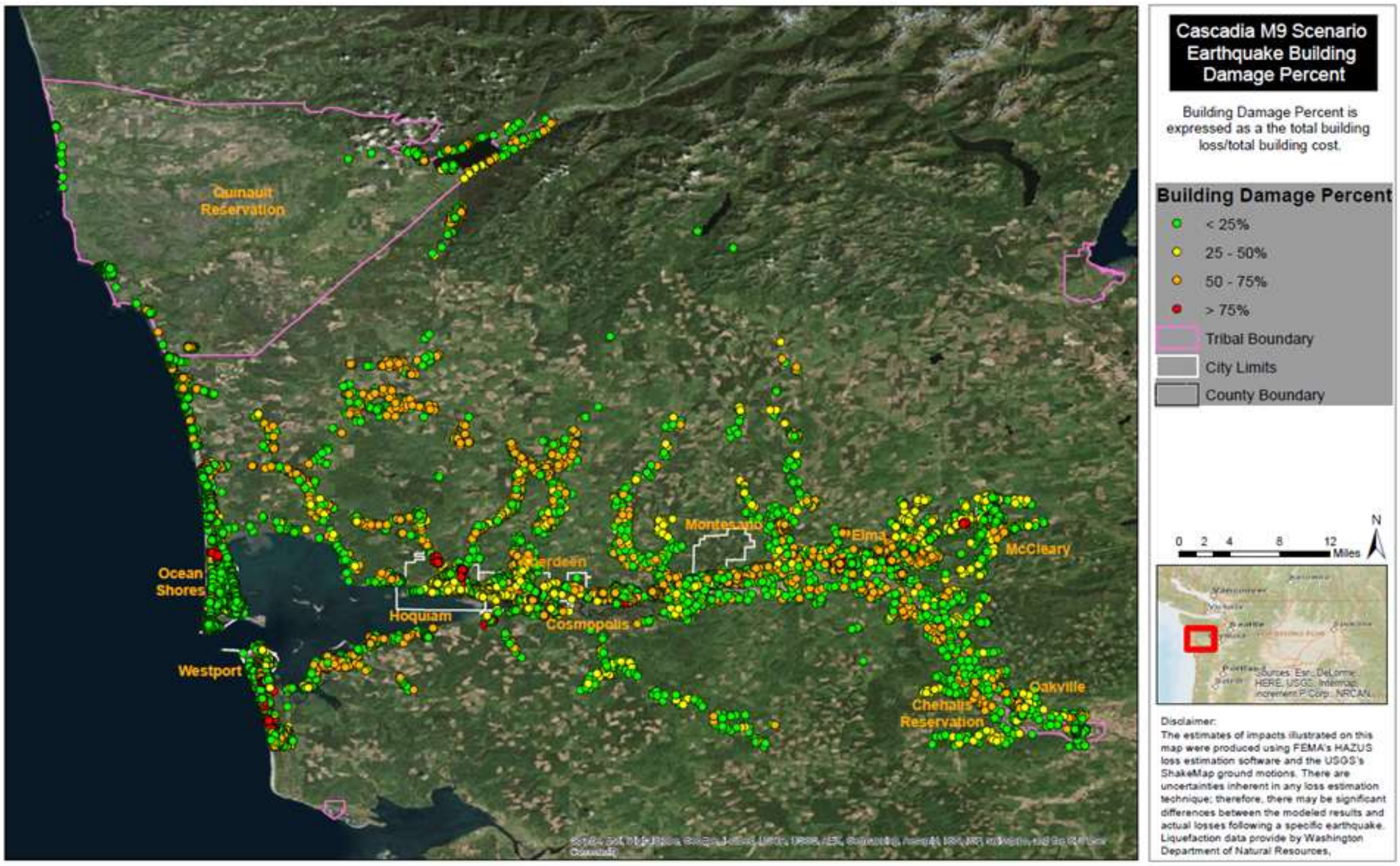


Figure 7-14 FEMA (2015) Hazus Output for Building Damages for a M9.0 Cascadia Scenario

Building Age

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

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

An analysis was also completed to identify how many buildings were built to a specific building code. Hazus identifies key changes in earthquake building codes based on year. Homes built prior to 1941 are considered pre-code; they were constructed before earthquake building codes were put in place. Homes constructed after 1941 are considered moderate code and may include some earthquake building components. Table 7-9 and Table 7-10 show the results of this analysis.

Table 7-9
Timeline of Building Code Standards

Time Period	Code Significance for Identified Time Period
Pre-1974	No standardized earthquake requirements in building codes. Washington State law did not require the issuance of any building permits, or require actual building officials
1975-2003	UBC seismic construction standards were adopted in Washington.
1994-2003	Seismic Risk Zone 3 was established within the Uniform Building Code in 1994, requiring higher standards.
2004-Present	Washington State upgrades its building codes to follow the International Building Code Standard. As upgrades occur, the State continues to adopt said standards.

Table 7-10
Age Of Structures Within Planning Area

Community	Number of Pre-Code	Number of Moderate Code	Total
Unincorporated County	1,848	11,053	12,901
Aberdeen	3,507	2,824	6,331
Cosmopolis	244	496	740
Elma	368	860	1,228
Hoquiam	2,257	1,200	3,457
McCleary	222	450	672
Montesano	531	1,023	1,554
Oakville	113	218	331
Ocean Shores	3	4,597	4,600
Westport	149	1,142	1,291
Total	**9,242**	**23,863**	**33,105***

*Building counts based on 2015 Assessor's data and are not inclusive of all structures (e.g., tax exempt or private-non-profit structures).

7.3.4 Impact on Critical Facilities and Infrastructure

All critical facilities in Grays Harbor County are exposed to the earthquake hazard. Additionally, 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 residences 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. A large portion of the county is coastal. As such, hazardous materials are of particular concern with respect to spills into water bodies, including the coastline or significant rivers in the area, which could have devastating impact. Additionally, the potential for landslide-induced roadway closure is of significant concern. Closure of major arterials could require increased evacuation periods in some instances by several hours. In some instances, commodities would also be impacted in areas, requiring supplies by air or water.

Magnitude 9+ earthquakes can potentially trigger slope failures as well. Figure 7-15 illustrates the slopes susceptible to seismically induced shallow landslides associated with a M9+ Cascadia subduction zone earthquake in Aberdeen, Cosmopolis, Hoquiam, Ocean Shores, and Westport, Grays Harbor County, Washington (Slaughter and others, 2013) (FEMA 2015 Risk Report). These landslides would impact roadways, as well as increase infrastructure impact.

Figure 7-15 Shallow Landslide Susceptibility Zones- Ocean Shores / Westport/ Aberdeen Areas

Debris

The Hazus analysis also estimated the amount of earthquake-caused debris in the planning area for a M9.0 Cascadia Earthquake event (see figure below). The model breaks the debris into two general categories: a) Brick/Wood and b) Reinforced Concrete/Steel. The distinctions in types of materials are made due to the different types of material-handling equipment required to process the debris. The model estimates that a total of 1.02 million tons of debris will be generated (based on Hazus 4.0 analysis conducted for 2017 Westport Study). Of the total amount, brick/wood comprises 31 percent of the total, with the remainder being reinforced concrete/steel. Converting that amount to an estimated number of truckloads, this will require approximately 40,760 truckloads to remove the debris generated if the trucks utilized are 25-ton trucks (standard dump-truck load).

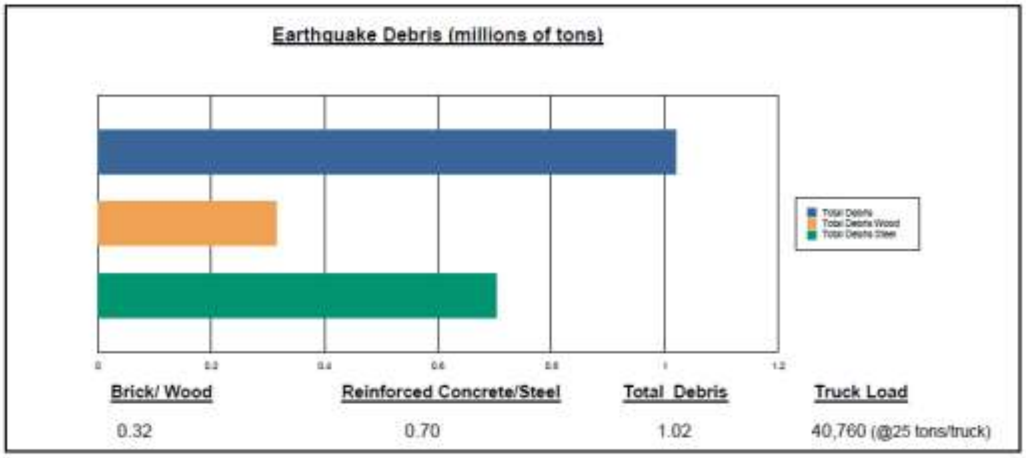


Figure 7-16 Hazus-generated Debris in Tons (FEMA 2017 Westport Study)

7.3.5 Impact on Economy

Economic losses due to earthquake damage include damage to buildings, including the cost of structural and non-structural damage, damage to contents, and loss of inventory, loss of wages and loss of income. Loss of tax base both from revenue and lack of improved land values will increase the economic loss to the County and its planning partners. In addition, loss of goods and services may hamper recovery efforts, and even preclude residents from rebuilding within the area. No specific loss data is available with respect to loss of inventory, wages or loss of income; however, economic loss with respect to building impact is identified in Table 7-7 (above) for a Cascadia M9-type event.

7.3.6 Impact on Environment

Earthquake-induced landslides can significantly impact habitat. It is also possible for streams to be rerouted after an earthquake. This can change water quality, possibly damaging habitat and feeding areas. There is a possibility of streams fed by groundwater drying up because of changes in underlying geology.

7.4 FUTURE DEVELOPMENT TRENDS

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

7.5 ISSUES

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

Earthquakes can cause large and sometimes disastrous landslides and mudslides. River valleys are vulnerable to slope failure, often as a result of loss of cohesion in clay-rich soils. Soil liquefaction occurs when water-saturated sands, silts or gravelly soils are shaken so violently that the individual grains lose contact with one another and float freely in the water, turning the ground into a pudding-like liquid. Building and road foundations lose load-bearing strength and may sink into what was previously solid ground. Unless properly secured, hazardous materials can be released, causing significant damage to the environment and people. Earthen dams and levees are highly susceptible to seismic events and the impacts of their eventual failures can be considered secondary risks for earthquakes. Earthquakes at sea can generate destructive tsunamis. Important issues associated with an earthquake include, but are not limited to the following:

- More information is needed on the exposure and performance of construction within the planning area. Much information on the age, type of construction, or updated work on facilities is not readily available in a useable format for a risk assessment of this type.
- It is presently unknown to what standards portions of the planning area's building stock were constructed or renovated.
- Based on the modeling of critical facility performance for this plan, a high number of facilities in the planning area are expected to have complete or extensive damage from scenario events. These facilities are prime targets for structural retrofits.
- The County and its planning partners are 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.
- Dam failure warning, evacuation plans and procedures should be updated (and maintained) to reflect dam risk potential associated with earthquake activity in the region, with said information being distributed to the County and its planning partners to allow for appropriate planning to occur.
- Earthquakes could trigger other natural hazard events such as a tsunami, which would have far-reaching impacts.

7.6 RESULTS

Based on review and analysis of the data, the Planning Team has determined that the probability for impact from an Earthquake throughout the area is highly likely. A Cascadia-type event, such as that utilized as one of the scenarios modeled for this update, has a high probability of occurring within the region. The Cascadia M9.0 earthquake scenario generates the largest amount of damage. The highest loss ratio for a Cascadia M9.0 scenario earthquake would occur in the Cities of Hoquiam and Aberdeen, but overall countywide, 55 percent of buildings affected by the shaking. The losses related to earthquake scenarios are largely due to the proximity to the faults. In addition, there is a large percentage of buildings located in the moderate-high liquefaction zone, as well as a large number of buildings being designated as pre-code buildings. Due to the age of these buildings and the absence of building codes at time of construction, they may not perform as well during an earthquake compared to structures built after code implementation. Based on the potential impact, the Planning Team determined the CPRI score to be 3.85, with overall vulnerability determined to be a high level.

CHAPTER 8.
EROSION - COASTAL

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

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

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

The Grays Harbor shoreline south of Point Grenville is composed of fine sand derived from the Columbia River that is readily mobilized by wind and wave action. Seasonal fluctuations in waves and water levels typically cause beach erosion in the winter and beach accretion (or build up) in the summer. Where the beaches are backed by bluffs composed of older sedimentary deposits, bluff erosion constitutes a permanent loss of the upland.

8.1 GENERAL BACKGROUND

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

Along the southwest Washington coast, the introduction of exotic dune grasses and other vegetation during the 1930s have resulted in a sharper distinction between the beach and the barrier-dune upland. The introduced vegetation increased the accumulation and stability of barrier dunes that were previously more prone to wind drift, erosion, and constant change. As the dunes became densely colonized and stabilized by vegetation, they were developed and perceived as land not subject to further loss. Moreover, what was once a wide dune and buffer zone between the beach and the older barrier formation that was sustained during the 1700 Cascadia subduction zone earthquake became an abrupt vegetation line that separated the beach from the upland. While this vegetation line may mark the upland boundary of typically inundated land on an annual scale, it does not mean the land is not subject to erosion hazards. In fact, coastal erosion hazards associated with a co-seismic subsidence event with a return interval of about 500 years may extend a few hundred meters inland from the vegetation line. Such a hazard zone is comparable to a landslide hazard zone that is informed by the occurrence of a slide within the last 10,000 years. For context, the entirety of the coastal barriers along the southwest Washington coast are only a few thousand years old and record several events of massive erosion from co-seismic subsidence events since their formation.

Coastal erosion generally occurs as a result of physical forcing or an imbalance in the sediment budget. For example, the construction of jetties at the mouth of Grays Harbor in the early 1900s caused a large change in the way sediment is shared between the adjacent coasts along Westport and Ocean Shores. The jetties have enabled more sediments to accumulate north of Grays Harbor than to the south along the Grayland Plains. The sediment imbalance initiated a century ago by the construction of the jetties still contributes to the net erosion of sediment from the Westport area. Along Ocean Shores, coastal erosion is more recently exacerbated by the deterioration of the Grays Harbor North Jetty. Absent of reconstruction, the capacity of the jetty to sustain the beach in its present location diminishes over time, contributing to the net loss of sediment along the beach north of the jetty.

North of Point Grenville, coastal sediments are derived locally from the nearshore, streams, rivers, and bluffs. Here, local geology can determine how much erosion occurs independent of hydrodynamic forcing. Where sediments are limited, the erodibility of the coastal substrate and bluffs depends on the relative hardness and mechanical strength of the material. Headlands and outcrops are composed of highly erosion-resistant rock. In general, rocky coasts erode through hydraulic action of waves and abrasion action of debris, progressively splintering and removing pieces of rock. Rock fragments then undergo a process of attrition, becoming smaller and rounder particles as they collide with each other.

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

On a seasonal scale, coastal erosion typically occurs during the winter, when distant and local storms produce large waves, high winds, and elevated water levels. Winter storms typically approach the shoreline from the southwest, resulting in northerly and offshore sediment transport that erodes beaches, whereas as fair-weather summer conditions generally produce smaller waves approaching from the northwest that result in southerly and onshore sediment transport that builds up the beaches. During strong El Niño events, sustained elevated water levels can accentuate seasonal coastal erosion, such as during the 1997/98 winter, when monthly averaged water levels were as much as 1.3 ft higher than normal (Kaminsky et al., 1998).

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

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

8.2 HAZARD PROFILE

8.2.1 Extent and Location

The best predictor of where coastal erosion might occur is along shorelines that have eroded in the past. A range of geological, historical, and contemporary approaches can be used to identify coastal erosion hazard areas and their associated time and space scales. One way to reveal if either chronic or episodic erosion has occurred is through the mapping of historical shorelines. Coastal erosion can also be recognized in surface topography by steep scarps and slumps along dunes and bluffs that are generally unstable and unvegetated. Eroded beaches are typically narrower, steeper, and composed of coarser sediment than adjacent stable beaches. Sandy beaches may have higher concentrations of heavy minerals and surface lag deposits that are more resistant to transport relative to other local sediments. Past erosion events may also be detected by ground-penetrating radar and recorded as subsurface lag deposits that were subsequently buried during an accretion phase.

Scientific research studies such as the Southwest Washington Coastal Erosion Study (Gelfenbaum and Kaminsky, 2010) have provided a strong foundation for understanding and anticipating coastal changes from a multi-disciplinary perspective.

For the purposes of this hazard mitigation plan, coastal erosion hazard areas are identified through the analyses of changes in shorelines derived from aerial photographs and quarterly beach profile surveys that have been performed by the Washington State Department of Ecology Coastal Monitoring & Analysis Program (CMAP) along the southwest Washington coast since 1996.

Erosion hazard areas are mapped only where these existing data indicate a chronic erosion trend over the past 10 years or more, and where, without mitigation, future erosion impacts can be anticipated over the next 10 years (Figure 8-1). The erosion hazard areas are based on existing data and knowledge that is focused on the outer coast south of Point Grenville, and are not necessarily inclusive of coastal erosion areas for the entirety of Grays Harbor County. Erosion hazard areas are mapped for Westport (Figure 8-2), Cohassett Beach (Figure 8-3), the shoreline near the Grays Harbor North Jetty (Figure 8-4), the Ocean Shores Oyhut Wildlife Recreation Area (Figure 8-5), Damon Point (Figure 8-6), Whitcomb Flats in Grays Harbor (Figure 8-7), and along the mouths of Connor Creek and the Copalis River (Figure 8-8). As additional hazard areas are identified, information will be utilized to update this hazard profile.

The erosion hazard areas indicated do not account for various interventions that could reduce or prevent coastal erosion, other conditions such as jetty deterioration that might lead to accelerated erosion, nor the fact that other areas could be affected by coastal storms and erosion. For example, wave breaking over the Grays Harbor North Jetty may scour sand and damage East Ocean Shores Boulevard, yet this is not indicated on the maps since there is no chronic erosion of the shoreline along the North Jetty. Similarly, episodic erosion driven by a large storm could also occur outside of the mapped erosion hazard areas. The erosion hazard maps only indicate areas with a documented erosion trend that has occurred over the past decade or longer. Each erosion hazard area map shows the erosion trend in feet per year along the shoreline. Table 8-1 provides a summary of the number of affected structures, parcels, shoreline length, and acres. The reader should be aware that while other areas are not mapped as erosion hazard areas, it does not eliminate the potential for erosion hazards to exist in those locations.

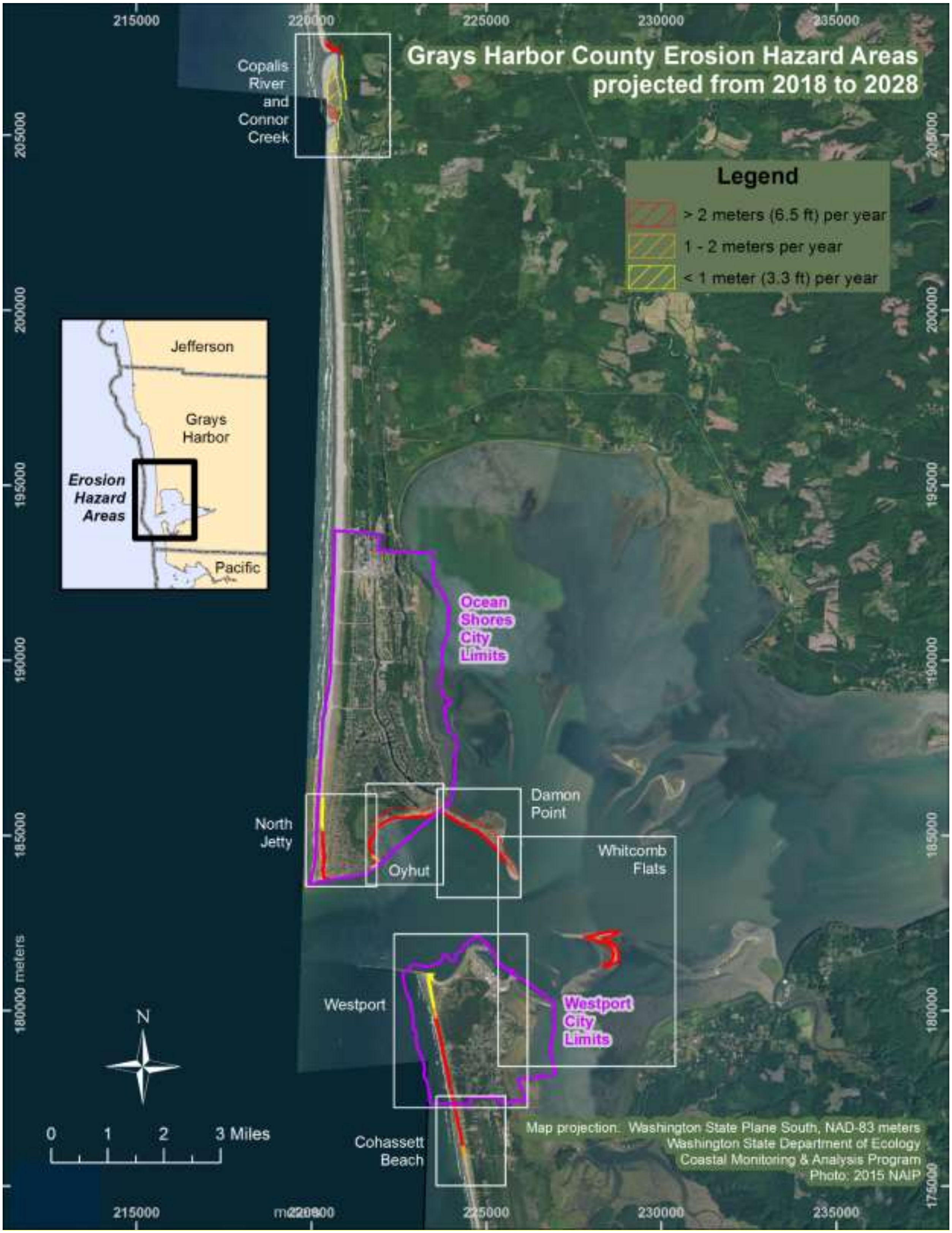


Figure 8-1 Overview of Erosion Hazard Areas

Figure 8-2 Westport Erosion Hazard Areas

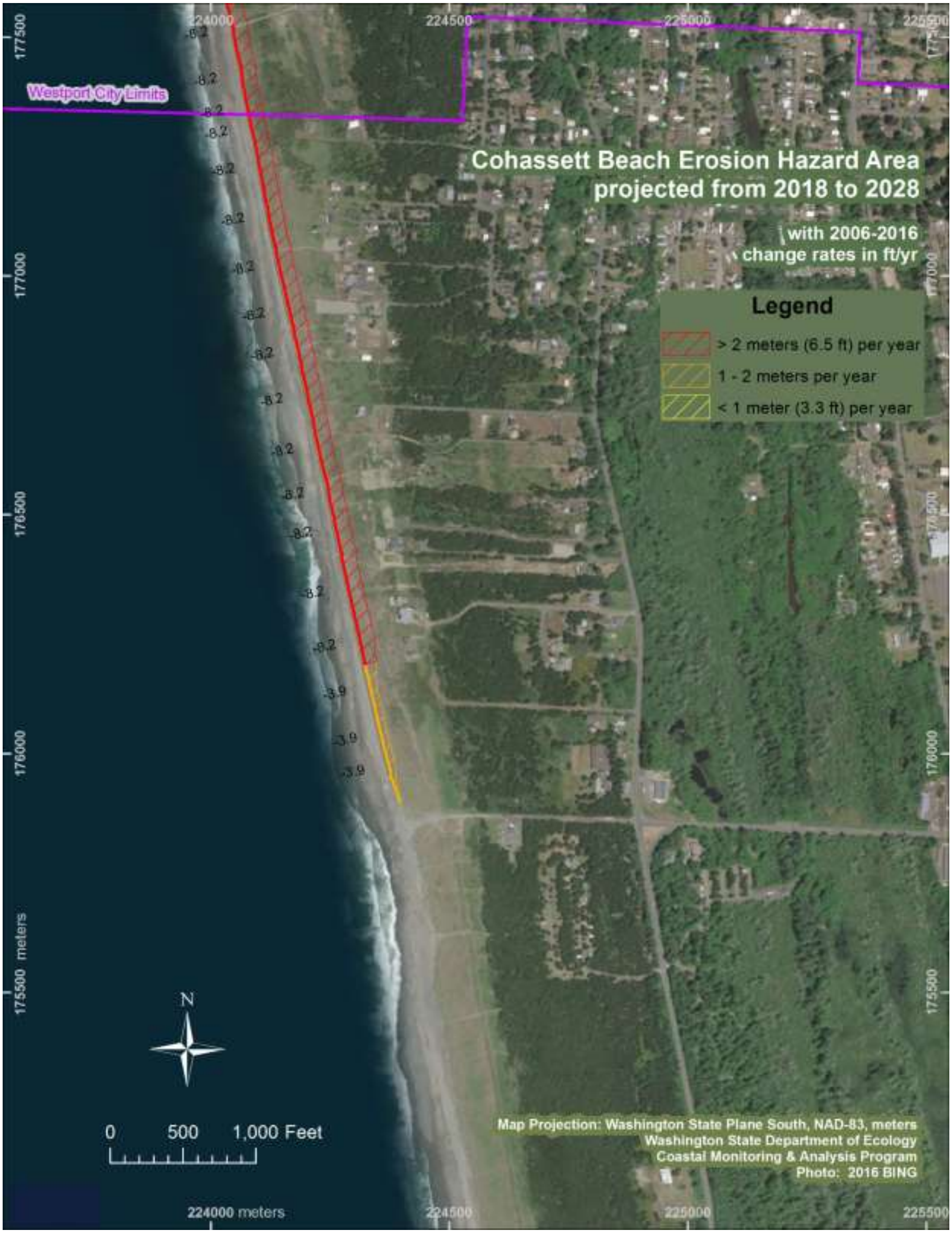


Figure 8-3 Cohassett Beach Erosion Hazard Areas

Figure 8-4 Ocean Shores North Jetty Erosion Hazard Areas

Figure 8-5 Oyhut Erosion Hazard Areas

Figure 8-6 Damon Point Erosion Hazard Area

Figure 8-7 Whitcomb Flats Erosion Hazard Area

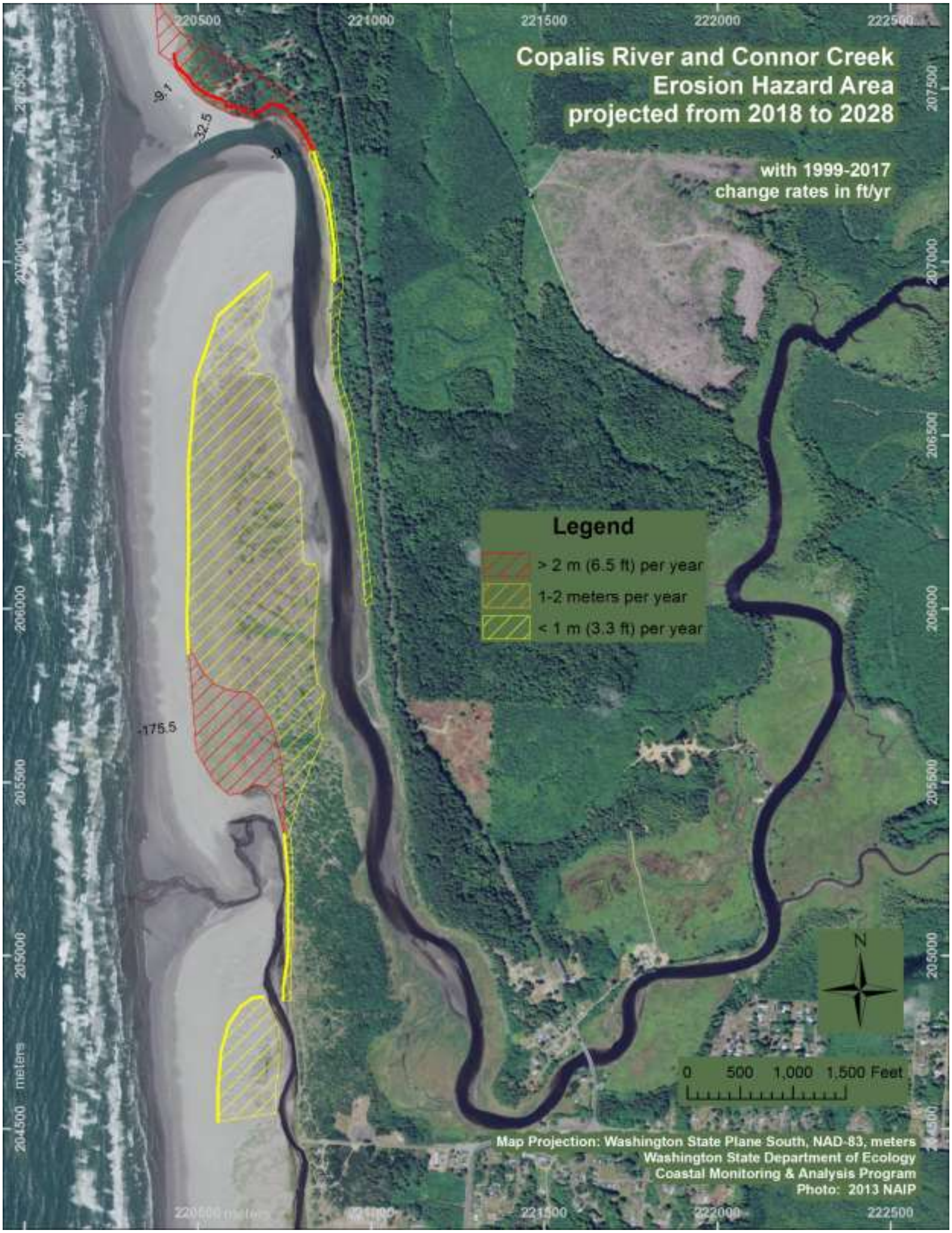


Figure 8-8 Copalis River and Connor Creek Erosion Hazard Areas

Table 8-1
Summary Inventory of Grays Harbor Erosion Hazard Areas

Jurisdiction & Name of Area	Num. of Structures	Num. of Parcels	Length of Shoreline (km)	Length of Shoreline (miles)	Num. of Acres	Other
City of Ocean Shores						
North Jetty area	13	31	2.53	1.57	16.9	
Oyhut Wildlife Recreation Area	20	30	3.28	2.04	139.9	Also Sewage Treatment Plant, Marine View Dr
Subtotal	**33**	**61**	**5.81**	**3.61**	**156.8**	
City of Westport						
Westport	9	49	4.00	2.49	25.6	4 State Parks & 2 City of Westport parcels are excluded
Subtotal	**9**	**49**	**4.00**	**2.49**	**25.6**	
Grays Harbor County						
Copalis River & Connor Creek	3	24	3.73	2.32	141.7	
Cohassett Beach	0	1	1.49	0.93	9.6	
Whitcomb Flats	0	0	4.39	2.73	63.5	
Damon Point	0	0	2.49	1.55	150.2	Affects access to a recreation area
Subtotal	**3**	**25**	**12.10**	**7.52**	**365.0**	
Total	**45**	**135**	**21.91**	**13.62**	**547.4**	

8.2.2 Previous Occurrences

The barrier beaches along the southwest Washington coast have a relatively short geological history. Grayland Plains, the barrier beach between Grays Harbor and Willapa Bay began to sustain seaward growth from the back edge only about 2,800 years ago, while the oldest portions of the North Beach Peninsula north of Grays Harbor have built seaward from the bay side only for the last 2,500 years (Peterson et al., 2010b). These coastal barriers are built from the accumulation of sand supplied by the Columbia River and shaped by tectonic processes of the Cascadia Subduction Zone that produces great earthquakes (magnitude ≥ 8) with a recurrence interval that averages about 500 years (Atwater and Hemphill-Haley, 1997; Atwater et al., 2004).

Each great subduction zone earthquake is accompanied by coseismic subsidence of 0.5 to 2.5 m (Atwater, 1996, Atwater and Yamaguchi, 1991; Atwater and Hemphill-Haley, 1997), and corresponding shoreline retreat on the order of a few hundred meters (Doyle, 1996; Peterson et al., 1999, 2000). These large-scale, episodic coastal erosion events are recorded by a sequence of scarp formations that have been mapped with ground penetrating radar in the subsurface of the coastal barriers (Meyers et al., 1996; Jol et al., 1996; Smith et al., 1999: Peterson et al., 2010b). The buried erosion scarps manifest as heavy mineral layers that are preserved by interseismic rebound, beach recovery, and continued accumulation of sediment between events that results in shoreline advance at long-term average rates of approximately 0.5 m/yr (Meyers et al., 1996; Woxell, 1998; Peterson et al., 1999). Meyers et al. (1996), Woxell (1998), and Phipps et al. (2001) correlate the most seaward and recent paleoscarp to the A.D. 1700 Cascadia earthquake subsidence event on January 26, 1700 (Satake et al., 1996; Atwater et al., 2005).

Cascadia Subduction Zone earthquakes affect the coast not only through abrupt subsidence, but also through the generation of large tsunamis (e.g., Atwater, 1987; Darienzo and Peterson, 1990; Clague et al., 2000; Kelsey et al., 2002, 2005; Peters et al., 2003; Witter et al., 2003; Atwater et al., 2005; Nelson et al., 2006). While dramatic shoreline retreat occurs due to subsidence, tsunamis erode beach sediments and transport them landward in high-velocity flows (Dawson, 1994; Dawson and Stewart, 2007) to form deposits that normally extend 0.5 to 1.5 km inland from the open coast (Peters et al., 2003; Schlichting and Peterson, 2006; Jol and Peterson, 2006).

The shape and location of the shoreline have undergone substantial change since 1700, particularly over the past century following construction of jetties at the mouth of Grays Harbor (Kaminsky et al., 2010). The Grays Harbor South Jetty was constructed between 1898 and 1902 to a length of 2.6 miles, and the Grays Harbor North Jetty was built to a length of 3.2 miles between 1908 and 1916. Within the first several decades following jetty construction, shoreline changes are closely correlated with changes in jetty condition (Buijsman et al., 2003). Over time, the net result has been significantly more seaward growth of the North Beach Peninsula, accumulating roughly 8 to 10 times more sand than Grayland Plains, resulting in an imbalance in the sharing of sediment between the adjacent coasts and accentuated erosion in the Westport area (Kaminsky et al., 2010). Coastal erosion has been shown to be an issue in Westport since the construction of the Grays Harbor South Jetty in the early 1900s and since the shoreline accretion began to slow along the Ocean Shores Peninsula during the 1950s (Buijsman et al., 2003). There have been numerous reports documenting challenges, costs, and impacts of coastal erosion over the past few decades.

Table 8-2 provides a historical chronology of coastal construction, erosion, and mitigation along the Grays Harbor County shoreline. Table 8-3 identifies the locations and volumes of sand placed to nourish eroding areas to mitigate the impacts of coastal erosion. A brief summary of historical shoreline changes and events are discussed below.

Table 8-2
Grays Harbor Coastal Construction, Erosion, and Mitigation History

Period	Event
Jan 1700	Cascadia earthquake causes coast-wide erosion.
May 1792	Captain Robert Gray surveys Grays Harbor.
Aug 1841	Wilkes Expedition surveys Grays Harbor.
Apr 1854	Chehalis County is formed, later to become Grays Harbor County.
1856	Pioneers settle at Chehalis Point (Westport).
1860-1862	U.S. Coast Survey surveys Grays Harbor and publishes Hydrographic Survey.
1862	George Davidson of the U.S. Coast Survey publishes Directory of the Pacific Coast, or Coast Pilot of California, Oregon, and Washington (first edition).
1881	The USACE conducts study of Grays Harbor.
1886-1887	U.S. Coast Survey surveys Grays Harbor and adjacent shorelines and publishes Topographic Sheet.
1889	George Davidson of the U.S. Coast Survey publishes Coast Pilot of California, Oregon, and Washington (completely rewritten third edition).
1894	The USACE conducts a field survey of the Grays Harbor entrance.
1897	Grays Harbor Coast Guard Station is established.
May 1898-Sep 1902	The USACE constructs the Grays Harbor South Jetty to an elevation of +8 ft MLLW and a total length of 13,734 ft, of which 11,950 ft extended seaward of the high-water line in 1902. During construction, the channel adjacent to the jetty undermined the structure causing

Table 8-2
Grays Harbor Coastal Construction, Erosion, and Mitigation History

Period	Event
	material overruns that depleted project funds before the design length of 18,154 ft could be reached. A groin (spur) pointing into the channel is constructed 11,952 ft from the high-water line in 1902.
Jun 1898	Gray Harbor light is commissioned.
Sep 1902	Moclips is platted.
Apr 1904	Pacific Beach is platted.
1904-1906	By 1904, the depth over the Grays Harbor ebb-shoal increases from -12 to -22 ft MLLW as a result of jetty construction, meeting the stated purpose of the project. In addition, the beach south of the jetty accretes, creating a 3,000-ft seaward progradation of the high-water shoreline. However, deterioration of the jetty began around 1904. By 1906, the South Jetty had settled due to scour, and the bar channel began to widen and shoal. This unfavorable shoaling led to construction of the North Jetty.
1907-1910	The USACE constructs 10,000 ft of the Grays Harbor North Jetty to an elevation of +5 ft MLLW.
1910-1913	The USACE completes the North Jetty to a project length of 16,000 ft and an elevation of +5 ft MLLW.
Feb 1911	Moclips Beach Hotel and other buildings on Moclips beach destroyed by coastal storm.
1913-1916	The USACE reconstructs the North Jetty is to +8 ft MLLW and extended it to a length of 17,204 ft.
1916	As jetties continued to deteriorate and were inadequate to maintain project dimensions in the bar channel, dredging commenced (57,000 cy) and continued at regular intervals until 1926 (except for 1918 and 1919).
Dec 1920	A small tsunami washes 12 Sunset Beach Cottages in Moclips from their foundations.
1925	Ocean City is platted.
1926-1942	The bar channel required almost continuous dredging between 1926 and 1942. The total quantity dredged from the entrance between 1916 and 1942 is approximately 22 x 106 cy (USACE 1967).
1933	By 1933, the South Jetty had subsided to an average depth of 5 to 10 ft below MLLW (+6 ft MLLW at the high-water shoreline and -10 ft MLLW at the outer end).
1934	The outer 8,000 ft of the North Jetty, between the high water shoreline and the tip of the jetty, subsides to approximately -1.5 ft MLLW.
1935-1939	The USACE reconstructs a 12,656-ft section of the South Jetty (about Sta. 80+00 to 220+00) to an elevation of +20 ft MLLW. Jetty reconstruction blocked the supply of sand to Point Chehalis, causing serious erosion of Point Chehalis. A 32-ft section of the jetty is removed to try to restore the supply of sand, but it is quickly blocked by accretion south of the jetty.
1939-1946	The outer 900 ft of the South Jetty is destroyed, and crest rock is displaced to +2 ft MLLW over the next 2,656 ft.
1940	The inner 7,300 ft of the North Jetty, shoreward of the high-water shoreline, is impounded with sand.
Feb 1941-May 1942	The USACE reconstructs the North Jetty to an elevation of +20 ft MLLW for 7,700 ft seaward of the high-water shoreline, then to +30 ft MLLW for an additional 528 ft. A 412-ft segment seaward of the reconstructed section is at MLLW and is not restored. The structure landward of the high-water shoreline is not rebuilt.

Table 8-2
Grays Harbor Coastal Construction, Erosion, and Mitigation History

Period	Event
1942	Maintenance dredging of the bar and entrance channels is no longer required due to scouring effects of the jetties.
1942-1949	The outer 325 ft of the North Jetty is leveled, and about 400 ft of the reconstructed section is lowered 4 ft below grade.
1946-1951	An additional 900 ft of the South Jetty is destroyed, and the next 4,100 ft subsided to 0 to +10.
1946	Half Moon Bay begins to form east of the South Jetty root.
1950-1957	The USACE constructs the Point Chehalis Revetment (2,880 ft) and 7 groins, and 3 timber pile breakwaters to serve as shore protection for marina at Westport due to erosion associated with South Jetty reconstruction.
1949-1953	An additional 325 ft of outer end of the North Jetty is leveled, and more than 1,000 ft of the remaining section subsided to +10 ft MLLW.
1951-1953	An additional 900 ft of the outer South Jetty is destroyed, and the next 4,500 ft subsided to 0 to +2 ft MLLW. The next 2,400 ft subsided to +4 ft MLLW.
1952-1954	More than 300 ft of the South Jetty (between Sta. 70+00 and 80+00) is dismantled, and the rock used for construction of the Point Chehalis revetment.
1956	Joe Creek threatens Pacific Beach as the mouth erodes through dunes.
1961	Only 2,100 ft of the reconstructed portion of the North Jetty remained at or near grade (+20 ft MLLW).
1962	By April 1962, average elevation of the South Jetty between Sta. 135+00 and 198+00 (6,300 ft) is about MLLW; seaward of this point from Sta. 198+00 to 220+00 (2,200 ft), crest elevation ranged from -6 ft MLLW to -48 ft MLLW. The landward section from about Sta. 88+00 (high-water shoreline) to 135+00 (4,700 ft) is near grade.
Mar 1964	Alaskan tsunami causes damages beach front houses and bulkheads at Moclips, buildings and State Highway 109 log bridge over Joe Creek at Pacific Beach, State Highway 109 at Iron Springs Resort at Boone Creek, and buildings, mobile homes, and State Highway 109 bridge at Copalis River.
1966	The USACE reconstructs a 4,000-ft section of the South Jetty (from Sta. 110+00 to 150+00) to +20 ft MLLW, leaving the outer 7,000 ft in a degraded condition (-10 ft MLLW or deeper).
1970	City of Ocean Shores is incorporated.
1970-1973	The USACE performs extensive groin replacement, revetment repair, and timber breakwater construction along Point Chehalis (including timber pile closure of Westport Marina entrance between breakwaters A and B).
1974	A section of the North Jetty, about 1,300 ft seaward of the high-water shoreline, ranged from +3 to +14 ft MLLW. The jetty seaward of this point is below MLLW.
Winter 1974-1975	The North Jetty is severely damaged in a major storm and portions of the adjacent beach and primary dune are washed away, with debris scattered several hundred ft inland.
1975-1976	The USACE reconstructs a 6,000-ft section of the North Jetty, from the high-water shoreline seaward to an elevation of +20 MLLW.

Table 8-2
Grays Harbor Coastal Construction, Erosion, and Mitigation History

Period	Event
1976 -1977	Ocean Shores Critical Area Dune Stabilization. The City of Ocean Shores and the Grays Harbor Conservation District repair and stabilize the primary dune area adjacent to the North Jetty that was washed away in the Winter of 1974- 1975. Fertilizer is spread over 55 acres, extending approximately 1.5 miles long by 300 ft wide to enhance plant growth along the primary dune north of the North Jetty. European beachgrass is planted to stabilize the 9-acre denuded area, and two 500-ft long, 3-ft high picket fences are installed 35 ft apart, starting 100-ft landward of the high water mark, to enhance sand deposition and rebuild the primary dune. The first fence failed in November 1976, and a second sand fence was installed farther inland from the first fence, and this second fence was partially destroyed in March 1977 by high tides accompanied by storm conditions.
Winter 1982-1983	Strong El Niño causes greater than normal winter beach erosion.
1988	The northward migration of the mouth of Connor Creek appears to accelerate to as much as 1,000 ft/yr, driven by winter storms and wave overwash of barrier into the channel.
1990	The USACE constructs outer harbor navigation channel improvements including deepening of bar and outer entrance channel to 46 ft MLLW, widening of bar channel to 1000 ft, and entrance channel to 600 ft. The USACE deepens the inner harbor reaches and turning basins from -30 ft MLLW to -36 ft MLLW.
1991	The USACE reactivates maintenance dredging of the bar and entrance channel.
1986-1992	The Half Moon Bay shoreline receded at a rate of more than 10 ft/yr, destroying several US Coast Guard structures, and endangering the City of Westport's sewer outfall.
1992	The USACE places 200,000 cy of sand in the form of a submerged nearshore berm in Half Moon Bay to mitigate erosion.
Fall 1993	The USACE rehabilitates the southern 800 ft of the Point Chehalis revetment, and places 373,000 cy of sand in the nearshore of South Beach to nourish the eroding shoreface.
Dec 1993	A breach occurred between the ocean and Half Moon Bay adjacent to the South Jetty, threatening Westport's municipal water well and wastewater treatment plant.
May 1994	The USACE nourishes the Half Moon Bay nearshore with 146,000 cy of sand and the South Beach nearshore with 265,000 cy of sand.
Fall 1994	The USACE fills the South Jetty breach with 600,000 cy of sand dredged from the navigation channel, at a cost of approximately $8 million.
Dec 1994	The City of Westport declares state of emergency over coastal erosion in Half Moon Bay that caused four sections of sewer outfall pipe (40 ft) to break apart.
Jan 1995	The City of Westport places 82,000 cy of sand and armor rock to protect the sewer outfall line.
Jul 1995	The USACE relocates 150,000 cy of breach fill material from western Half Moon Bay shoreline to South Beach.
1995	Whitcomb Flats loses its remnant dune and vegetation to wave overwash.

Table 8-2
Grays Harbor Coastal Construction, Erosion, and Mitigation History

Period	Event
Dec 1995	The USACE places 300,295 cy of sand along Half Moon Bay extending 800 ft south from the Point Chehalis revetment due to erosion threatening Westport's wastewater treatment plant, north well, and business district.
1996	The USACE nourishes the Half Moon Bay berm with 274,780 cy of sand.
Oct 1996	A two-tiered rock revetment, 850-ft long named "wave bumpers" are constructed at Ocean Shores at a cost of approximately $600,000.
Feb 1997	Governor Locke allocates $50,000 from emergency funds for an Ocean Shores study of coastal erosion. The USACE places 5,000 cy of sand on the Moon Bay shoreline berm adjacent to the Point Chehalis revetment to reinforce the revetment terminus and reduce the potential for storm induced wave overtopping of the backshore berm and associated flooding of the City of Westport business district.
Jul 1997	Congress appropriates $6 million to study a long-term solution to coastal erosion at the Grays Harbor South Jetty. The Washington State Legislature appropriates $1 million to the Southwest Washington Coastal Erosion Study, and $70,000 emergency funds to study Ocean Shores coastal erosion, while Governor Locke provides an additional $30,000 for the Ocean Shores study.
Dec 1997	Damon Point State Park access road washes out during a coastal storm.
1998	The USACE nourishes the Half Moon Bay nearshore with 421,468 cy of sand.
Aug 1998	Governor Locke's Coastal Erosion Task Force begins to develop policy recommendations.
Dec 1998	Ocean Shores installs geotubes north of the wave bumpers to protect an additional 540 ft of dune from erosion at a cost of approximately $200,000.
Dec 1998	Damon Point State Park access road washes out approximately 1300 ft east of the 1997 washout.
Dec 1998-Mar 1999	Point Chehalis Revetment Extension Project. The USACE extends the Point Chehalis Revetment 1,900 ft south along Half Moon Bay at a cost of $2.6 million.
Jan 1999	By the beginning of 1999, Connor Creek had migrated north of Heath Road, cutting off beach access.
Feb 1999	Waves overtop the North Jetty and damage East Ocean Shores Boulevard.
Mar 1999	A storm lowers a 200-ft section of the South Jetty to about +9 ft MLLW and damages the jetty where it intersects the shoreline. A storm removes the Ocean Shores restroom facility adjacent to North Jetty. Ocean Shores incurs over $1 million in damages but is not eligible for federal disaster assistance. East Ocean Shores Boulevard is further damaged by wave overtopping the North Jetty.
Apr-May 1999	The USACE places 228,963 cy of dredged sand on top of and seaward of the revetment extension at a cost of approximately $1 million.
1999	The USACE nourishes the Half Moon Bay nearshore with 228,470 cy of sand and the South Beach nearshore with 76,187 cy of sand.
Sep 1999-May 2002	The USACE reconstructs a 3,500-ft section of the South Jetty seaward of the high-water shoreline (Sta. 87+00 to 120+00) to an elevation of +23 ft MLLW.

Table 8-2
Grays Harbor Coastal Construction, Erosion, and Mitigation History

Period	Event
Dec 1999-Feb 2000	The USACE constructs a wave diffraction mound at landward end of south jetty to reduce wave-induced erosion of Half Moon Bay, and constructs a cobble transition beach with 11,600 cy (17,358 tons) of 12-inch minus cobble and gravel designed to slow Half Moon Bay beach erosion directly adjacent to the jetty.
2000-Nov 2001	The USACE reconstructs the North Jetty from Sta. 95+00 to 145+00, to a top elevation of +23 ft MLLW at a cost of approximately $3 million.
Feb 2000	A section of the Damon Point access road, paved in 1999, is washed out.
Mar 2000	Connor Creek erodes beach access road at Griffiths-Priday State Park.
Nov 2000	High wind and waves destroy several pedestrian bridges over Connor Creek.
Winter 2001-2002	A series of storms erodes South Beach and overtops the breach fill and temporary truck haul road across the breach fill to the South Jetty and damages the temporary truck haul road across the breach fill to the South Jetty.
Dec 2001-Jan 2002	The USACE places an additional 16,100 cy of 12-inch minus cobble and gravel along the breach fill portion of the Half Moon Bay shoreline to slow the erosion.
Apr-May 2002	The USACE excavates 135,000 cy of sand from the Point Chehalis Revetment Extension Mitigation site and places it by truck haul over 8 acres at the breach fill in the form of a natural dune with a top elevation of +36 ft MLLW at a cost of $519,750. The USACE also nourishes the Half Moon Bay nearshore with 378,441 cy of sand and the South Beach nearshore with 75,219 cy of sand.
Jun 2002	The USACE restores upland revetment stockpile with 135,706 cy of dredged sand.
Nov 2002	The USACE plants 50,000 sprigs of native American dune grass (Elymus mollis) on 3 acres of the breach fill to prevent wind and rain erosion of the restored area.
2003	The USACE nourishes the Half Moon Bay nearshore with 329,106 cy of sand and the South Beach nearshore with 125,388 cy of sand.
Oct 2003	Approximately 70 ft of concrete walking trail (Lighthouse Dune trail extension) along Half Moon Bay is undermined by erosion extending over 350 ft along the shoreline. The City of Westport makes an emergency declaration to place ecology blocks and 1,700 cy of sand at an estimated cost of $53,000.
Feb 2004	The USACE excavates 29,553 cy of sand from the revetment stockpile and places it at the breach fill.
2004	The USACE nourishes the Half Moon Bay nearshore with 289,652 cy of sand and the South Beach nearshore with 262,176 cy of sand.
Dec 2004	The USACE excavates 22,779 cy of sand from the revetment stockpile and places it at the breach fill.
2005	The USACE nourishes the Half Moon Bay nearshore with 102,184 cy of sand and the South Beach nearshore with 217,909 cy of sand.
Jan 2006	A landslide occurs along approximately 80 ft of Roosevelt Beach bluffs, spreading bluff material about 300 ft across the beach.
Feb 2006	Erosion of Damon Point exposes about 100 ft of the Catala shipwreck.
2006	The USACE nourishes the Half Moon Bay nearshore with 126,892 cy of sand and the South Beach nearshore with 55,170 cy of sand.
2007	The USACE nourishes the Half Moon Bay nearshore with 140,406 cy of sand.

Table 8-2
Grays Harbor Coastal Construction, Erosion, and Mitigation History

Period	Event
Nov 2007	Connor Creek bridge at the end of Heath Road opens to allow pedestrian access to the beach at a cost of $334,000.
Dec 2007	The narrowest section of Damon Point was washes out again, resulting in the closure of the Damon Point access road.
2008	The USACE nourishes the Half Moon Bay nearshore with 171,353 cy of sand.
2009	The USACE nourishes the Half Moon Bay nearshore with 144,975 cy of sand and the South Beach nearshore with 214,502 cy of sand.
2010	The USACE nourishes the Half Moon Bay nearshore with 91,720 cy of sand and the South Beach nearshore with 118,182 cy of sand.
Oct 2010	The USACE places 20,000 cy sand on the South Beach shoreline and 10,000 cy sand on the Half Moon Bay shoreline as an interim measure to reduce the potential for a breach to occur.
Oct-Nov 2010	The USACE repairs 300 ft of the Point Chehalis revetment in two locations damaged by wave overtopping. 1,120 tons of 2-4 ton rock is placed to repair 100 ft of revetment between Groin C and D during an emergency repair during a storm on October 23, 2010. 200 ft of revetment west of Groin A is repaired in Nov. 2010 with 2,800 tons of 9-17 ton rock.
2011	The USACE nourishes the Half Moon Bay nearshore with 177,150 cy of sand and the South Beach nearshore with 298,251 cy of sand.
Jan 2012	The Quinault Marina RV park loses five sites to coastal erosion.
2012	The USACE places 30,000 cy of sand from an upland source to the breach fill. The USACE nourishes the Half Moon Bay nearshore with 111,205 cy of sand and the South Beach nearshore with 142,313 cy of sand.
2013	The USACE nourishes the Half Moon Bay nearshore with 86,147 cy of sand and the South Beach nearshore with 477,637 cy of sand.
Nov 2013	The USACE repairs another 300 ft section of the Point Chehalis Revetment damaged by wave overtopping at a cost of $500,600.
Jan 2014	The USACE adds rock to shoreline revetment at Taholah.
Apr 2014	The USACE places 4,500 tons of rock to repair a breach in the shoreline revetment at Taholah at a cost of $300,000.
2014	The USACE nourishes the South Beach nearshore with 498,440 cy of sand.
2015	The USACE nourishes the South Beach nearshore with 506,330 cy of sand.
Oct 2015	The City of Ocean Shores replaces failing geotubes with geobag structure in same footprint as failed geotubes at a cost of $100,000.
Nov 2015	The USACE places 1,600 cy of sand at the toe of the geobags.
Dec 2015	The City of Ocean Shores declares emergency after geotubes become severely damaged and places 1,750 cy of additional sand at the toe of the geotubes. A bluff landslide occurs at Seabrook, Pacific Beach.
Jan 2016	The USACE proposes to install a dynamic cobble revetment fronting the Ocean Shores geotubes, but when that material is unavailable, they install a revetment using approximately 3,850 cy (5,000 tons) of 24" angular rock.
Feb 2016	The Westport by the Sea Homeowners Association repairs the eroded dune with coir fabric, sand fill, and anchored logs in front of Building 8 condominium.
Mar 2016	Taholah shoreline revetment is damaged and breached.

Table 8-2
Grays Harbor Coastal Construction, Erosion, and Mitigation History

Period	Event
2016	The USACE nourishes the South Beach nearshore with 544,980 cy of sand.
Jul-Oct 2016	The City of Ocean Shores installs and removes seasonal sand fence to help build up sand accumulation at the toe of the primary dune.
2017	The USACE nourishes the Half Moon Bay nearshore with 101,019 cy of sand and the South Beach nearshore with 499,001 cy of sand.
Oct 2016-Feb 2017	The USACE repairs up to 500 ft of the Point Chehalis revetment with approximately 640 tons of underlayer filter stone (quarry spall), 640 tons core stone (3-7 ton), and 6,400 tons of armor stone (9-13 ton). The work is the same as in 2013, but at three different segments.
May-Oct 2017	The City of Ocean Shores installs and removes seasonal sand fence to help build up sand accumulation at the toe of the primary dune.

Table 8-3
History of Beach and Nearshore Nourishment in Grays Harbor County

Year	Nearshore Sites		Beach Sites				Description
	South Beach (cy)	Half Moon Bay (cy)	Breach Fill (cy)	Half Moon Bay (cy)	Westport (cy)	Ocean Shores (cy)	
1992		200,000					
1993	373,000						
1994	265,000	146,000	600,000				600,000 cy sand to fill the breach
1995				300,295	82,000		300,295 cy sand south of revetment; 82,000 cy sand at City outfall
1996		274,780					
1997		308,604		5,000			5,000 cy sand at HMB shoreline berm south of revetment
1998		421,468					
1999	76,187	228,470		228,963			228,963 cy sand at revetment extension beach fill
2000			11,600				11, 600 cy of 12" minus cobble and gravel along HMB Breach Fill
2001			16,100				16,100 cy of 12" minus cobble and gravel along HMB Breach Fill
2002	75,219	378,441	135,000				135,000 cy sand at HMB
2003	125,388	329,106			1,700		1,700 cy sand at HMB beach along dune trail
2004	262,176	289,652	29,553				29,553 cy sand at HMB Breach Fill
2005	217,909	102,184	22,779				22,779 cy sand at SB at Breach Fill
2006	55,170	126,892					
2007		140,406					
2008		171,353					
2009	214,502	144,975					
2010	118,182	91,720	30,000				10,000 cy sand at HMB Breach Fill; 20,000 cy sand at SB Breach Fill
2011	298,251	177,150					

Table 8-3
History of Beach and Nearshore Nourishment in Grays Harbor County

Year	Nearshore Sites		Beach Sites				Description
	South Beach (cy)	Half Moon Bay (cy)	Breach Fill (cy)	Half Moon Bay (cy)	Westport (cy)	Ocean Shores (cy)	
2012	142,313	111,205	30,000				30,000 cy sand from upland source to Breach Fill
2013	477,637	86,147					
2014	498,440						
2015	506,330					3,350	1,600 cy of sand + 1,750 cy of sand placed in front of geotubes
2016	544,980						
2017	499,001	101,019					
Sum	**4,749,685**	**3,829,572**	**875,032**	**534,258**	**83,700**	**3,350**	
	Total Nearshore 8,579,257		**Total Beach 1,496,340**				**Total Nourishment 10,075,597**

Westport and Cohassett Beach

During and immediately after construction of the South Jetty, the adjacent shoreline advanced seaward by 2,077 ft, before retreating by 846 ft between 1909 and 1926 (Kaminsky et al., 2010). As the South Jetty deteriorated, sand from the ocean shoreline passed over the jetty to nourish the shoreline on the harbor side until the jetty was rehabilitated between 1935 and 1940. The jetty repairs resulted in further build out of the shoreline to the south until about 1960 (Buijsman et al., 2003), while shoreline erosion commenced and began to form Half Moon Bay by 1946, which necessitated construction of a 2,880-ft long revetment, seven groins, and three timber pile breakwaters to stabilize the Point Chehalis shoreline between 1950 and 1957 (Osborne et al., 2003). Over time, the Half Moon Bay shoreline between the revetment and the south jetty continued to recede, destroying several U.S. Coast Guard structures and continuing to endanger city infrastructure (USACE, 1997).

Portions of the Point Chehalis revetment have been rebuilt several times since 1960, with a major reconstruction of the revetment and groins between 1972 and 1973 (USACE, 1973). A 4,000-ft landward section of the South Jetty was rebuilt in 1966, but the shoreline within 1.5 miles of the jetty continued to erode and, after 1987, began to accelerate as the more landward portion of the jetty was exposed by the retreating shoreline and continued to deteriorate (Buijsman et al., 2003). Shoreline erosion along both Half Moon Bay and South Beach narrowed the neck of land remaining connected to the South Jetty. To help mitigate the erosion, the U.S. Army Corps of Engineers placed 200,000 cy of dredged sand in the form of a submerged nearshore berm in Half Moon Bay in May 1992 and 373,000 cy of dredged sand in the South Beach nearshore in the fall of 1993 (Osborne et al., 2003).

In December 1993, a storm with only a 2-year return period initiated a breach along the south side of the South Jetty between the ocean and Half Moon Bay, which deepened and widened from only about 13 ft, initially, to about 650 ft in the subsequent months, eroding a portion of Westhaven State Park and posing a threat to City of Westport public facilities, including the municipal water well and wastewater treatment plant (Kaminsky et al., 1997; Arden, 2003; Buijsman et al., 2003; Kraus and Wamsley, 2003; Wamsley et al., 2006). The magnitude of the erosion and its implications caught coastal communities and governmental agencies by surprise, and there was much debate and controversy over the appropriate response (Kaminsky et al., 1997). In May 1994, the U.S. Army Corps Seattle District nourished both the Half Moon Bay berm with an additional 146,000 cy of dredged sand and the South Beach nearshore with 265,000 cy of dredged sand before subsequently closing the breach in the fall of 1994 by filling it with 600,000 cy of sand dredged from the navigation channel at a cost of $3,730,000 (approximately $6.22 per cubic yard) (Arden, 2003; Kraus and Wamsley, 2003; Osborne et al., 2003) (Figure 8-9).

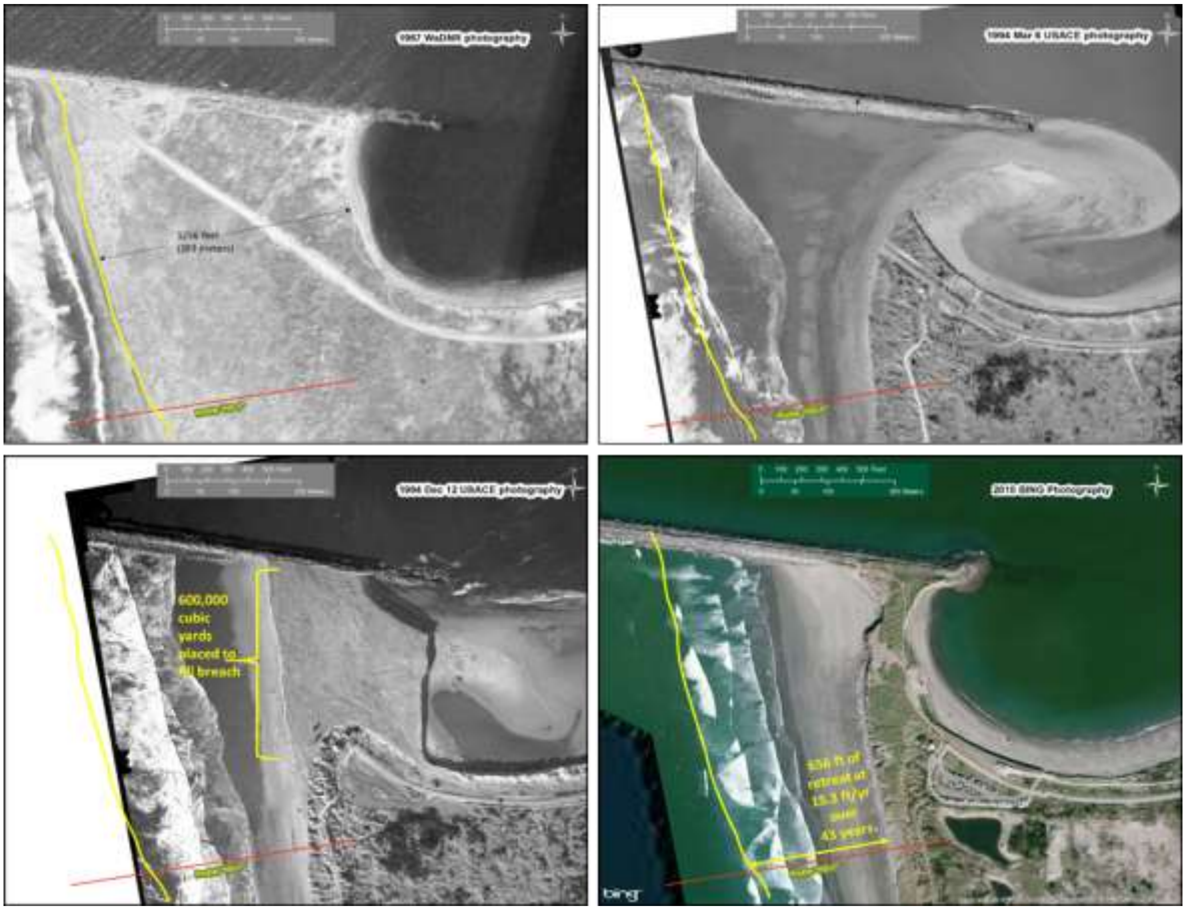


Figure 8-9 Photo set of South Jetty breach area

The shoreline breach was a catalyst for focusing attention on the need for better information on regional coastal processes. In the fall of 1994, the Washington Department of Ecology convened a series of meetings with local, state, and federal agencies to determine how to develop this information; the meetings resulted in a cooperative interagency proposal to investigate the natural hazards, coastal changes, and sediment dynamics along the southwest Washington coast (Kaminsky and Gelfenbaum, 1999).

Despite the closure of the breach and nearshore placement of additional sand in Half Moon Bay in the fall of 1994, coastal erosion continued to impact development along Half Moon Bay. In January 1995, the City of Westport declared a state of emergency when four sections of sewer outfall pipe broke apart due to erosion. The City carried out emergency repairs and placed 82,000 cubic yards of sand on the Half Moon Bay shoreline to protect their sewer outfall line from additional damage. Nearly all of this material eroded by the end of winter, and in the fall of 1995, the U.S. Army Corps of Engineers placed 300,295 cubic yards of dredged sand directly onshore south of the Point Chehalis revetment (Osborne et al., 2003).

By this time, it became clear that ongoing nourishment of sand to Half Moon Bay would be needed to maintain a stable beach profile and shoreline position. Between 1996 and 1999, the U.S. Army Corps of Engineers increased the sand supply to Half Moon Bay, placing more than 300,000 cy per year, on average.

In 1999, the U.S. Army Corps of Engineers also resumed substantial beach nourishment and further protection of upland facilities by extending the Point Chehalis revetment by 1,900 ft and placing 228,963 cy of sand on top of and seaward of the revetment extension. The revetment extension was designed and constructed as a buried revetment behind the primary dune along the shoreline, and as part of an interagency mitigation agreement, periodic nourishment of the beach along the revetment is required to ensure the armor stone toe of the revetment is not exposed (Arden, 2003; USACE, 2014). As such, the sand fronting the buried revetment could also be used, as needed and available, as an upland stockpile of sand suitable for rehandling to nourish adjacent eroding beaches, particularly the breach fill, as was done in 2002, 2004, 2005, and 2010 (Table 8-2) to prevent breaching.

During the winter of 1999-2000, the U.S. Army Corps of Engineers installed a wave diffraction mound at the landward end of the south jetty to reduce wave-induced erosion of Half Moon Bay. While the stated purpose was to reduce the potential for another breach by distributing the wave energy more evenly throughout the bay, the net effect near the breach fill was to increase the wave energy, and 11,600 cy of cobble and gravel fill was placed on the beach along the breach fill to counter these effects. The wave diffraction mound effectively changed the hard point that determines the equilibrium shape of the crenulate bay. As a result, the western end of Half Moon Bay experienced erosion between 1999 and 2004, as the bay adapted to the changed anchor point (Hughes and Cohen, 2006). This adjustment toward a new shoreline planform made it imperative to continue the placement of dredged material in Half Moon Bay until a dynamic equilibrium was reached. Hughes and Cohen (2006) acknowledge, however, that while the nearshore bathymetry and shoreline will change over time in response to storms and longer periods of milder waves, any loss of dunes along the bay would not be replaced by these natural forces. In October 2003, erosion of the southwest Half Moon Bay shoreline undermined a concrete pedestrian walkway and the City of Westport installed ecology blocks and 1,700 cubic yards of sand to prevent collapse of the walkway as an emergency action (Figure 8-10).

Figure 8-10 Emergency Dune Protection Constructed at Half Moon Bay, Westport, October 2003

By this time, it was also evident that the shoreline and nearshore area south of the South Jetty was undergoing chronic erosion and that any new breaching would likely be caused by erosion and dune recession from the ocean side (Hughes and Cohen, 2006). Between 1954 and 1999, the nearshore area within 3.7 miles south the South Jetty lost 70.5 million cy of sediment (1.57 million cy/yr) (Kaminsky et al., 2010). From 2002 onward, the U.S. Army Corps of Engineers continued nearly annual nearshore nourishment of both South Beach and Half Moon Bay (Table 8-3). The 3,500-ft reconstruction of the South Jetty between 1999 and 2002 did not reduce the nearshore erosion or the rate of shoreline recession. Figure 8-9 illustrates the shoreline retreat near the South Jetty. From 2009 to 20012, the average annual nearshore nourishment to South Beach was about 193,000 cy/yr. This amount was substantially increased to an average of about 505,000 cy/yr between 2013 and 2017.

During the strong El Niño during the winter of 2015-2016, the last remnant of the primary dune in the vicinity of the Westport by the Sea Condominiums was lost. The dune had been chronically eroding since 1997 at an average rate of 7.2 ft/yr as documented by quarterly beach surveys collected by the Washington Department of Ecology Coastal Monitoring & Analysis Program at nearby beach profile “Worm” (Table 8-4; Figure 8-11). The erosion threatened the Westport by the Sea Condominiums and in February 2016, the Homeowners Association repaired the eroded dune with coir fabric, sand fill, and anchored logs in front of Building 8.

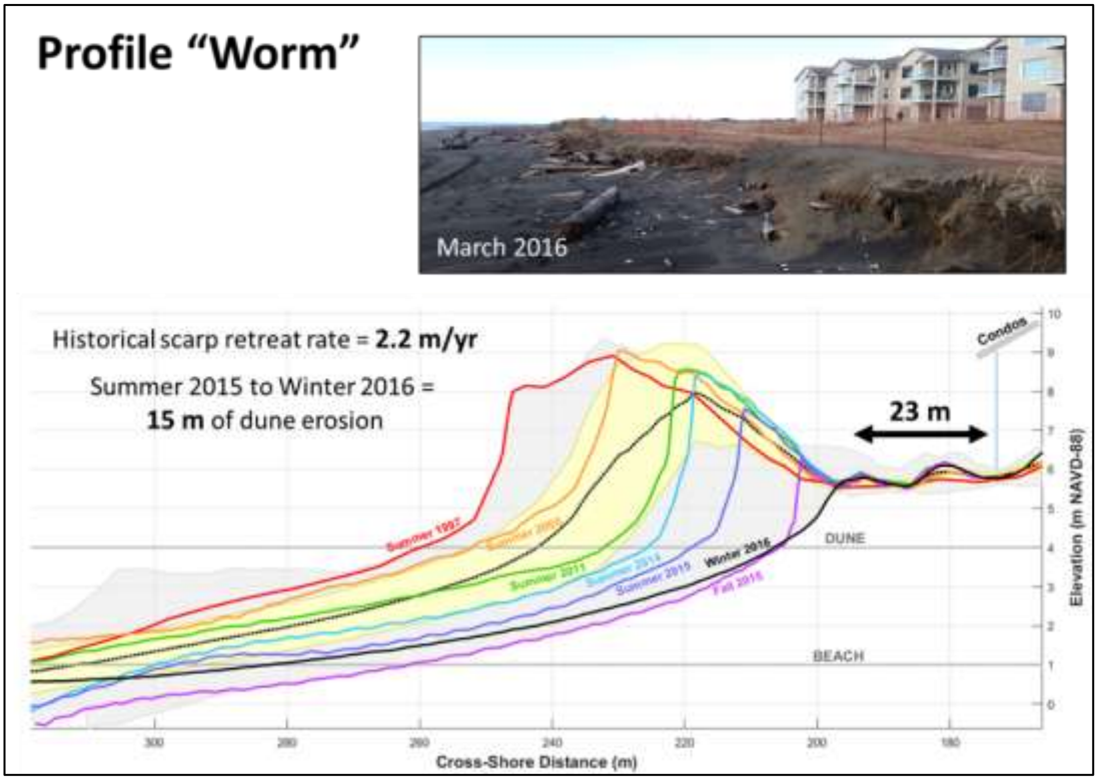


Figure 8-11 WDOE Cross-shore Beach Profile Data - Summer 1997 and Winter 2016

With $200,000 support from the legislature for the Grays Harbor Coastal Resilience Coalition, the Washington Department of Ecology Coastal Monitoring & Analysis Program performed augmented monitoring at chronically eroding beaches at both Westport and Ocean Shores beginning in 2015, which resulted in profile data. This enabled a more detailed analysis of the amount of sand being lost to the beaches and dunes. At Westport between the South Jetty and 2.1 miles south of the jetty at profile "Spice", the average loss of sand is 63,100 cy/yr (Table 8-4). The columns on the far right of Table 8-4 show total erosion and net loss or gain for the North Beach and Grayland Plains subcells.

This quantity represents a feasible amount of sand that could be potentially added to the coast if cost-shared with the U.S. Army Corps of Engineers. Without additional augmentation of the sediment budget to this area, the shoreline is expected to continue to retreat in the future.

Table 8-4 Beach and Dune Volume Change Trends

					Volume Change Trends (m^3/yr/m)			Total Volume (cubic yards per year)				
	Description	Profile Name	Approx Northing	Length of shoreline represented (m)	DUNE	BEACH	DUNE + BEACH	DUNE	BEACH	DUNE + BEACH	Erosion only	Net loss or gain
		Diana	199545	3900	9.8	10.2	20.0	49,700	52,100	101,900	-25,800	487,300
	the casino	Casino	196555	2902	3.5	14.4	17.9	13,100	54,800	68,000		
		Damons	193740	2778	10.5	21.2	31.7	38,100	77,000	115,100		
North Beach		ET	191000	3068	12.9	17.8	30.6	51,600	71,400	123,000		
		Butter	187605	1800	15.0	13.7	28.7	35,300	32,200	67,400		
		NB #19	187400	604	8.7	10.9	19.6	6,800	8,600	15,500		
		NB #14	186397	909	8.3	5.2	14.1	9,900	6,200	16,700		
	scarp ends	NB #10	185582	499	6.2	-2.8	4.1	4,000	-1,800	2,700		
		NB #9	185398	195	1.8	-2.4	-0.6	500	-600	-100		
		NB #8	185192	203	6.1	-5.2	-2.6	1,600	-1,400	-700		
		NB #7	184992	196	0.7	-6.6	-6.3	200	-1,700	-1,600		
		NB #6	184799	196	2.7	-9.8	-12.0	700	-2,500	-3,100		
		NB #5	184601	198	-2.0	-15.4	-16.1	-500	-4,000	-4,200		
		NB #4	184404	183	-5.7	-15.4	-21.5	-1,400	-3,700	-5,200		
	geobags	X1-North	184235	100	-0.4	-8.3	-8.8	-100	-1,100	-1,200		
		NB #3	184204	115	-3.8	-11.6	-17.5	-600	-1,700	-2,600		
	wave	NB #2	184005	128	-4.3	-12.8	-22.9	-700	-2,100	-3,800		
	bumpers	X1-South	183948	102	0.0	-7.1	-7.6	0	-1,000	-1,000		
	North Jetty	NB #1	183801	146	7.0	-4.5	2.7	1,300	-900	500		
					Grays Harbor							
Grayland Plains	*South Jetty*	HD-1	180642	1120	1.3	-2.8	-1.4	2,000	-4,100	-2,100	-63,100	-26,900
	Westport By	Worm	179078	877	-7.2	-7.8	-15.0	-8,300	-8,900	-17,200		
	the Sea	GP #85	178887	195	-2.8	-7.0	-11.5	-700	-1,800	-2,900		
		GP #84	178687	188	0.2	-7.4	-9.5	0	-1,800	-2,300		
		GP #83	178512	149	-0.7	-6.3	-4.5	-100	-1,200	-900		
		GP #82	178389	362	NaN	-6.7	NaN	NaN	-3,200	NaN		
		Spice	177787	1776	-4.9	-7.1	-12.0	-11,400	-16,400	-27,800		
	scarp ends	Rdan	174837	2900	8.3	-1.4	6.9	31,500	-5,200	26,300		

Despite the placement of over 2.1 million cy of sand in the Half Moon Bay nearshore between 2002 and 2013, the Point Chehalis revetment has recently required routine repairs due to the increased wave energy associated with the continued deepening of the inlet. Typical winter storm waves now overtop the revetment that is not possible to eliminate under the constraints of the current project authorization (Michalsen and Brown, 2015). The overtopping causes flooding throughout the Westport business district and Marina area. Frequent wave overtopping removes armor stone and core material and erodes the sand foundation on the landward side which causes progressive damage, destabilization, and subsidence of the revetment. The U.S. Army Corps of Engineers performed structural repairs along different sections of the revetment in 2010, 2013, and 2015 (Table 8-2; Figure 8-12).

Figure 8-12 Photo of Point Chehalis Revetment Repairs in 2013 from Michalsen and Brown (2015)

Ocean Shores at North Jetty

Following completion of the Grays Harbor North Jetty in 1916, the shoreline rapidly advanced seaward adjacent to the jetty. By 1927, the shoreline within 4 miles of the jetty advanced an average of 0.75 mile seaward from its pre-jetty position. The shoreline advanced progressively less seaward as far north as Copalis Beach, which changed the regional shoreline orientation to face more to the west-northwest (Kaminsky et al., 2010). Between 1927 and 1950, the regional shoreline continued rotate and build seaward, advancing at an average rate of 45 ft/yr near the jetty and progressively decreasing to a rate of about 5 ft/yr near Moclips. After 1967, the shoreline all the way to Point Grenville advanced seaward. Thus, the North Jetty effectively established a new seaward anchor point for the North Beach Peninsula that affects the shoreline position all the way to Point Grenville.

Closer to the jetty, and upon inspection of shorter intervals of time, the shoreline within about 2 miles north of the jetty is highly affected by the condition of the jetty. By 1934, the outer 1.5 miles of the North Jetty between the shoreline and its western end subsided to approximately -1.5 ft mean lower low water (MLLW). Consequently, the shoreline within 2 miles of the jetty began to retreat in 1923 until the jetty was reconstructed in 1942 to an elevation of +20 ft MLLW for 7,700 ft seaward of the shoreline and then to +30 ft MLLW for an additional 528 ft (Buijsman et al., 2003; Byrnes and Baker, 2003).

Following jetty reconstruction, the shoreline adjacent to the jetty began to advance again until about 1950 when the shoreline within about 1.5 miles north of the jetty stabilized as the outer end of the North Jetty subsided. By 1974, the North Jetty seaward of the shoreline had subsided to an elevation ranging from +3 to +14 ft MLLW for 1,300 ft (1/4 mile) after which the remaining jetty farther to the west was below MLLW. The North Jetty was again reconstructed in 1976, returning a 6,000-ft section of the jetty seaward of the shoreline to +20 ft MLLW. This jetty reconstruction did not significantly affect the local shoreline, as the shoreline remained relatively stable within about 1.5 miles north of the jetty. Figure 8-13 illustrates relatively little change in the shoreline position within about a mile of the jetty since 1951.

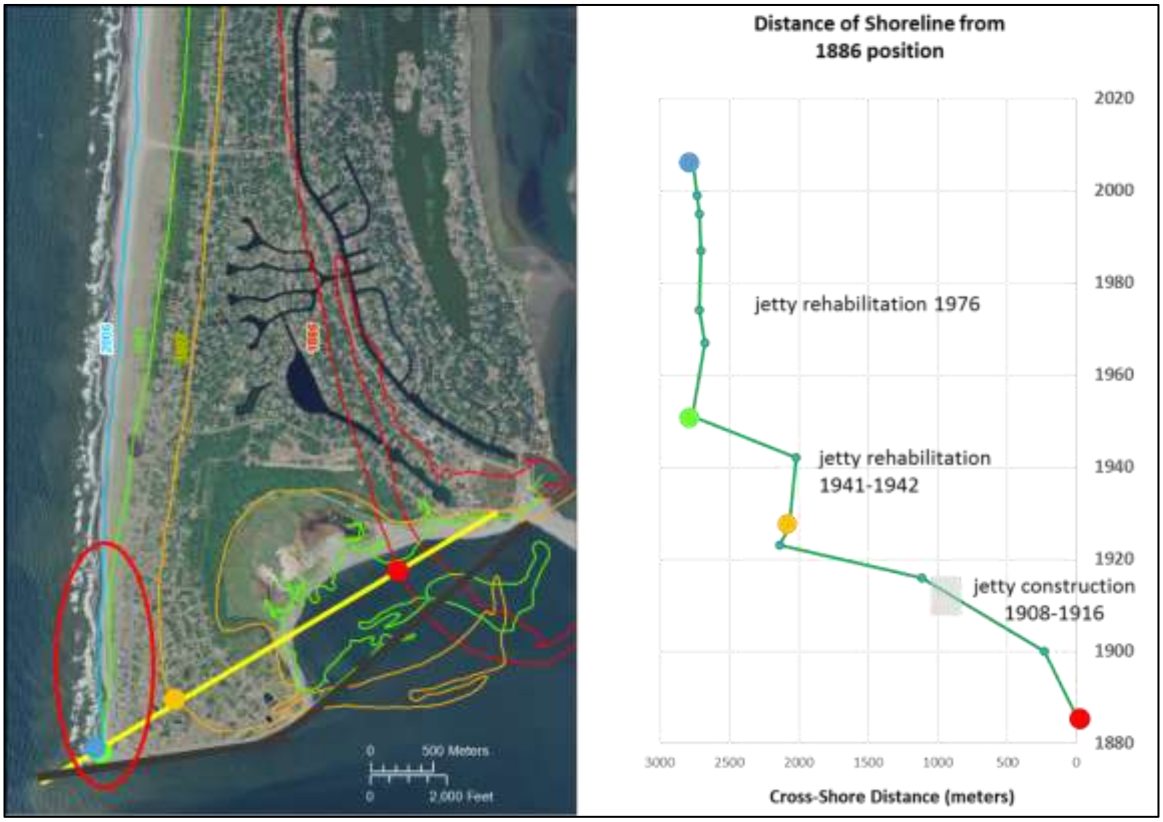


Figure 8-13 Change in Shoreline Position Near the Ocean Shores North Jetty
(Note: Figure 8-13 represents the change in shoreline position near the Ocean Shores North Jetty; shoreline positions through time are taken along the yellow line in the image on the left as a cross-shore distance from the 1886 shoreline (red); the green dots in the plot on the right denote additional shoreline positions not shown on the map on the left.)

Following reconstruction of the jetty, in 1976 and 1977, the City of Ocean Shores and the Grays Harbor Conservation District sought to assist in the repair and stabilization of the primary dune that had been severely damaged during the winter of 1974-1975, just prior to the jetty repair. A major storm had completely washed away the dune next to the jetty and had blown-out the dune in several locations within 1.5 miles north of the North Jetty (Grays Harbor Conservation District, 1975). Fertilizer was spread over 55 acres, extending over a swath about 1.5 miles long by 300 ft wide to enhance plant growth along the primary dune north of the North Jetty. European beachgrass was planted to stabilize a 9-acre denuded area near the jetty that had been washed out during the storm. The project also installed two 500-ft long, 3-ft high picket fences along the previous dune line that were spaced 35 ft apart to enhance sand deposition and rebuild the primary dune. The first fence failed in November 1976, and a second sand fence was installed farther inland from the first fence, and this second fence was partially destroyed during a March 1977 storm (Grays Harbor Conservation District, 1977).

While the shoreline position near the jetty did not significantly change since 1951, nor advance seaward following substantial jetty reconstruction in 1976, development along the primary dune continued to occur, allowing little buffer to account for future shoreline retreat commensurate with jetty degradation over time. Homes and condominiums near the jetty started to be built in the 1980s, and during the winter of 1995-1996, up to 40 ft of the primary dune eroded, placing five developed properties at imminent risk (Figure

8-14). In October 1996, an 850-ft long terraced revetment structure, referred to as the "wave bumpers," was built to provide temporary protection. In January 1998, after a major storm event and high tide, flanking erosion on both ends of the wave bumpers concerned the City and private property owners, and they proposed the installation of geotubes to prevent additional retreat of the primary dune along the north end of the wave bumpers (City of Ocean Shores, 1999). Following a lengthy permit process, 540 ft of geotubes were installed in December 1998, and as part of permit conditions, the City agreed to develop an Environmental Impact Statement associated with a long-term strategy for coastal erosion management.

During a March 1999 storm, waves overtopping the jetty brought over five feet of water to an area 0.75 miles inland of the jetty, damaging East Ocean Shores Boulevard, washing away a public restroom, and causing over $1 million in damages to public and private property (Figure 8-15). While part of the overtopping was due to the degradation of the jetty, it can also be attributed to the erosion of the ebb delta and overall deepening of the inlet that exposes the jetty to larger and more frequent ocean waves approaching from the southwest (USACE, 2000). The more frequent overtopping caused more frequent and extensive flooding of southern Ocean Shores, erosion of two of the four lanes of Ocean Shores Boulevard along the jetty, as well as erosion along the landward side of the jetty and the formation of swash channels at both ends of the structure (along the Ocean shoreline and along the Oyhut shoreline next to the wastewater treatment plant) (USACE, 2000).

In May 1999, the City of Ocean Shores released a Draft Environmental Impact Statement on their long term coastal erosion management strategy (City of Ocean Shores, 1999) which identified several alternatives including: (1) no action, (2) retreat and retreat with dune construction, (3) onshore and/or offshore beach nourishment, and (4) construction of structural features, including seaward extension of the jetty that was not reconstructed in 1976.

During 2000 to 2001, the U.S. Army Corps of Engineers reconstructed a 5,000-ft section of the North Jetty landward of the ocean shoreline to the wastewater treatment plant to +23 ft MLLW; the section seaward of the shoreline was not reconstructed.

Beach monitoring data by the Washington Department of Ecology Coastal Monitoring & Analysis Program showed that following the La Niña winter of 1998-1999 through 2006, the shoreline and dune recovered from it erosive state and built seaward, resulting in most of the wave bumpers and geotubes to become buried in sand. The beach then began to lose volume while the dune continued to build until the fall of 2011. Both the dune and beach retreated sharply during the winter of 2010-2011 and continued on an erosional trend through the winter of 2015 (Figure 8-16 and Figure 8-17).

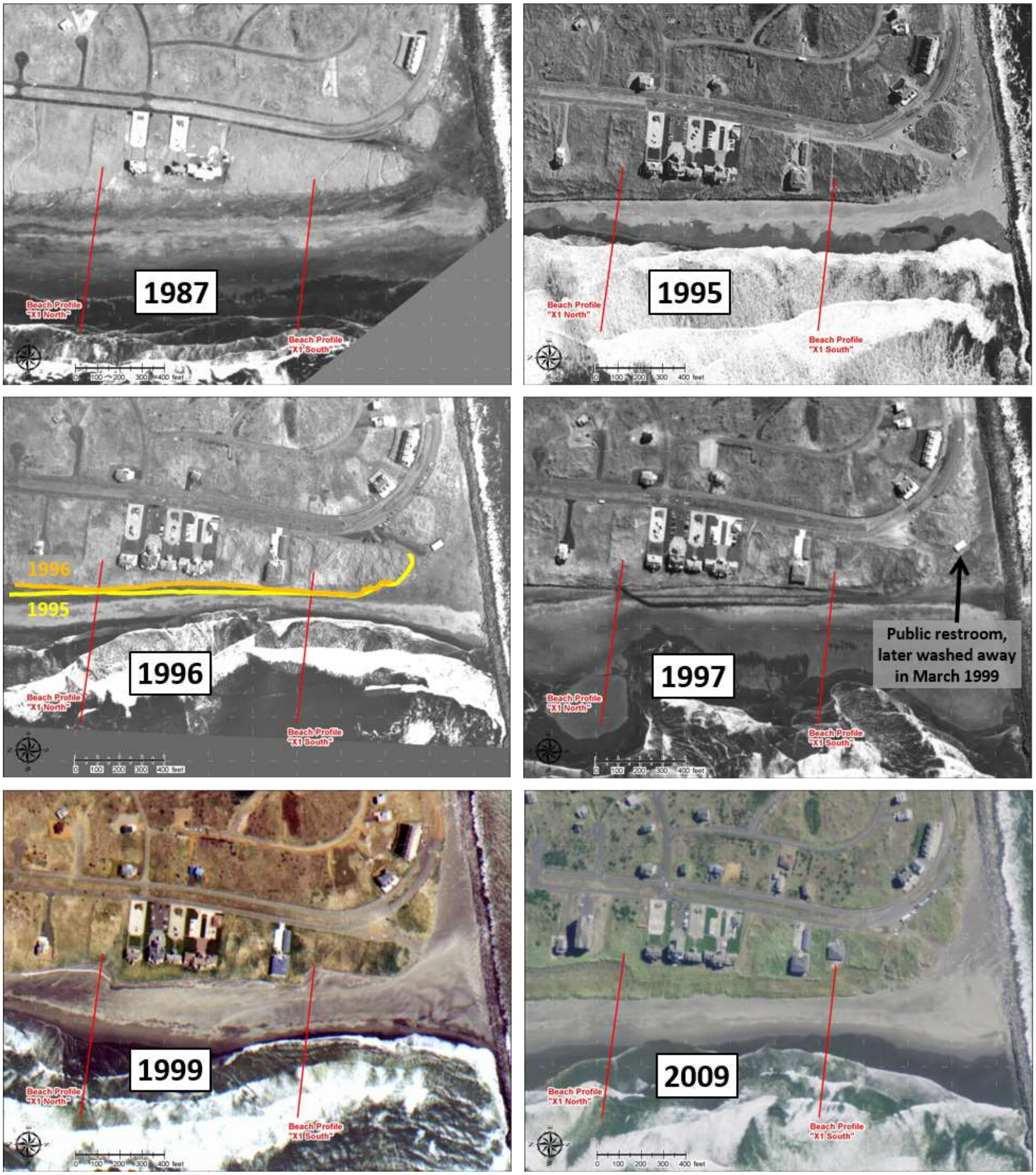


Figure 8-14 Historical Aerial Photos of the Beach North of the Ocean Shores North Jetty

Note: In the historical aerial photos of the beach north of the Ocean Shores North Jetty, the 1996 photo shows the position of the vegetation line in 1995 (yellow) and 1996 (orange) the 1996 photo shows the position of the vegetation line in 1995 (yellow) and 1996 (orange).

Figure 8-15 Flooding and Erosion of the Ocean Shores Public Restroom During March 1999 Storm

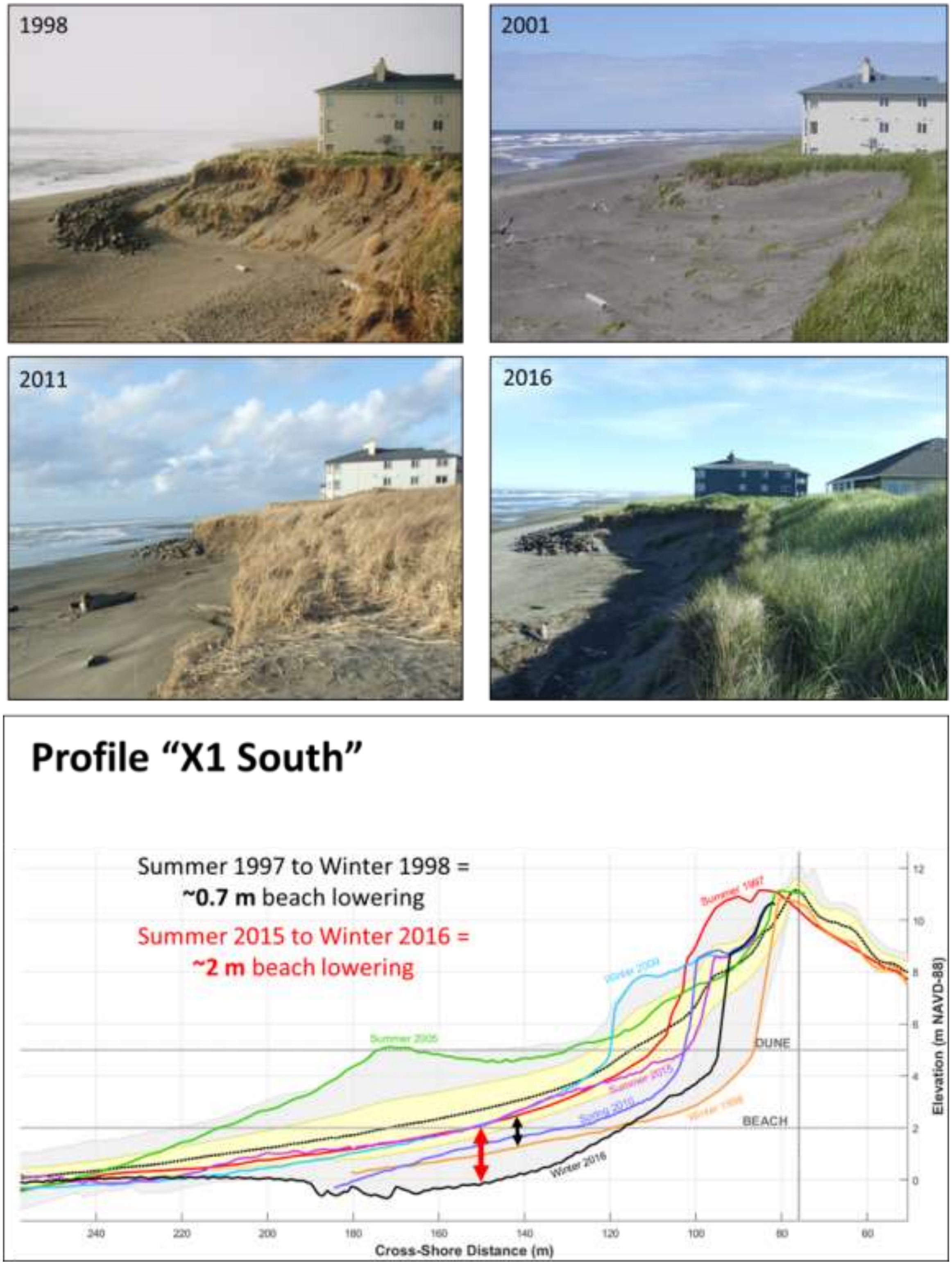


Figure 8-16 Cross-shore Beach Profile Data North of the Ocean Shores North Jetty
Note: Data collected by the Washington Department of Ecology north of the Ocean Shores North Jetty between summer 1997 and winter 2016

Figure 8-17 Dune Erosion South Beach Profile July 2008 (top) and November 2015 (bottom)
Photo by Washington State Department of Ecology

In October 2015, a section of the geotubes immediately north of the wave bumpers was undermined, resulting in a failure at the base. The City of Ocean Shores responded quickly and replaced the failed section with a geobag block structure. By early November 2015, storms threatened to undermine the geobags and the U.S. Army Corps of Engineers provided emergency assistance by placing 1,600 cy of sand at the toe of the geobags (Figure 8-18). A December 2015 storm further exposed and damaged the remaining geotubes to the north, and the City of Ocean Shores placed an additional 1,750 cy of sand at the toe of the geotubes. By January 2016, those sand supplies were lost to erosion and under a declaration of emergency, the U.S. Army Corps installed a rock revetment fronting the full length of the geobags and geotubes (Figure 8-19). This resulted in substantial flanking erosion of the dune to the north of the revetment (Figure 8-20). During the summers of 2016 and 2017, the City of Ocean Shores installed sand fences to the south and north of the revetment structures at the base of the eroded dune to enhance the accumulation of sand during the summer recovery periods (Figure 8-21).

Figure 8-18 Photos of Geobags and Dune Nourishment at Ocean Shores in November 2015

Figure 8-19 Geobags Nov. 2015 and Rock Revetment Installed in Front of Geobags Winter 2016

Figure 8-20 Eend Scour North of the Ocean Shores Rock Revetment

Figure 8-21 Sand Fences Installed North of the Ocean Shores Rock Revetment in 2016

With augmented beach profile monitoring by the Washington Department of Ecology Coastal Monitoring & Analysis Program (CMAP) since 2015, a persistent erosion scarp of the dune up to about 1.2 mile north of the North Jetty has been mapped. Analyses of the beach profile data has shown that the erosion trend between 2010 and 2015 resulted in the average loss of 25,800 cy of sand from the beach and dune within about 1.2 mile of the North Jetty (Table 8-4). CMAP concluded that without rehabilitation of the North

Jetty seaward of the shoreline, nourishment of sand to the beach and dune would only offer a temporary solution to the erosion.

In 2003, the U.S. Army Corps published a study that evaluated feasible methods for reducing annual maintenance dredging by modification of the North Jetty (Kraus and Arden, 2003). This study further established the relationship between the jetty condition and its seaward extent to the position of the shoreline. The study predicted that each structural alternative considered would result in beach accretion adjacent to the jetty relative to the existing conditions ("Alternative 1"). The larger structures created the greatest change, with maximum advance in shoreline position of approximately 250 ft.

Two of the more feasible scenarios involved jetty extensions westward from the existing end: Alternative 3A involved a 500-ft extension and Alternative 3B involved a 1,200-ft extension. For the 5-yr ("short-term") model simulations, Alternative 3A advanced the shoreline up to 140 ft next to the jetty, and Alternative 3B produced a shoreline as much as 250 ft seaward. Shoreline advance was predicted to be greatest at the jetty and rapidly reduce to no change within 0.5 miles to the north. Between about 0.5 and 2.5 miles north of the jetty, the shoreline was projected to retreat up to a maximum of 30 ft for Alternative 3A and 55 ft for Alternative 3B, with the erosion maximums occurring about 0.75 miles north of the jetty for both alternatives (Figure 8-22[24]). The predicted shoreline erosion relative to the existing condition is associated with a northward shift of a gyre and rip current due to the jetty extension. Existing conditions show a rip current embayment that tends to migrate between about 600 and 1,000 ft north of the jetty; this embayment is predicted to shift northward with the extension of the jetty and contribute to localized net shoreline retreat.

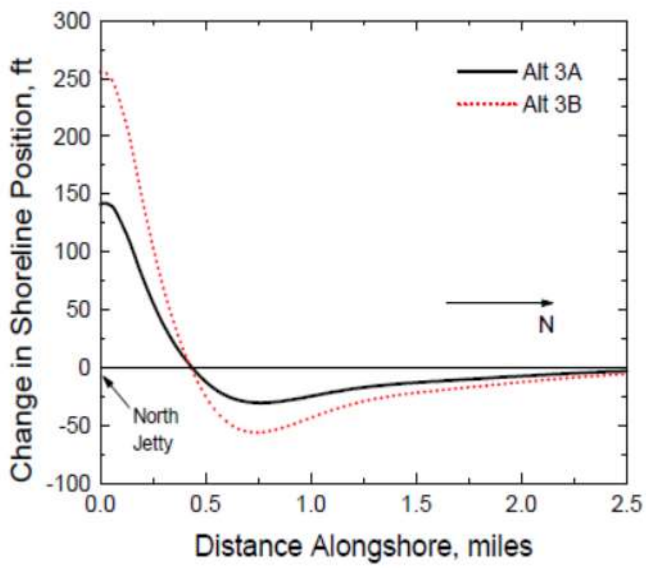


Figure 8-22 Short-term Change in Shoreline Position Relative to Alternative #1

[24] Excerpted from Kraus and Arden, 2003

For long-term model simulations of 30 years, the maximum shoreline advance distances are similar, but the maximum shoreline retreat to the north is reduced compared to the 5-year projection (Figure 8-23[25]).

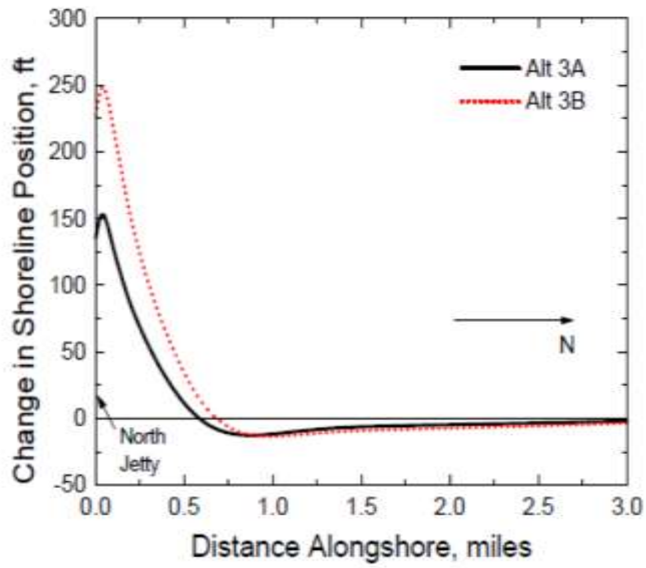


Figure 8-23 Long-term Change in Shoreline Position Relative to Existing Conditions

While these study results are favorable to the City of Ocean Shores, these alternatives would only be expected to reduce southward bypassing of sand into the inlet by 16,000 to 80,000 cy/yr. These reductions are small compared to the estimated 400,000 cy/yr of sand bypassing southward from the North Jetty under the existing conditions. This situation does not result in a sufficient benefit/cost ratio to enable the U.S. Army Corps of Engineers to construct the jetty extensions.

A comparative analysis was more recently performed by Coast & Harbor Engineering on behalf of the City of Ocean Shores (Coast and Harbor, 2016). This study developed a qualitative empirical relationship between the stability of the shoreline and the effective length of the North Jetty and estimated that approximately 1,000 ft of jetty repairs to the existing jetty are required to stabilize the shoreline (i.e., prevent chronic landward retreat). As a result, the City of Ocean Shores has made a request to the State Legislature to provide $4 million to implement at least a partial jetty repair.

Oyhut Wildlife Recreation Area and Damon Point

Surveys prior to the construction of the North Jetty consistently show an outer spit or elongated island extending from the North Beach peninsula into the mouth of Grays Harbor. In the 1841 and 1860 surveys, this feature is identified as Eld Island (for illustrations, see Figures 10 and 11 in Kaminsky et al., 2010). Following construction of

[25] *Eexcerpted from Kraus and Arden, 2003.*

the North Jetty in 1916, a new outer spit rapidly grew seaward and southward toward the jetty. By 1921, the spit reached the jetty to form an intertidal embayment on the leeward side. (
Figure 8-24). With the deterioration of the jetty over time, the spit grew into the entrance to Grays Harbor, and by 1927 extended eastward approximately 5,000 ft from its westward connection to the jetty. The shallow embayment to the north developed as a salt marsh and became known as the Oyhut tidal flats.

The elongated spit continued to grow until the North Jetty was reconstructed in 1942. As a result of the elimination of sand supply from north to south over the jetty, the spit quickly eroded and became an island by 1943 (Figure 8-25[26]). As the jetty landward of the reconstructed section deteriorated, a spit reformed along the axis of the jetty to the east and, by 1948, reconnected to the remnant island that had migrated eastward to the south of the jetty. This spit was the beginning of what later evolved into Damon Point.

By 1975 when the North Jetty to the west was again reconstructed, two spits extended toward the southeast from the eastern portion of the original jetty. Following completion of jetty reconstruction in 1976, the westward lesser spit deteriorated, likely from the reduction of sediment supply entering the inlet from the north. By 1981, the basal end of the spit along the axis of the North Jetty was breached, allowing for greater tidal flow into the Oyhut embayment (Figure 8-26). By 1985, the two spits to the east merged at the basal end of Damon Point.

With continued deterioration and subsidence of the original jetty section to the west of Damon Point, an elongated spit developed from the southwest portion of the Oyhut tidal flats by 1990. To the north and east of the distal end of this spit was another sand barrier that extended to Damon Point by a narrow neck of land just west of the submerged jetty. At this time the main tidal outflow from the tidal flats was directed toward Damon Point. Kaminsky et al. (1999) suggest that the discharge of sediment through the drainage channel oriented toward Damon Point may be responsible for the nearly stable Damon Point shoreline position between 1990 and 1997.

By 1997, the southwestern area of the Oyhut tidal flats had become more exposed, with deeper water penetrating farther northward, inside the area bounded by the submerged jetty. The elongated spit that extended to the northeast in 1990 ceased to exist. Kaminsky et al. (1999) note that 1998 photography reveals sedimentation near the outflow of the main drainage outflow area at the southwestern portion of the Oyhut tidal flats. It is likely that little of this sediment flows toward Damon Point and, as a result, most of the western end of the Damon Point began to rapidly retreat at rates greater than 98 ft/yr. This is similar to the period between 1985 and 1990 that followed the period when the Oyhut drainage outflow in the southwestern portion of the tidal flats became more dominant. The high rates of shoreline retreat along Damon Point between 1997 and 1998 may have been partially due to higher wave and water levels associated with the El Niño event. The basal end of Damon Point has narrowed over time and the access road washed out during storms in December 1997, December 1998, February 2000, and December 2007, after which no further attempt was made to keep it open to vehicles.

From 1999 to present, the Oyhut shoreline continued to retreat landward and become more of a barrier beach with a gradual infilling of the salt marsh with sand (Figure 8-27). The development and expansion of Oyhut Bay between the remaining hard points at the eastward end of the reconstructed North Jetty near the wastewater treatment plant and the Ocean Shores Marina at the west end of the Bay will control the future evolution of this crenulate bay. The remnant deteriorating section of North Jetty between the Wastewater Treatment Plant and the Marina offers little protection from large waves entering the bay and

[26] *Baker and Byrnes, 2004.*

transforming its shoreline. As Damon Point continues to retreat toward the northwest, the marina breakwater and the Quinault RV Park has become increasingly exposed. Five RV sites were lost to coastal erosion in 2012. As Damon Point has retreated to the northwest along the basal end, the distal end has continued to grow toward the southeast. This growth has forced the southward migration of the channel thalweg and has altered the transmission of ocean waves into the inner harbor (USACE, 2014).

Figure 8-24 Historical Shoreline Change at the Mouth of Grays Harbor 1886 to 1942

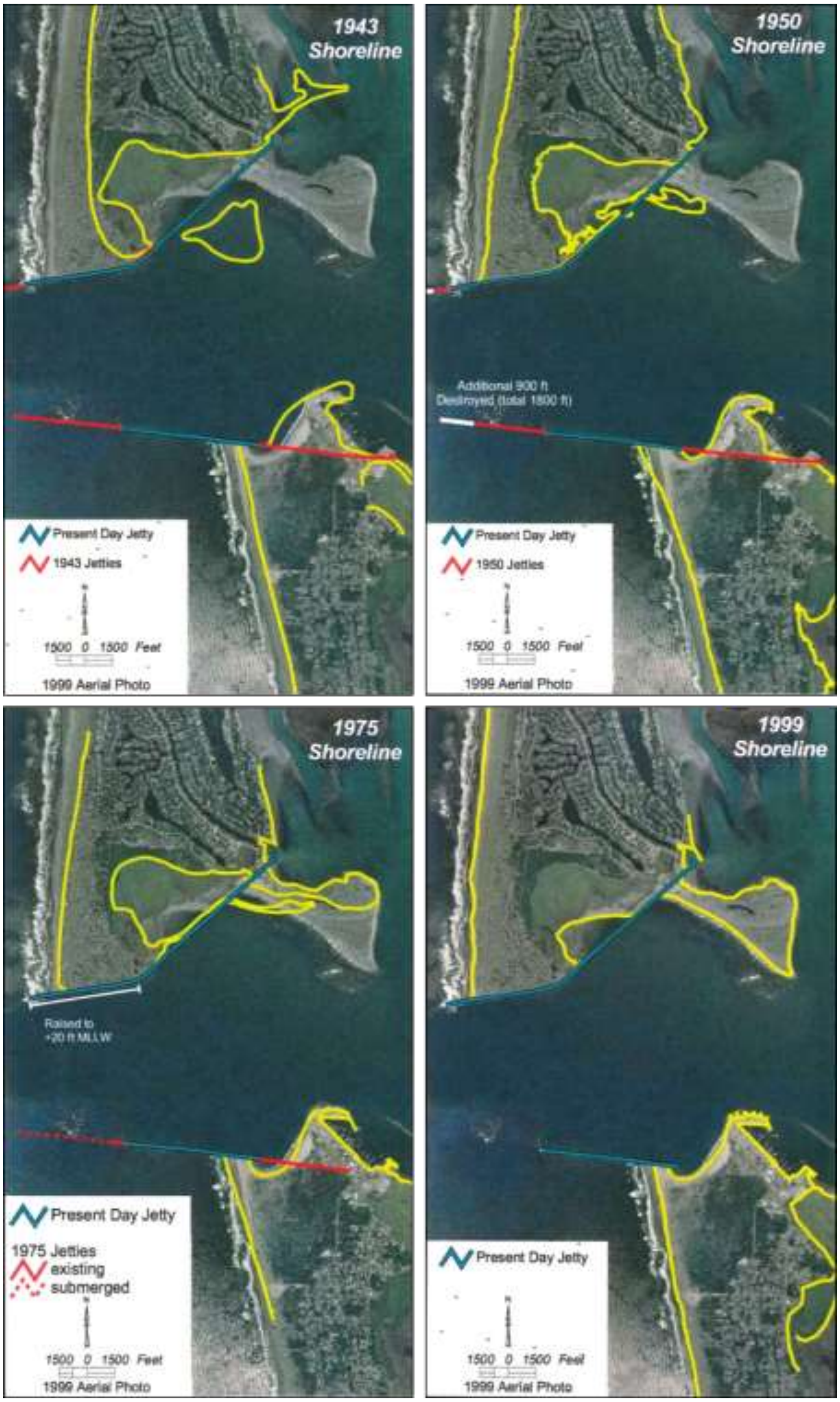


Figure 8-25 Historical Shoreline Change at the Mouth of Grays Harbor 1943 to 1999
Source: Baker and Byrnes, 2004

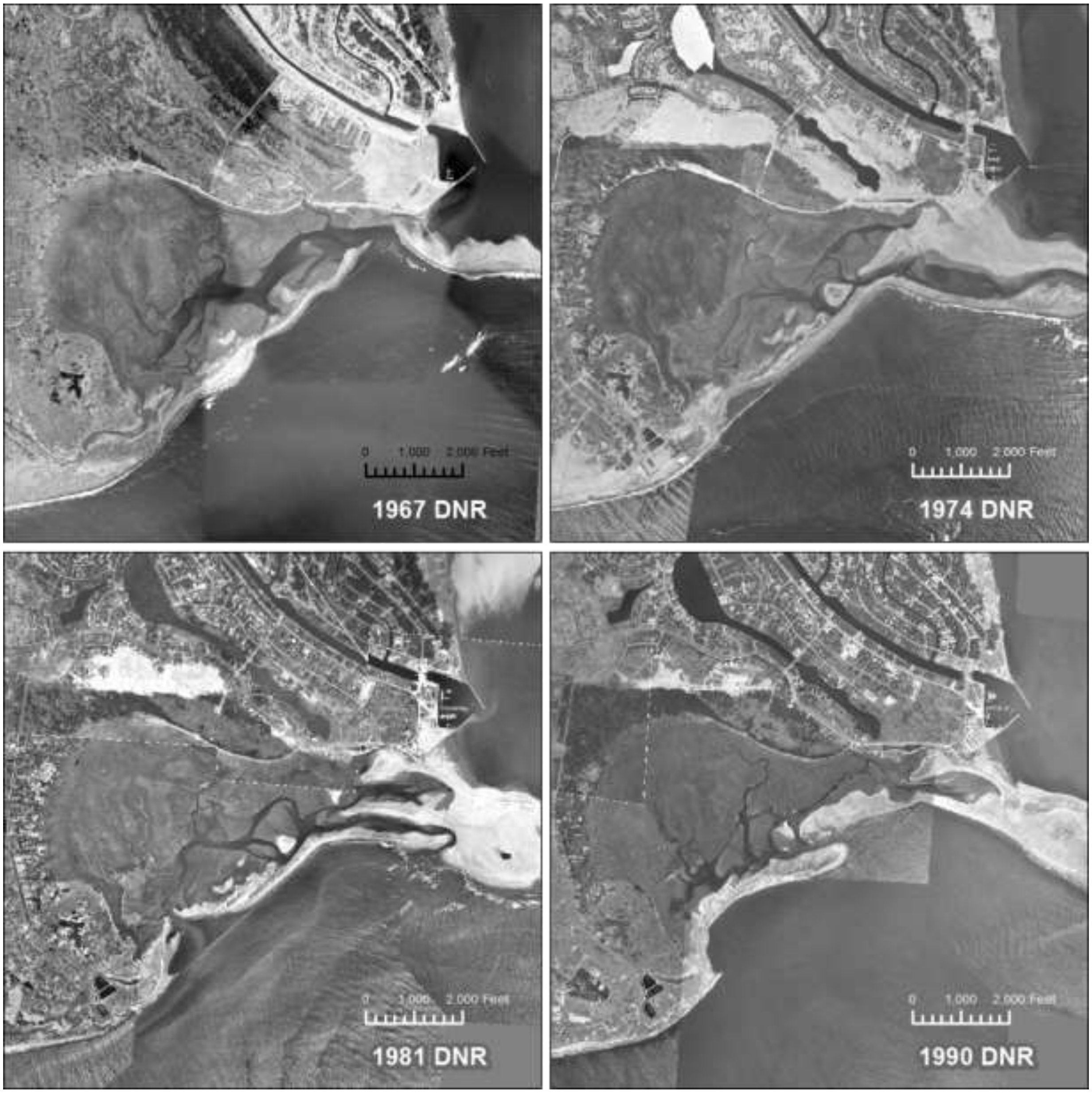


Figure 8-26 Historical Shoreline from the Oyhut Wildlife Recreation Area 1967 to 1990

Figure 8-27 Historical Shoreline from the Oyhut Wildlife Recreation Area from 1999 to 2015

Whitcomb Flats[27]

Whitcomb Flats is a flood tidal shoal complex located approximately 1 mile east of Point Chehalis (Figure 8-1). Its sediments are composed of sand derived of marine origins which were deposited by tidal flood currents and wave-induced transport. The flood shoal has been a long standing land feature within Grays Harbor which predates the navigation project; Whitcomb Flats was mapped in the 1890 condition survey prior to jetty construction in 1898. Osborne (2003) conducted a geomorphology study on the evolution of

[27] This section is primarily modified after USACE, 2014

Whitcomb Flats using georectified aerial photographs from 1962 to 2001. Figure 8-28 shows Whitcomb Flats has experienced a net eastward migration over this time period. This migration is tied closely with the morphology of the inlet throat.

As discussed in the previous section, the deteriorated condition of the North Jetty resulted in significant sediment transport from North Beach over and through the North Jetty. This caused the distal end of Damon Point to grow toward the southeast, which is a trend that has continued up until present time. This has, in turn, constricted the throat of the inlet between Damon Point and Point Chehalis and resulted in net erosion of 40 million cubic yards of sediment from the seabed since 1954. The pathways of sediment scoured from the inlet throat have primarily been directed offshore due to the strength of the ebb currents on an outgoing tide and has resulted in a diminished sediment supply to Whitcomb Flats over time. Additionally, as Damon Point continued to grow southeast, this forced the southward migration of the channel. As the thalweg migrated south, the wave transmission into the inner harbor was also altered. Deepwater wave energy transmitted into the harbor through the inlet throat refracts into the shallows near Whitcomb Flats. Geomorphology analysis suggests these waves can overwash the low-relief sand flat and cause the eastward migration of Whitcomb Flats.

Osborne (2003) concludes that the eastward migration of Whitcomb Flats appears to be caused by a combination of factors that may include: wave-induced overwash processes and erosion by storm waves; tidal transport; a reduction in sediment supply caused by armoring of the shoreline on the south side of the inlet at Point Chehalis in the 1950s; and, perhaps to a lesser extent, aeolian transport by prevailing westerly winds. Relocation of the navigation channel from Sand Island Reach to South Reach in the late 1970s, maintenance dredging at South Reach, and the widening and deepening project in the 1990s have also contributed to the overall increase in depth locally that has allowed larger waves to reach Whitcomb Flats.

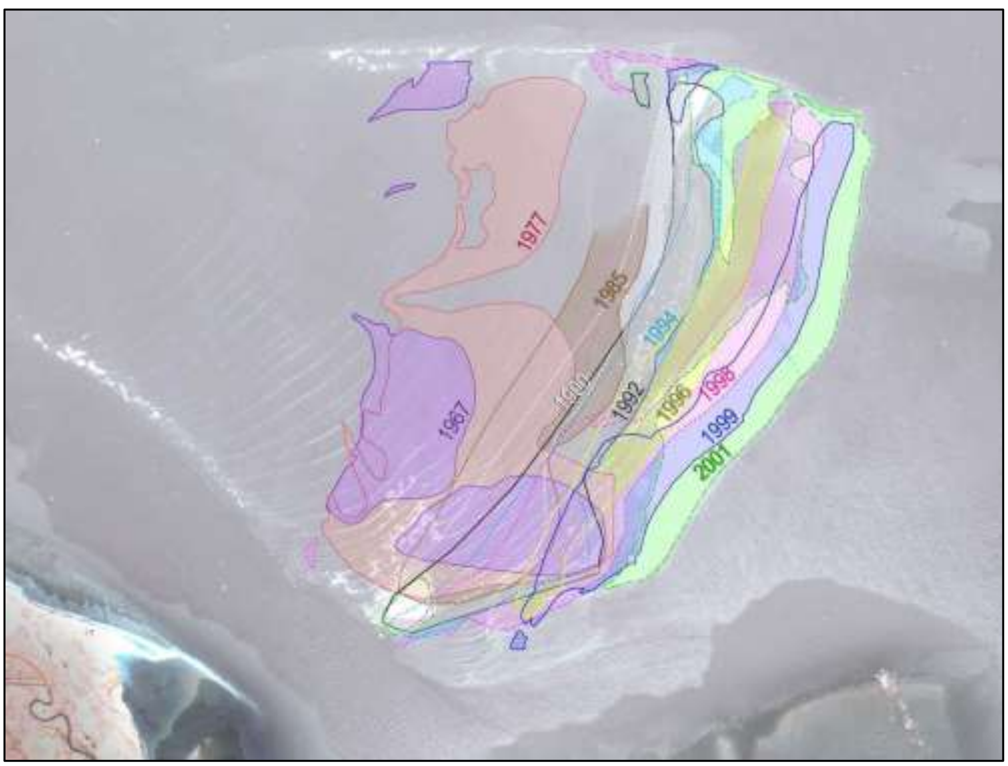


Figure 8-28 Eastward migration of Whitcomb Flats from 1967 to 2001 (from Osborne, 2003)

Copalis River and Connor Creek

As described in the Ocean Shores section, the construction of the North Jetty in 1916 enabled the rapid accumulation of sediment to advance the shoreline seaward as far north as Copalis Beach by 1927 and as far north as Moclips by 1950. This northward pulse of beach accretion over time likely induced the net northward migration of river and stream mouths along North Beach. The historical shorelines mapped by the U.S. Coast Survey in 1868 and 1927 show the Copalis River mouth located near the center of Griffiths-Priday State Park. The 1950 shoreline mapped by the U.S. Coast Survey shows the Copalis River mouth migrated northward, and it has continued that trend to the present, though at an increasingly slower rate (Figure 8-29).

Connor Creek, located farther to the south, migrated an even greater distance over time. In 1887, the mouth of Connor Creek was in the vicinity of its crossing under State Highway 109 immediately north of Dunes Lane, which is about 0.8 miles north of the intersection of State Highway 109 and State Highway 115 (Figure 8-29). By 1927, the creek mouth migrated approximately 1.5 miles north and, by 1950, it migrated an additional 0.8 miles north.

Historically, during the 1950s to 1970s, many efforts were undertaken to hold the mouth of Connor Creek between Surfcrest Condominiums to the south and Sea View Estates to the north. The northward migration of the creek mouth appeared to accelerate northward around 1988 at a rate as high as 1,000 ft/yr, affecting a number of properties, including Beachwood Resort, Dunes Beach Resort, Griffiths-Priday State Park, Rod's RV Park, Sea View Estates, Sunrise Resorts, Tidelands Campgrounds, and numerous private residences. The northward migration is likely caused by the predominance of northward sediment transport that lengthens the barrier spit between the ocean and the creek channel. The deposition of sand along the tip of the spit encroaches on the channel and forces the mouth northward. In addition, during winter storms, wave overwash of the barrier can significantly enhance the outflow at the creek mouth, causing erosion along the northern bank.

From 1987 to 2007, the migration of Connor Creek mouth impacted septic systems, cut off vehicular and pedestrian beach access, increased flooding, and decreased tourism. The Heath Road beach access was lost to erosion in January 1999 and the Griffiths-Priday beach access at Benner Road was cut off in March 2000. In November 2007, the Connor Creek pedestrian bridge was opened at the Heath Road beach approach to provide public and emergency vehicle access to the beach. From 1987 to 2016, the mouth of Connor Creek migrated northward by about 2.3 miles (Figure 8-29 and Figure 8-30). Figure 8-29 identifies the historical shorelines extending from Connor Creek to the Copalis River illustrating the northward channel mouth migration and seaward shoreline growth over time. Figure 8-30 identifies the historical migration of Copalis River mouth and Connor Creek mouth; the 1950 shoreline is overlain on the 1987 photo.

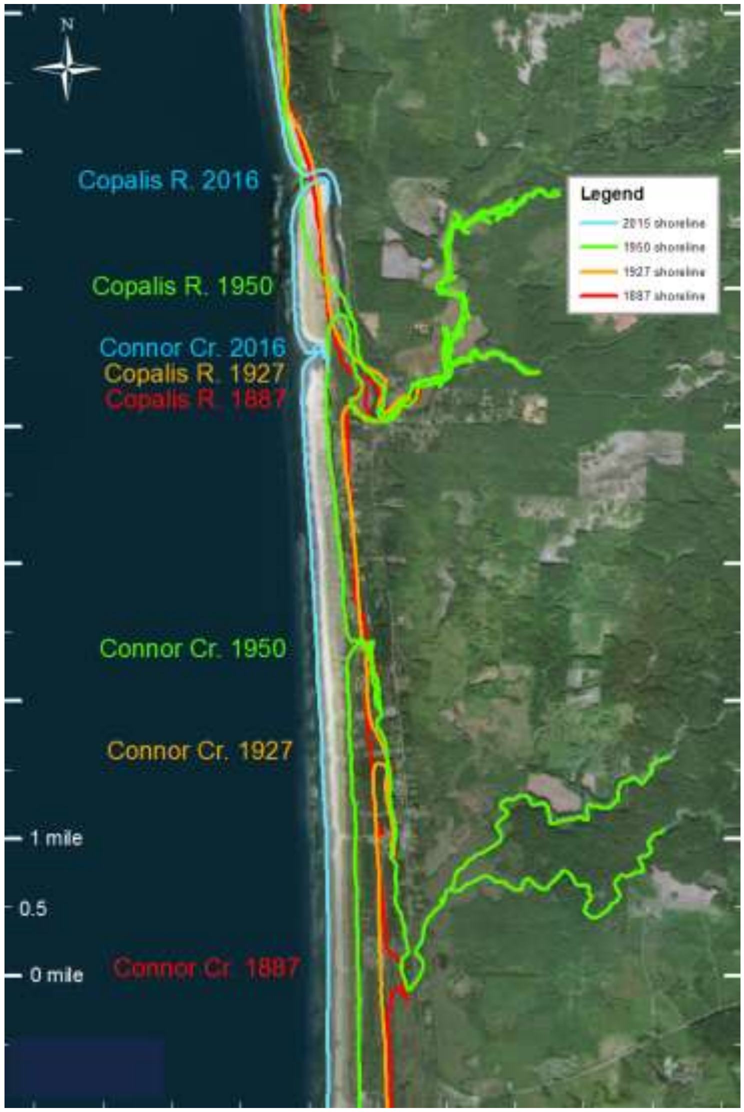


Figure 8-29 Historical Shorelines Extending from Connor Creek to the Copalis River

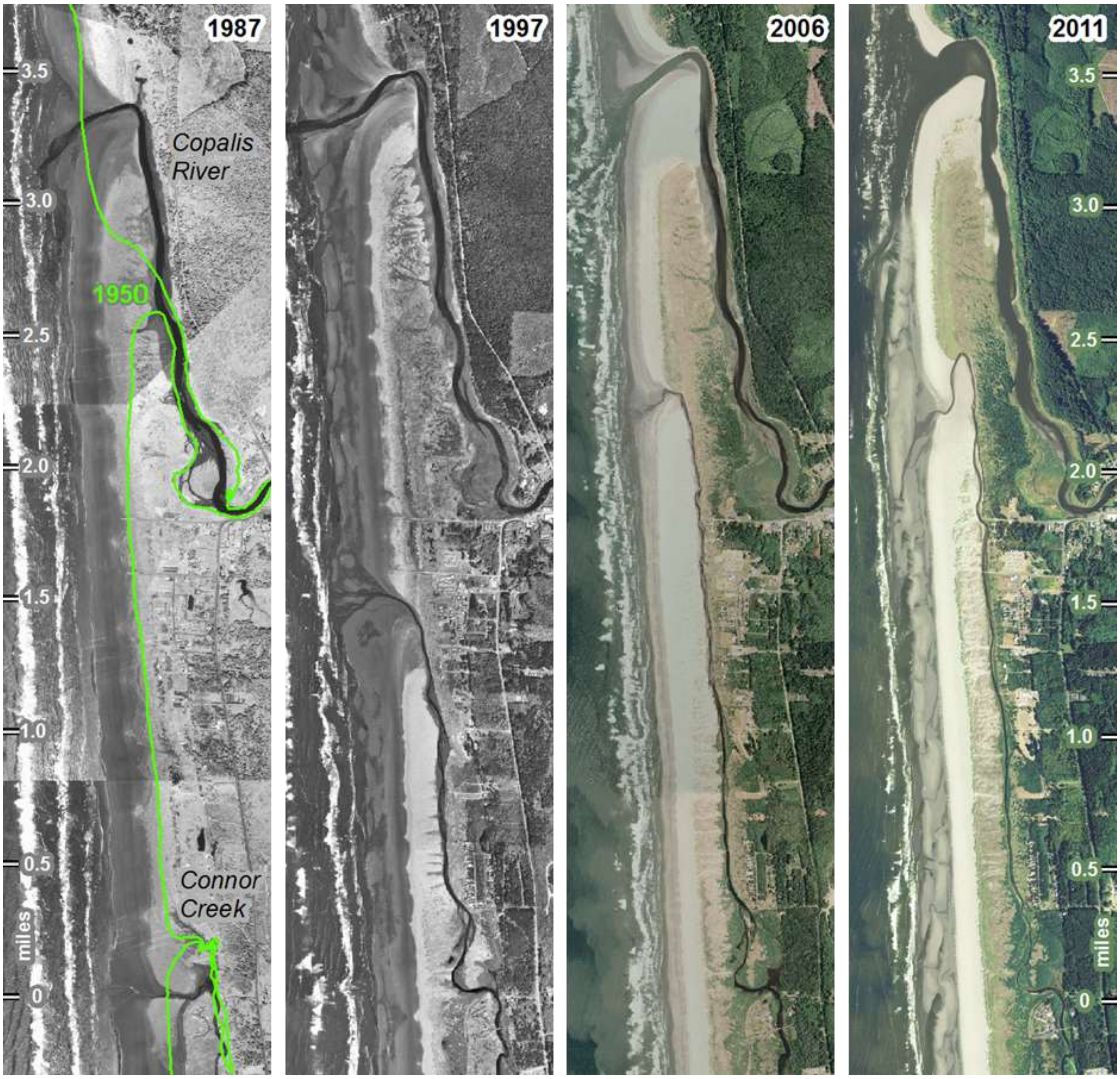


Figure 8-30 Historical Migration of Copalis River Mouth and Connor Creek Mouth

8.3 VULNERABILITY ASSESSMENT

8.3.1 Overview

The probability for frequent impact from coastal erosion in the identified coastal erosion areas (Figures 8-1 to 8-8) areas is highly likely, whereas less frequent and higher intensity events may impact a larger geographic extent. Coastal erosion does not physically impact the entire county, except in the case of a Cascadia subduction-zone earthquake and/or large tsunami that would likely induce large county-wide coastal erosion. Ocean Shores and Westport have had significant incidents that required emergency measures to be taken by the local government and U.S. Army Corps of Engineers to protect property and public infrastructure.

Coastal areas in Grays Harbor do experience some level of significant erosion activities annually primarily along the ocean coast within about 2 miles of the Grays Harbor jetties and along the shorelines along the Grays Harbor entrance.

The environmental impact from erosion is highly significant, with historic data demonstrating significant changes to sub-tidal, inter-tidal, and sub-aerial coastal environments. Erosion of low-lying entrance spits have resulted in a decline in snowy plover habitat and massive loss of Oyhut salt marsh, and deeper entrance conditions have enabled larger waves to enter Grays Harbor to cause the decline of Whitcomb Flats and loss of productive oyster beds. In addition, some erosion responses have been to protect public and private investments with shoreline armoring, which can also have detrimental impacts on natural processes that support ecosystem functions and exacerbate the geographic extent of the problem.

New construction in critical areas, which includes geologically sensitive areas, is regulated. However, erosion-related impacts to existing commercial and residential structures and associated infrastructure (utilities, roadways, etc.), when coupled with the economic impact to tourism and potential negative impact on real estate taxes, have the potential to harm the entire region.

8.3.2 Impact on Life, Health, and Safety

Erosion is generally a slow moving, chronic stressor on a community. However, during storm events, high rates of shoreline retreat can occur, also causing damage from associated flooding and the transport of drift logs and other debris. Wave overtopping of coastal structures, dune blowouts, and infragravity “sneaker” waves can cause can cause high velocity flows over inland areas thought to be safe by unsuspecting observers. The wave climate of the Pacific Northwest is one of the most severe in the world and the mobility of the fine Columbia River sand that make up the beaches of southwest Washington result in relatively large seasonal morphology changes and long-term regional changes from sediment imbalances that may not be realized until the shoreline is within close proximity to human use areas that have been commonly viewed as stable and secure from the coastal hazards. While both chronic and episodic erosion have severe consequences associated to loss of private assets and critical public infrastructure, the direct impacts on life, health and safety is typically low compared to other shoreline natural hazards. Erosion from co-seismic subsidence and large tsunamis can have a high impact on life, health, and safety, but the frequency of these events are relatively low.

8.3.3 Impact on Property

Coastal erosion impacts both private and public assets alike, including homes, businesses, public beach and public infrastructure such as roads and utilities. Land use along Grays Harbor County coastal areas varies from private single family homes, public beach, to commercial and industrial uses. A report produced by the Grays Harbor Resilience Coalition (2017) found that coastal erosion and flooding risks have historically caused severe problems for the county and these factors continue to be significant concerns.

Areas of Grays Harbor County that experience the highest risk of shoreline erosion are influenced by the condition of the north and south jetties at the mouth of Grays Harbor. When installed by the U.S. Army Corps of Engineers (USACE), these jetties created artificially stable shoreline conditions, and the surrounding coastal communities continue to develop nearby with the expectation these structures will provide continual protection from erosion. However, coastal processes change as jetties degrade over time, which lead to unintended and significant impacts to adjacent shorelines.

It is estimated that coastal erosion threatens more than $275 million worth of residential structures and community assets in Grays Harbor County. In the City of Ocean Shores erosion scarp runs for two miles, starting at the south end of the city’s North Jetty and toward the city center. The scarp is now a third of the overall length of Ocean Shores itself and has increased every year since 2009. Twenty percent of Ocean Shores' property value is in jeopardy due to this scarp – $200 million of the city's $1 billion valuation. In the City of Westport, a dune erosion scarp extends more than 1,500 ft south along the shoreline from the South Jetty. Despite significant nearshore nourishment of sand from the U.S. Army Corps of Engineers, every year more than 63,000 cy of sediment erodes from Westport beaches and dunes, threatening loss of State Park property as well as houses and condominiums along the beach.

8.3.4 Impact on Critical Facilities and Infrastructure

Critical facilities and infrastructure at risk from erosion along the coastal zone of Grays Harbor County depends on the location of the facility or infrastructure relative to an erosion hazard area. Several types of infrastructure may be exposed to erosion hazards and associated flooding, especially along coastal roads and transportation infrastructure. Significant infrastructure along the coast exposed to erosion hazard includes the following:

- **Roads**—Access to major roads is crucial to life-safety after a disaster event and to response and recovery operations, though smaller erosion events can cause disruption as well. Erosion debris 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.
- **Marinas**—The Westport Marina is protected by the Point Chehalis revetment but the structure is not designed for the increasing wave climate that causes frequent overtopping and structural degradation. The Ocean Shores/Quinault Marina and RV Park is increasingly at risk of erosion as well as sedimentation within the marina.
- **Bridges**—Loss of pedestrian and vehicle access across Connor Creek due to erosion has been a recent historical problem, particularly for emergency services.
- Wastewater treatment plants—while the Westport plant is protected from erosion by the Point Chehalis revetment, beach erosion has damaged its outfall pipe in the past. The Ocean Shores wastewater treatment plant is not in immediate risk of erosion, but the formation a runnel along the landward side of the North Jetty and retreat of the Oyhut shoreline portend to increasing risk for the future.

In the City of Ocean Shores, municipal infrastructure including sewer, water, roads and the city's $24.8 million wastewater plant are all vulnerable to inundation due wave overtopping of the North Jetty and the potential for a breach of the primary dune within two miles of the North Jetty. The elevation of the land and infrastructure behind the primary dune, and inadequate drainage create the potential for extensive damages as has been observed in the past prior to jetty reconstruction. Along an erosion scarp in the City of Westport, a sanitary sewer pump station is currently under threat of inundation if erosion continues unabated. Damage to the pump station would affect $50 million of assessed value within the city– about 25 percent of Westport's assessed value and 20 percent of the city's water and sewer utilities' revenue.

8.3.5 Impact on Economy

Erosion events shutting down major transportation routes along the Grays Harbor County coast would not only limit the resources available for citizens' use, but also would cause economic impact on businesses in the area. Highway 101 serves as a primary transportation route along the county coast, running very near shore in some areas. Impacts to this highway could also significantly reduce the tourism industry along the coastal sections of the county, especially summer months. Beach access becoming limited may reduce local tourism, impacting the local community and economy, as has been experience in the past along Connor Creek. Washington beaches are accessible by common law to the public in both wet and dry areas, though this does not guarantee access. While this gives more access to public beach than in some other states where the public domain on beaches differs, erosion of beaches may still have an impact on recreational tourism as accessible areas experience erosion. High and steep erosion scarps along Ocean Shores and Westport can limit public beach access. Reduced access to Damon Point due to erosion of the road and a decline in navigable access to the Quinault Marina and RV Park facilities due to erosion reduces economic opportunities. For example, the seasonal passenger ferry that once operated between Westport and Ocean Shores is no longer in service.

Loss of access to businesses and beaches may result in decreased tax revenues to coastal municipalities, school districts, and the County overall. While these impacts will be temporary, more severe and chronic erosion may result in loss of private property, causing permanent decreases in property tax revenue.

8.3.6 Impact on Environment

Erosion has the potential to impact coastal environments in nearshore areas and tidal marshes, beaches, and upland dune areas. Erosion and increased sediment input from shore areas may impact habitat for Dungeness crab, razor clam, and surf smelt (Shipman, MacLennan, and Johannessen, 2014). Grays Harbor is the second largest estuary in Washington State, with the Grays Harbor National Wildlife Refuge located on the north side of the bay comprising 1500 acres of salt marsh, intertidal mud flats, and upland habitat (https://www.fws.gov/refuge/Grays_Harbor/about.html). The harbor area may be of concern with regards to possible climate change impacts on increased erosion rates, as the delta may experience increased erosion at a greater rate than it is able to accrete sediment into the marsh and tidal areas and compensate for rises in sea level (Mauger et al., 2015). Grays Harbor estuary is also part of the Western Hemisphere Shorebird Reserve Network, it being a crucial habitat area for roughly 500,000 shorebirds of 24 different species during migration periods (https://www.whsrn.org/grays-harbor-estuary).

At the south end of the Ocean Shores Peninsula, Oyhut Wildlife Recreation Area encompasses 683 acres. Maintained as waterfowl habitat and recreation area, the Grays Harbor Estuary Management Plan (1986) considers this area a high priority area for active wildlife management, with significant riparian vegetation and saltwater marsh habitat. Except by natural processes, minimal alteration of this valuable habitat area should be allowed. That is, any future development adjacent to Oyhut should avoid negatively impacting the marsh and riparian areas, even those actions deemed erosion mitigation measures. Loss of back bay marsh in Oyhut due to the erosion of waterward spits and conversion of the tidal flats to barrier beach has likely contributed to significant and rapid loss of valuable marsh habitat. With continuing expansion and formation of Oyhut Bay, little marshland may be remaining in the coming decades.

The deepening of the entrance and the transmission of increasing larger waves into the inner harbor has contributed to the chronic erosion of Whitcomb Flats and loss of productive oyster beds.

Certain types of response to shoreline erosion (i.e., hard armoring) could have adverse consequence and lasting impacts on the coast, including:

- Extending erosion to properties further along the shoreline and blocking onshore sources of sediment necessary for resupplying and maintaining a useable beach.
- Obstructing public access to and along the shoreline, which is to result in tourism losses, critical to our coastal economies.

Harming plant and animal species listed under the Endangered Species Act (ESA) as well as reducing natural on-shore vegetation and increasing nearshore wave energy. GHRC partners agree that harder shoreline armoring is not the desired result; however, it is difficult to prevent private projects without other feasible options for landowners and the cities to protect their investments.

8.4 FUTURE DEVELOPMENT TRENDS

Under the Growth Management Act, the County is required to address geologic hazards within its Critical Areas Ordinance, which it does in Section 18.06. Continued application of land use and zoning regulations, as well as implementation of the International Building Codes, will assist in reducing the risk of impact from coastal erosion hazards.

While the population of Grays Harbor County shrunk between 2014 and 2016, from 73,300 to 72,820, projections by the Washington State Office of Financial Management have the county experiencing an increase in population to roughly 75,500 in 2030. Though this is a modest increase development along the shoreline areas are in high demand. Large investments are made because of the views, access to the beach, and other ocean interests. These areas of the County and cities, however, are also some of the most vulnerable to erosion. Once development occurs, it is extremely difficult to adapt to the dynamics of Pacific Northwest coastal processes, placing increased pressure to protect when erosion occurs.

Climate change may impact storm patterns, increasing the probability of more frequent, intense storms with varying duration. Increase in global temperature could further raise sea levels, increasing beach erosion along the County's coastline. While total sea-level rise projections are uncertain, storm-induced increased water levels are likely. Higher water levels and increased wave action may overtop dunes and coastal structures and breach other coastal barriers and erosion mitigation measures, making the susceptibility of these areas to damaging erosion a greater threat.

8.5 ISSUES

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

Important issues associated with coastal erosion in Grays Harbor County include the following:

- The South Beach shoreline along Westport and Cohassett Beach are experiencing a sediment deficit that is not likely to be augmented by natural processes. The South Jetty induces offshore transport of sand that is carried northward by energetic winter waves approaching from the southwest, while blocking the southward onshore transport of sand by milder summer waves approaching from the northwest. The beneficial use of dredged material to increase the supply of sand to the nearshore and beaches are imperative to reducing the rate of chronic coastal erosion. Beach monitoring indicates an average erosion of 63,100 cy/yr of sand from the beach and dunes along the length of the winter dune erosion scarp about 3.1 miles south of the South Jetty. The loss of the primary dune fronting existing development on relatively low interdunal areas implies an urgency for dune restoration to retain sufficient buffer against large storms with elevated water levels.
- The maintenance of the Half Moon Bay shoreline is relatively intense, consisting of routine nourishment of the nearshore area, periodic beach and breach fill nourishment, and relatively routine repair of the Point Chehalis revetment. With expected continual deepening of the inlet, the level of maintenance is likely to remain high. Any loss of dunes along the Half Moon Bay shoreline are not likely to be substantially recovered by natural processes, and dune retreat may

be largely influenced by the occurrence and duration of elevated water levels in addition to wave action. Strong El Niño conditions can sustain higher than normal water levels.

- The Grays Harbor North Jetty has reached its sand holding capacity and is deteriorating over time. Its condition affects shoreline stability not just locally, but northward to at least Copalis Beach. The large historical accretion of the North Beach shoreline is a result of the North Jetty providing a seaward anchor point. The Grays Harbor jetties are built and maintained to provide safe navigation through the mouth of Grays Harbor; they are not maintained to prevent shoreline erosion. The Ocean Shores shoreline within about 2 miles of the North Jetty is subject to interannual variability. The existing development of the primary dune encroaches on the natural variability of the shoreline and provides little buffer against shoreline retreat commensurate with jetty deterioration or fluctuations in the position and intensity of a persistent rip current embayment. Jetty reconstruction and maintenance to authorized dimensions for at least a few hundred feet seaward of the existing shoreline is imperative for adaptive management of erosion hazards and prevention of chronic shoreline and dune retreat. Beach monitoring indicates an average erosion of 25,800 cy/yr of sand from the beach and dunes along the length of the winter dune erosion scarp about 1.2 miles north of the North Jetty. Beach and dune nourishment offers only a temporary solution due to the limited holding capacity of the jetty. However, the use of sand fences during the spring to fall may be a cost effective means of accumulating sand that may be otherwise lost to transport into the harbor and providing a greater buffer against storm conditions. The lack of a suitable transition between the end of existing rock revetment structures and adjacent dunes is contributing to flanking erosion of the dunes. A dune breach represents the highest risk to upland infrastructure as the elevation of the land behind the primary dune is relatively low.
- Rapid and chronic erosion of the Oyhut and Damon Point shoreline threatens to impact the Quinault Marina and RV Park. The basal end of Damon Point is becoming narrower, flatter, and increasingly susceptible to overwash and breaching and its continued migration contributes to sedimentation of the marina and navigation channel. The long term viability of the marina will require considerable engineering and maintenance dredging. The Marina breakwater and the eastward end of the maintained North Jetty near the wastewater treatment plant provide anchor points that control the equilibrium location of the Oyhut Bay shoreline. More study is needed to develop a long-term prediction of the Oyhut shoreline and the relative importance of the anchor point at the Quinault Marina. An environmental impact assessment of no action may be as important as an assessment of alternative actions.
- The beneficial use of dredged material is critical to reducing the effects of chronic erosion. However, the effectiveness of sediment management scenarios needs to be evaluated. There has been little monitoring of the fate of material placed for beneficial use to determine the relative benefits and cost of onshore vs. nearshore placement of sediment.
- Continued loss of Whitcomb Flats is anticipated. The consequences of the degradation are insufficiently known.
- The continued northward migration of Connor Creek and the Copalis River is anticipated but at lower rates and more variability than in the past due to lower stream gradients following historical migration.

8.6 RESULTS

Based on review and analysis of the data, the Planning Team has determined that the probability for impact from erosion throughout the coastal areas is highly likely, with variable levels of intensity from year to year. Chronic erosion areas have been identified and mitigation planning and projects are needed to reduce the impacts. The scale of historical and recent ongoing mitigation activities is relatively high considering the relatively large amount of annual sediment nourishment and periodic maintenance performed by the U.S. Army Corps of Engineers. The costs of managing coastal erosion are also high and optimized solutions require technical evaluation, engineering design, and project performance monitoring and assessment. Coastal erosion management is of highest intensity along both ocean and harbor shorelines within a few miles of the Grays Harbor jetties. Most of the erosion conditions are associated with long term adjustments to jetty construction and reconstruction and the effect on coastal processes and sediment budgets that these structures impose on the surrounding environment.

The economic and environmental impact from erosion is highly significant in those areas at risk. New construction in critical areas, which includes geologically sensitive areas, is regulated. However, erosion-related impacts to existing commercial and residential structures and associated infrastructure (utilities, roadways, etc.), when coupled with the economic impact to tourism and potential negative impact on real estate taxes, have the potential to harm the entire region. Based on the potential impact, the Planning Team determined the CPRI score to be 2.85, with overall vulnerability determined to be a medium level at a county level.

CHAPTER 9.
FLOOD

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

DEFINITIONS

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

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

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

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

9.1 GENERAL BACKGROUND

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

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

9.1.1 Flooding Types

Many floods fall into one of three categories: riverine, coastal or shallow (FEMA, 2005). Other types of floods include alluvial fan floods, dam failure floods, and floods associated with local drainage or high groundwater. For this hazard mitigation plan and as deemed appropriate by the County, riverine/stormwater flooding are the main flood types of concern for the entire planning area, with coastal and tidal surge impacting portions of unincorporated Grays Harbor County, and the cities of Westport, Ocean Shores, Hoquiam and Aberdeen.

Riverine

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

Flash Floods

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

Coastal Flooding

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

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

Coastal floods are extremely dangerous, and the combination of tides, storm surge, and waves can cause severe damage. Coastal flooding is different from river flooding, which is generally caused by severe precipitation. Depending on the storm event, in the upper reaches of some tidal rivers, flooding from storm surge may be followed by river flooding from rain in the upland watershed. This increases the flood severity. Within the National Flood Insurance Flood Maps (discussed below), coastal flood zones identify special flood hazard areas (SFHA) which are subject to waves with heights of between 1.5 and 3 feet during a 1-percent annual chance storm (100-year event). Figure 8-1 illustrates the various SFHA zones.

Tidal Flooding

Spring tides, the highest tides during any month, occur with each full and new moon. When these coincide with a northerly wind piling water, tidal flooding can occur. The tides can also enhance flooding in delta areas when rivers or creeks are at or near flood stage. The area at greatest risk to tidal flooding is the Ocean Shores and Westport areas, with Hoquiam and Aberdeen also experiencing flooding during these times, but not as extensive. Such flooding is also a threat to low-lying farmlands in the area. Tidal impact is of most concern in delta areas when rivers are at flood stage and high tide exacerbates the situation. Concerns about tidal flooding are anticipated to increase due to the impacts of global climate change and sea level rise.

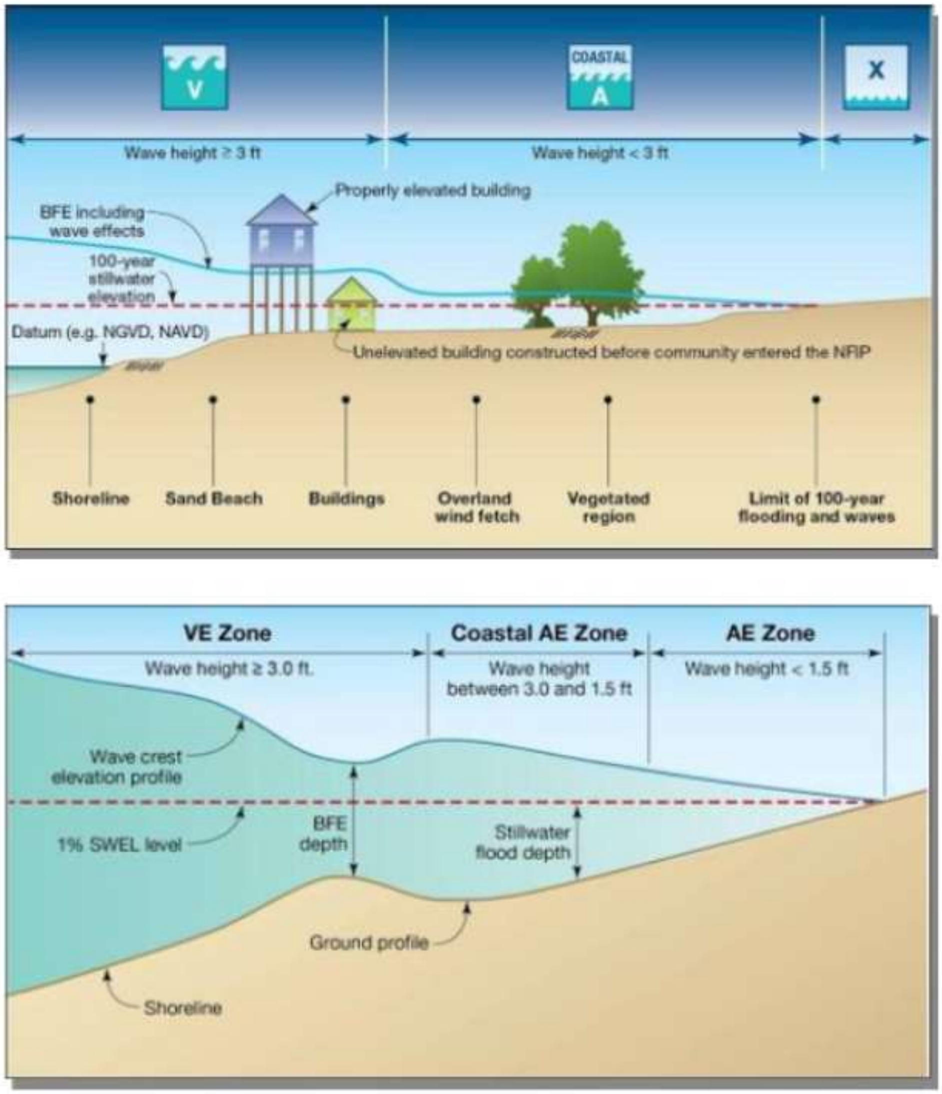


Figure 9-1 Schematic of Coastal Flood Zones within the National Flood Insurance Program

9.1.2 Dam Failure

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

- Overtopping of the primary dam structure, which accounts for 34 percent of all dam failures, can occur due to inadequate spillway design, settlement of the dam crest, blockage of spillways, and other factors.
- Foundation defects due to differential settlement, slides, slope instability, uplift pressures, and foundation seepage can also cause dam failure. These account for 30 percent of all dam failures.
- Failure due to piping and seepage accounts for 20 percent of all failures. These are caused by internal erosion due to piping and seepage, erosion along hydraulic structures such as spillways, erosion due to animal burrows, and cracks in the dam structure.

- Failure due to problems with conduits and valves, typically caused by the piping of embankment material into conduits through joints or cracks, constitutes 10 percent of all failures.

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

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

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

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

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

U.S. Army Corps of Engineers Dam Safety Program

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

Federal Energy Regulatory Commission Dam Safety Program

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

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

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

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

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

Grays Harbor County does have one FERC regulated dam within its county boundaries – the Wynoochee Dam.

Hazard Ratings

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

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

The Corps of Engineers developed the hazard classification system for dam failures shown in Table 8-1. The Washington and Corps of Engineers hazard rating systems are both based only on the potential consequences of a dam failure; neither system takes into account the probability of such failures.

Table 9-1
Corps of Engineers Hazard Potential Classification

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

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

Source: U.S. Army Corps of Engineers, 1995

Grays Harbor County has 18 dams within its boundaries identified by the Washington State Department of Ecology Dam Safety Program.[28] Those dams are identified below in Table 8-2.[29] Based on review of the data, Grays Harbor County has six (6) high hazard dams within its boundary, none of which are owned by the County itself. The County owns one low-impact Class 3 dam (Thompson Dam). The City of Aberdeen owns four Class 1B dams (high hazard); the City of Hoquiam owns two Class 1B (high hazard) dams. Four dams are Class 2 dams, meaning medium impact – one of those (Swano Lake Dam) is managed by Grays Harbor College State Board. Eight of the dams are Class 3 dams, meaning low impact (see map below).

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

Figure 9-2 Select Grays Harbor County Dams and Hazard Classification

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

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

The City of Aberdeen does have qualitative information available for two of its dams, the Lake Aberdeen Dam and the Malinowski Dam. Data for the Wynoochee dam is claimed as protected by Tacoma Public Utilities, the dam owner.

Lake Aberdeen Dam

- Two homes and three businesses could be affected by a major flood caused by a sudden breach of the Lake Aberdeen Dam. Flood water would reach the first residence and business immediately after the dam failure.

Malinowski Dam

- There is one home located at a fish hatchery that will be affected by a major flood caused by a sudden breach of the Malinowski Dam. Flood waters would reach the residence and hatchery 46 minutes after the dam failure.

Dam Inventory for Grays Harbor County

Counties: 39/39, Dams: 1194/1194

NAME OF DAM	RIVER OR STREAM	DAM TYPES	RESERVOIR PURPOSES	NAME OF OWNER	IMPOUNDMENT NAME	CREST LEN	DAM HT	SURFACE AREA	STATE ID	LATITUDE	STORAGE	NATIONAL ID	LONGITUDE	MAX STORAGE	YR COMPLETED	SEC TWN RNGE	MAX DISCHARGE	HAZARD CLASS	WRIA	DRAINAGE AREA
Aberdeen Lake Dam	Van Winkle Creek	RE	R, S	Aberdeen City	Aberdeen Lake	650 ft	33 ft	65.0 acres	GH22-112	46.9806070 deg	720 acre-ft	WA00112	123.742439 deg	1400 acre-ft	1928	T17 NR09 WS01	1975 cfs	1B	22	5.00 sq mi
Beacon Hill Reservoir	Hoquiam River - offstream	ER, OT	S	Hoquiam City	Beacon Hill Reservoir	420 ft	30 ft	0.0 acres	GH22-1790	46.9794150 deg	11 acre-ft	WA01790	123.876385 deg	14 acre-ft	1935	T17 NR10 WS12	0 cfs	1B	22	0.01 sq mi
Cline Dam	Unnamed Tr - Satsop R.	CN, RE	R	Gordon Cline	Schafer Lake 3	500 ft	16.5 ft	3.2 acres	GH22-1978	47.0625830 deg	19 acre-ft	WA01978	123.516238 deg	33 acre-ft	1944	T18 NR07 WS11	234 cfs	3	22	0.56 sq mi
College Hill Reservoir	Little Hoquiam R. - offstream	OT, RE	S	Hoquiam City	College Hill Reservoir	1000 ft	30 ft	0.0 acres	GH22-663	46.9878790 deg	23 acre-ft	WA00663	123.895376 deg	25 acre-ft	1900	T17 NR10 WS02	0 cfs	1B	22	0.01 sq mi
Davis Creek Dam	Davis Creek	PG	S	Hoquiam City	unnamed	90 ft	23 ft	12.0 acres	GH22-1120	47.0718080 deg	12 acre-ft	WA01120	123.934281 deg	12 acre-ft	1966	T18 NR10 WS04	0 cfs	3	22	0.00 sq mi
Failor Lake Dam	Deep Creek	RE	R	WA DFW	Failor Lake	250 ft	32 ft	65.0 acres	GH22-111	47.1071940 deg	394 acre-ft	WA00111	123.965758 deg	454 acre-ft	1956	T19 NR10 WS30	66 cfs	3	22	4.89 sq mi
Fairview Reservoir No. 1	Wishkah River-Offstream	RE	S	Aberdeen City	Fairview Reservoir No. 1	600 ft	35 ft	1.7 acres	GH22-548	46.9914380 deg	28 acre-ft	WA00548	123.818785 deg	30 acre-ft	1917	T17 NR09 WS04	5 cfs	1B	22	10.00 sq mi
Fairview Reservoir No. 2	Wishkah River-Offstream	RE	S	Aberdeen City	Fairview Reservoir No. 2	330 ft	25 ft	2.8 acres	GH22-1728	46.9912940 deg	46 acre-ft	WA01728	123.821752 deg	50 acre-ft	1921	T17 NR09 WS05	8 cfs	1B	22	0.01 sq mi
Malinowski Dam	Wishkah River	CN, PG	S	Aberdeen City	Aberdeen Reservoir	164 ft	61 ft	15.0 acres	GH22-341	47.2613700 deg	120 acre-ft	WA00341	123.714433 deg	120 acre-ft	1963	T21 NR08 WS33	10300 cfs	2	22	11.00 sq mi
Oestreich Dam	Tr-North River	RE	R	Harold W & Edna K Oestreich	unnamed	50 ft	12 ft	10.0 acres	GH24-1043	46.8812360 deg	10 acre-ft	WA01043	123.689361 deg	10 acre-ft	1971	T16 NR08 WS09	0 cfs	3	24	0.00 sq mi
Sea Horse Ranch Dike	Tr-Gillis Slough	RE	O	Grays Harbor Audubon Society	unnamed	165 ft	15 ft	75.0 acres	GH22-100	47.0425930 deg	75 acre-ft	WA00100	124.041479 deg	75 acre-ft	1961	T18 NR11 WS15	0 cfs	3	22	0.30 sq mi
Spoils Pond Dam	Grays Harbor-Offstream	RE	Q	Cosmo Specialty Fibers Inc.	unnamed	4750 ft	14 ft	260.0 acres	GH22-552	46.9531480 deg	260 acre-ft	WA00552	123.834611 deg	365 acre-ft	1970	T17 NR09 WS17	2 cfs	3	22	0.30 sq mi
Swano Lake Dam	Tr-Charley Creek	RE	F, R	Grays Harbor College State Board	Swano Lake	180 ft	25 ft	4.0 acres	GH22-547	46.9543490 deg	30 acre-ft	WA00547	123.801352 deg	40 acre-ft	1949	T17 NR09 WS16	308 cfs	2	22	0.53 sq mi
Sylvia Lake Dam_Grays Hrbr Co	Sylvia Creek	CB	R	State of Washington Parks	Sylvia Lake	120 ft	32 ft	32.0 acres	GH22-132	46.9960790 deg	320 acre-ft	WA00132	123.59838 deg	510 acre-ft	1918	T18 NR07 WS31	1510 cfs	2	22	5.07 sq mi
Thompson Dam - Grays Harbor Co.	Unnamed Tr - Satsop R	CN, RE	R	John Thompson	Thompson Pond	253 ft	18 ft	3.2 acres	GH22-1979	47.0609580 deg	27 acre-ft	WA01979	123.51346 deg	36 acre-ft	1944	T00 NR00 S00	108 cfs	3	22	0.58 sq mi
West Fork Dam	West Fk. Hoquiam River	PG, RE	S	Hoquiam City	West Fork Reservoir	100 ft	17 ft	0.0 acres	GH22-1791	47.0692520 deg	10 acre-ft	WA01791	123.929069 deg	40 acre-ft	1956	T18 NR10 WS04	0 cfs	2	22	8.00 sq mi
Wynoochee Dam	Wynoochee River	PG, RE	C, H, S	Aberdeen City	Wynoochee Lake	1700 ft	175 ft	1,122.0 acres	GH22-302	47.3848110 deg	70000 acre-ft	WA00302	123.60628 deg	76000 acre-ft	1973	T22 NR07 WS20	61700 cfs	1B	22	41.00 sq mi
Wynoochee Fish Barrier Dam	Wynoochee River	PG, RE	F	Aberdeen City	unnamed	210 ft	57 ft	1.0 acres	GH22-1406	47.3748110 deg	1 acre-ft	WA01406	123.627947 deg	10 acre-ft	1972	T22 NR07 WS19	9500 cfs	3	22	50.00 sq mi

Figure 9-3 Washington State Department of Ecology Dam Inventory

9.1.3 Measuring Floods and Floodplains

A floodplain is the area adjacent to a river, creek or lake that becomes inundated during a flood. Floodplains may be broad, as when a river crosses an extensive flat landscape, or narrow, as when a river is confined in a canyon. Connections between a river and its floodplain are most apparent during and after major flood events. These areas form a complex physical and biological system that not only supports a variety of natural resources, but also provides natural flood and erosion control. When a river is separated from its floodplain with levees and other flood control facilities, natural, built-in benefits can be lost, altered, or significantly reduced.

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

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

9.1.4 Flood Insurance Rate Maps

According to FEMA, flood hazard areas are defined as areas that are shown to be inundated by a flood of a given magnitude on a map (see Figure 9-4). These areas are determined using statistical analyses of records of river flow, storm tides, and rainfall; information obtained through consultation with the community; floodplain topographic surveys; and hydrologic and hydraulic analyses. Three primary areas make up the flood hazard area: the floodplains, floodways, and floodway fringes. Figure 9-5 depicts the relationship among the various designations, collectively referred to as the special flood hazard area.

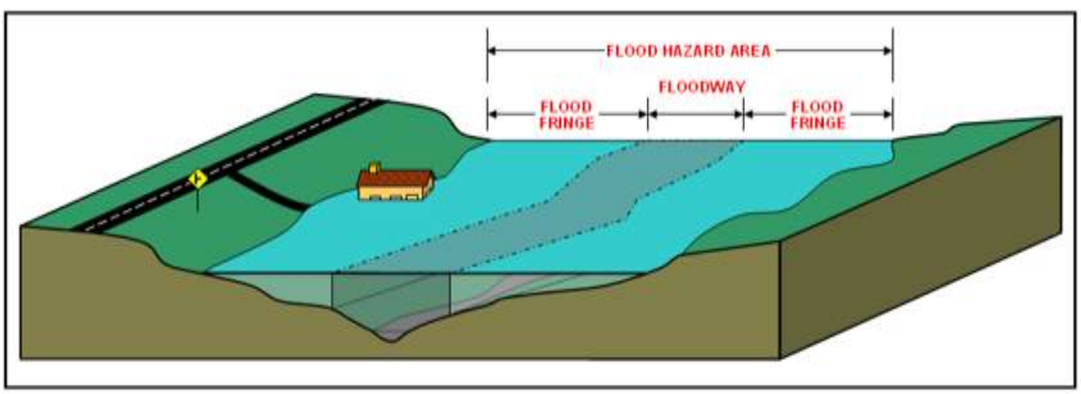


Figure 9-4 Flood Hazard Area Referred to as a Floodplain

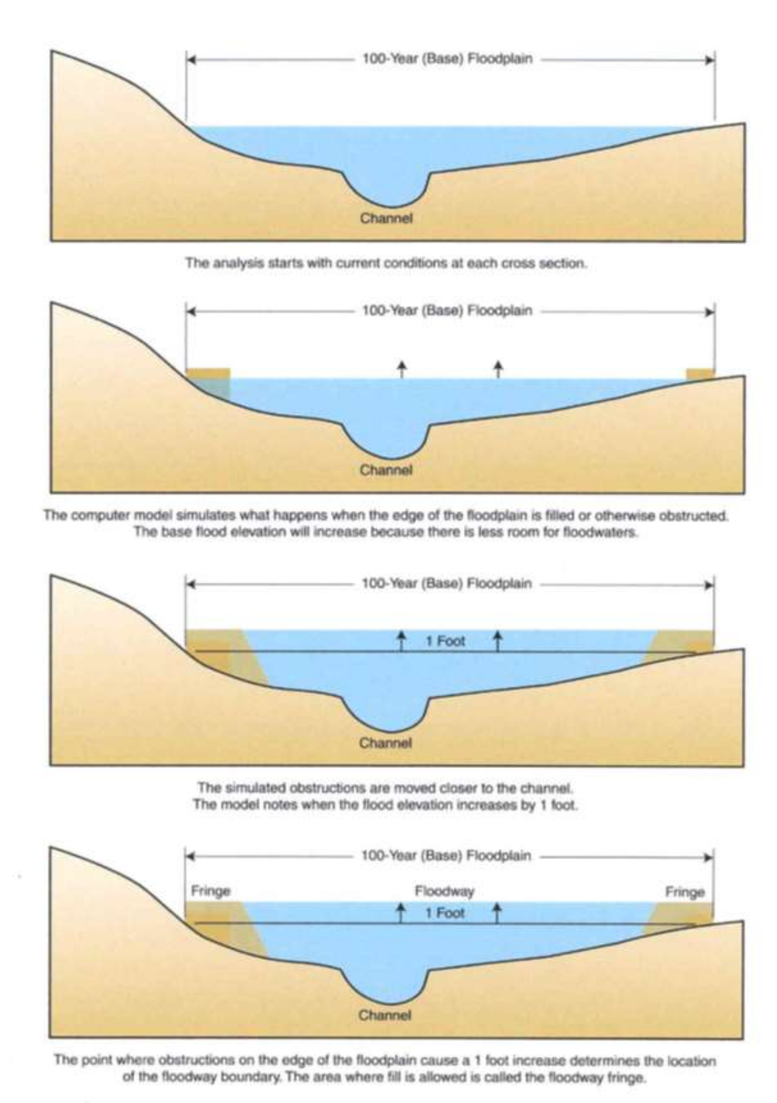


Figure 9-5 Special Flood Hazard Area

Flood hazard areas are delineated on FEMA's Flood Insurance Rate Maps (FIRM), which are official maps of a community on which the Federal Insurance and Mitigation Administration has indicated both the special flood hazard areas (SFHA) and the risk premium zones applicable to the community. These maps identify the geographic areas or zones that FEMA has defined according to varying levels of flood risk, and include: special flood hazard areas; the location of a specific property in relation to the special flood hazard area; the base (100-year) flood elevation at a specific site; the magnitude of a flood hazard in a specific area; and undeveloped coastal barriers where flood insurance is not available. The maps also locate regulatory floodways and floodplain boundaries—the 100-year and 500-year floodplain boundaries (FEMA, 2003; FEMA, 2005; FEMA, 2008). Table 9-2 identifies the various rate map zones.[30]

Table 9-2
Flood Insurance Rate Map Zones

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

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

Table 9-2
Flood Insurance Rate Map Zones

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

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

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

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

Table 9-3
Estimated Probability of Flood Event

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

9.1.5 National Flood Insurance Program (NFIP)

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

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

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

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

NFIP Status and Severe Loss/Repetitive Loss Properties

Grays Harbor County is a member in good standing in the NFIP, and does incorporate regulatory authority within its land use planning. Table 9-4 presents the NFIP policy status as of August 31, 2017.

Table 9-4
NFIP Insurance Policies in Force

Community Name	Policies In-Force	Insurance In-Force	Premiums In-Force
Grays Harbor County	447	100,213,500	435,464
Aberdeen, City of	597	100,681,400	833,046
Cosmopolis, City of	11	2,060,000	4,858
Elma, City of	8	1,187,400	3,834
Hoquiam, City of	722	94,168,600	1,046,937
McCleary, City of	3	507,000	2,511
Montesano, City of	6	2,363,400	10,370
Oakville, City of	8	2,208,100	4,484
Ocean Shores, City of	613	174,046,900	260,944
Westport, City of	251	45,440,800	88,202

Source: https://bsa.nfipstat.fema.gov/reports/1011.htm#WAT

Statistics as of 8/31/2017

Repetitive Flood Claims

Residential or non-residential (commercial) properties that have received one or more NFIP insurance payments are identified as repetitive flood properties under the NFIP. Such properties are eligible for funding to help mitigate the impacts of flooding through various FEMA programs, subject to meeting certain criteria and based on the State's Hazard Mitigation Plan maintaining a Repetitive Loss Strategy. Washington State's 2013 Hazard Mitigation Plan does contain such a strategy. Specifically, the Repetitive Loss Strategy must identify the specific actions the State has taken to reduce the number of repetitive loss properties, which must include severe repetitive loss properties, and specify how the State intends to reduce the number of such repetitive loss properties. In addition, the hazard mitigation plan must describe the State's strategy to ensure that local jurisdictions with severe repetitive loss properties take actions to reduce the number of these properties, including the development of local hazard mitigation plans.

Repetitive flood claims provide funding to reduce or eliminate the long-term risk of flood damage to structures insured under the NFIP that have had one or more claim payments for flood damages.

Severe Repetitive Loss Program

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

- a) That has at least four NFIP claim payments (including building and contents) over $5,000 each, and the cumulative amount of such claims payments exceeds $20,000; or
- b) For which at least two separate claims payments (building payments only) have been made with the cumulative amount of the building portion of such claims exceeding the market value of the building.

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

Flood claim, repetitive loss, and severe repetitive loss property data is indicated in Table 9-5, all of which are residential structures, with the exception of one severe repetitive loss property, which was identified as non-residential. Only one of the repetitive loss structures were within FEMA's designated FIRM map; the remainder were outside.

The Community Rating System

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

Table 9-5 also identifies the CRS Community Status in the County. At present, the County does not participate as a CRS community, with only the City of Westport maintaining such a status countywide. However, the County and the cities of Hoquiam, Aberdeen and Cosmopolis may elect to pursue the CRS during the life cycle of this plan.

Six ways to Protect Your Home

1. Elevate your home above possible flood levels on a new foundation. Alternatively, consider elevating or relocating furnaces/heat pumps, water heaters, appliances, and electrical panels higher above ground, out of harm's way.
2. Cut openings in foundation walls to allow water to flow freely through underneath the home. This helps to prevent the collapse of a wall(s).
3. Build and install flood shields for doors and other openings which will help prevent floodwaters from getting into your home or structure.
4. Install back-flow valves or plugs for drains, toilets, and other connections to prevent floodwaters from entering your home.
5. Install sump pumps with backup power in basements or crawl spaces to help pump out accumulating water.
6. Keep hazardous materials like fertilizers, pesticides, paint and household cleaners inside a plastic bucket or bin, off the floor to make sure floodwaters aren't contaminated. Make sure to take unwanted materials to an appropriate hazardous waste disposal site.
7. When building, renovating, or landscaping, remember that tree-cutting, grading, back-filling, concrete and asphalt work, retaining walls, and other land use development may increase flood waters and damage. When in doubt, check with the local building officials to make sure you won't be negatively impacting your or your neighbor's flood risk.

TABLE 9-5
COMMUNITY RATING SYSTEM, REPETITIVE LOSSES, AND FLOOD INSURANCE CLAIMS

Community Name	CRS Community	Total Losses	Flood Claims Closed	Total Flood Loss Payments	Repetitive Loss Properties	Severe Repetitive Loss Properties	Total Flood Policies	Total Insurance Coverage
Aberdeen, City of	NO	333	244	2,824,658	9	2	597	100,681,400
Cosmopolis, City of	NO	4	4	5,927	0	0	11	$2,060,000
Elma, City of	NO	18	18	487,641	0	2	8	$1,187,400
Hoquiam, City of	NO	237	188	3,658,794	4	1	722	$94,168,600
McCleary, City of	NO	0	0	0	0	0	3	$507,000

TABLE 9-5
COMMUNITY RATING SYSTEM, REPETITIVE LOSSES, AND FLOOD INSURANCE CLAIMS

Montesano, City of	NO	15	14	195,095	1	2	6	$2,363,400
Oakville, City of	NO	8	8	231,456	0	0	8	$2,208,100
Ocean Shores, City of	NO	23	12	194,080	0	0	613	$174,046,900
Westport, City of	YES- Class 8	13	8	127,860	0	0	251	$45,440,800
Unincor-porated Grays Harbor County	NO	225	201	4,675,351	24	0	447	$100,213,500

Source: Repetitive Loss and Severe Repetitive Loss Data from State and FEMA (8/2017); NFIP Policies in Force (8/17/2017) Data from NFIP

9.2 HAZARD PROFILE

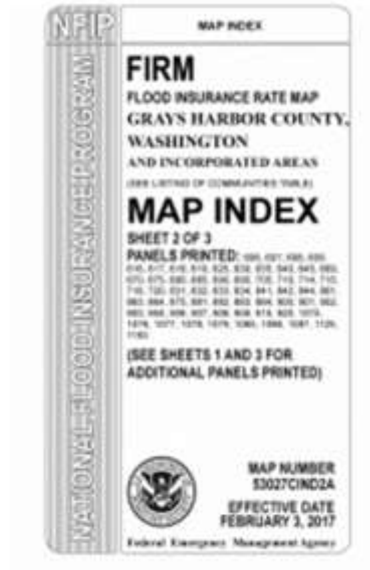
9.2.1 Extent and Location

Flooding is the most common hazard occurring in Grays Harbor County, and is mostly due to coastal and riverine flooding, with urban flooding also occurring. Riverine flooding is seen on all main rivers and tributaries in the rural portions of the county. Urban flooding generally occurs within the boundaries of the cities. In addition, the County is also subject to coastal flooding, which is significantly impacted as a result of a strong tidal influence due to low gradients in the planning area.

A predominately-marine climate with mild wet winters dictates weather patterns in the County. Flood season usually begins in late October/early November when heavy rainfall occurs. Pacific frontal systems become stationary over the region, bringing long periods of rainfall through February and often extending into March and April.

Annual precipitation is 65” to 75” on the coast, 80” to 90”near the foothills, 125” to 150” on the windward slopes of the Olympic Mountains, and 100” for the Willapa Hills. During long periods of rainfall, river and stream channels fill to overflowing. Intense precipitation combined with mild temperatures will cause snowmelt on the south slopes of the Olympic Mountains that can also induce or increase flooding. Coastal flooding is a result of tidal fluctuations and high wind events. River floods happen most often when winter storms bring heavy rains from the southwest.

FEMA 2017 Flood Maps



FEMA performed a new Flood Insurance Study (FIS) for the coastal areas of Grays Harbor County that resulted in the creation of new flood maps which were adopted on February 3, 2017. The project updated flood modeling along the Grays Harbor County coastlines only, with the non-coastal portions of the county remaining intact from the previous FIS. In addition, FEMA also initiated activities to complete a Flood Insurance Study along the Chehalis and Wynoochee Rivers; however, that process has not yet been completed. Therefore, based on the status of the various efforts, for this update, the NFIP maps utilized are those in place as adopted and effective as of this update, dated February 3, 2017. While portions of the new Chehalis and Wynoochee studies are referenced and included in this plan update, the County nor any of the jurisdictions have adopted the preliminary maps. Identification of the data and maps within this plan does not constitute adoption by the County or any of its jurisdictions.

Grays Harbor County's adopted 100- and 500-year flood areas are illustrated in Figure 9-6 and Figure 9-7. As illustrated, only a small area of the County's land mass falls within the 500-year flood hazard area based on the FIRMs in place as of this 2017 update.

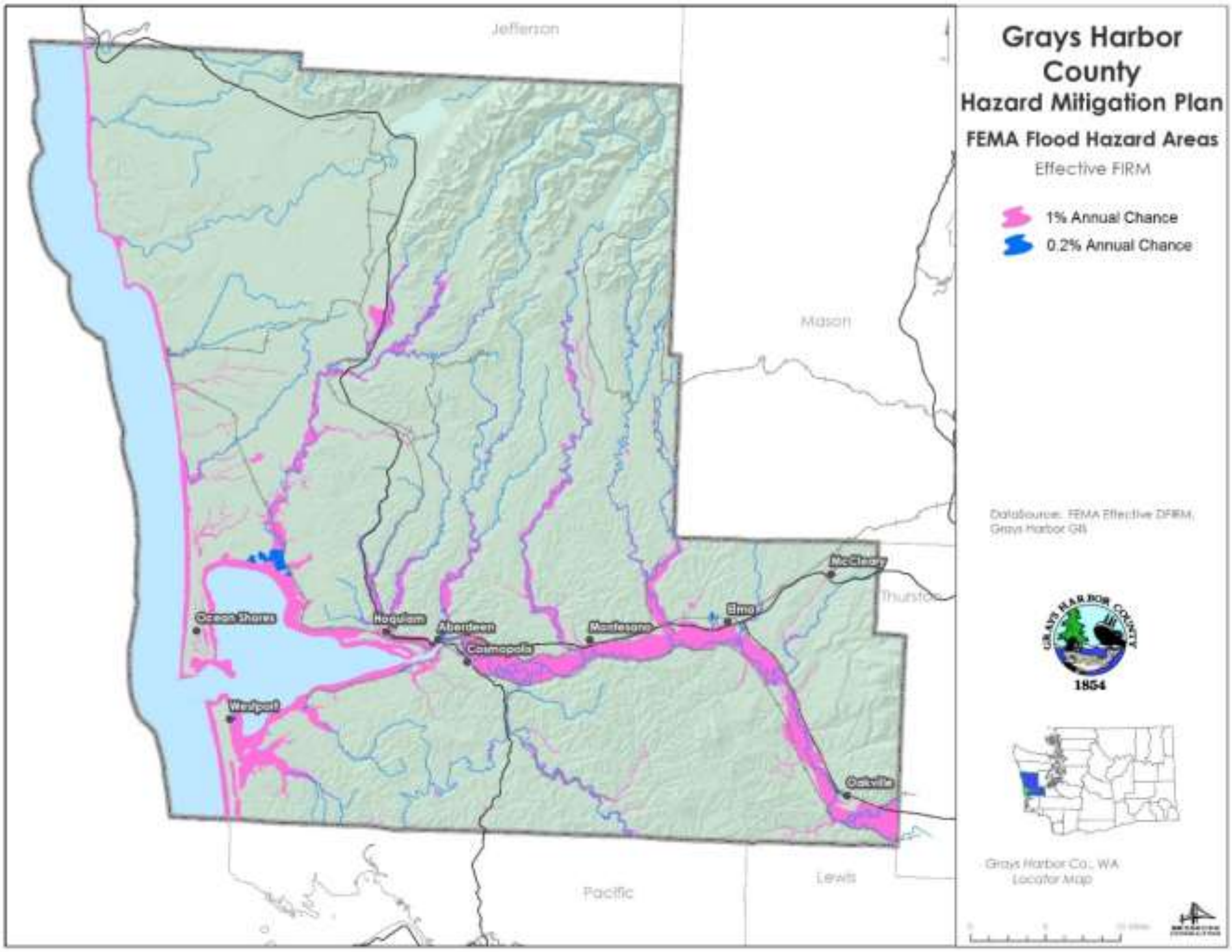


Figure 9-6 100- and 500-year Flood Hazard Areas

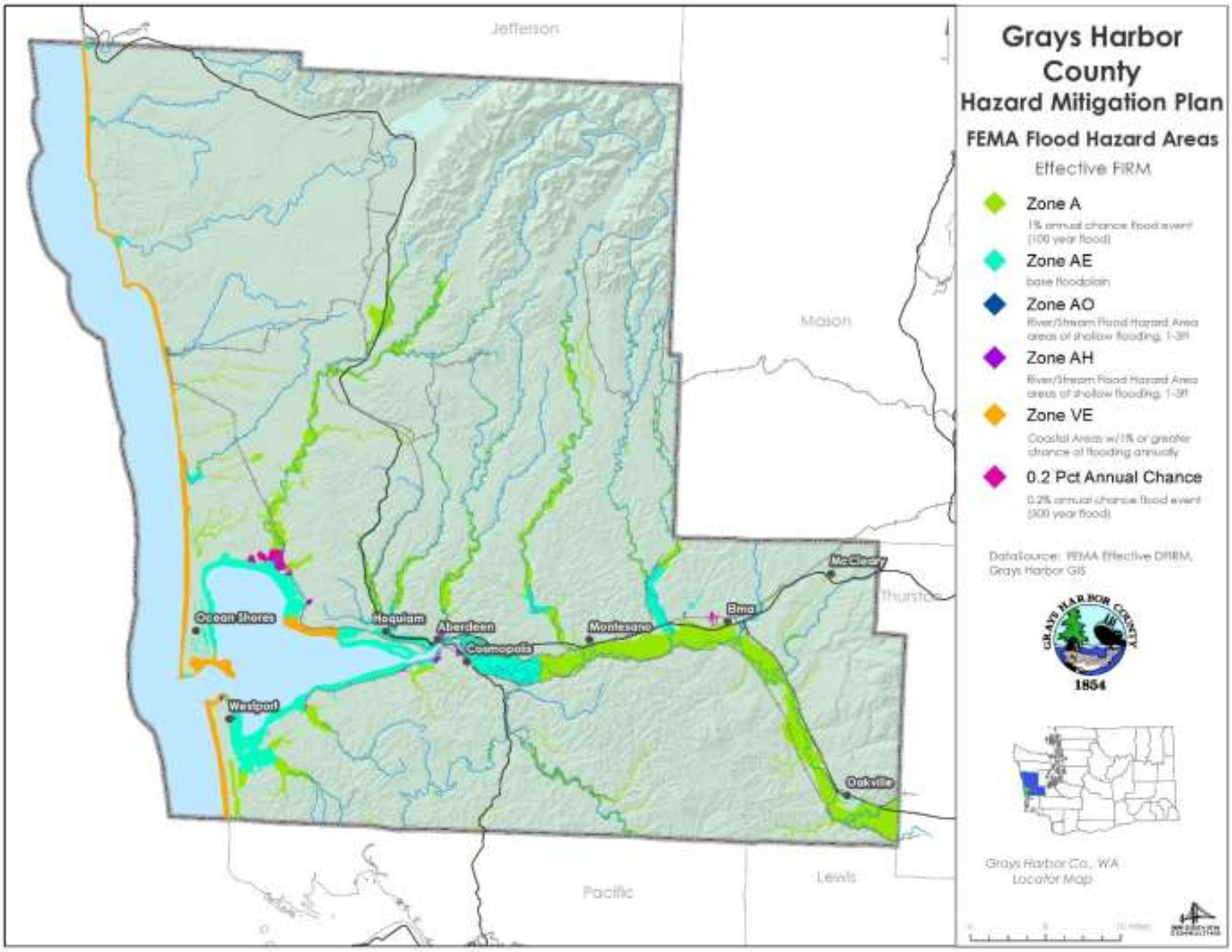


Figure 9-7 Grays Harbor County Flood Hazard Areas

The 1-percent-annual-chance depth grid developed by FEMA for the Cities of Hoquiam, Aberdeen and Cosmopolis areas are shown in Figure 9-8 (FEMA, 2015).

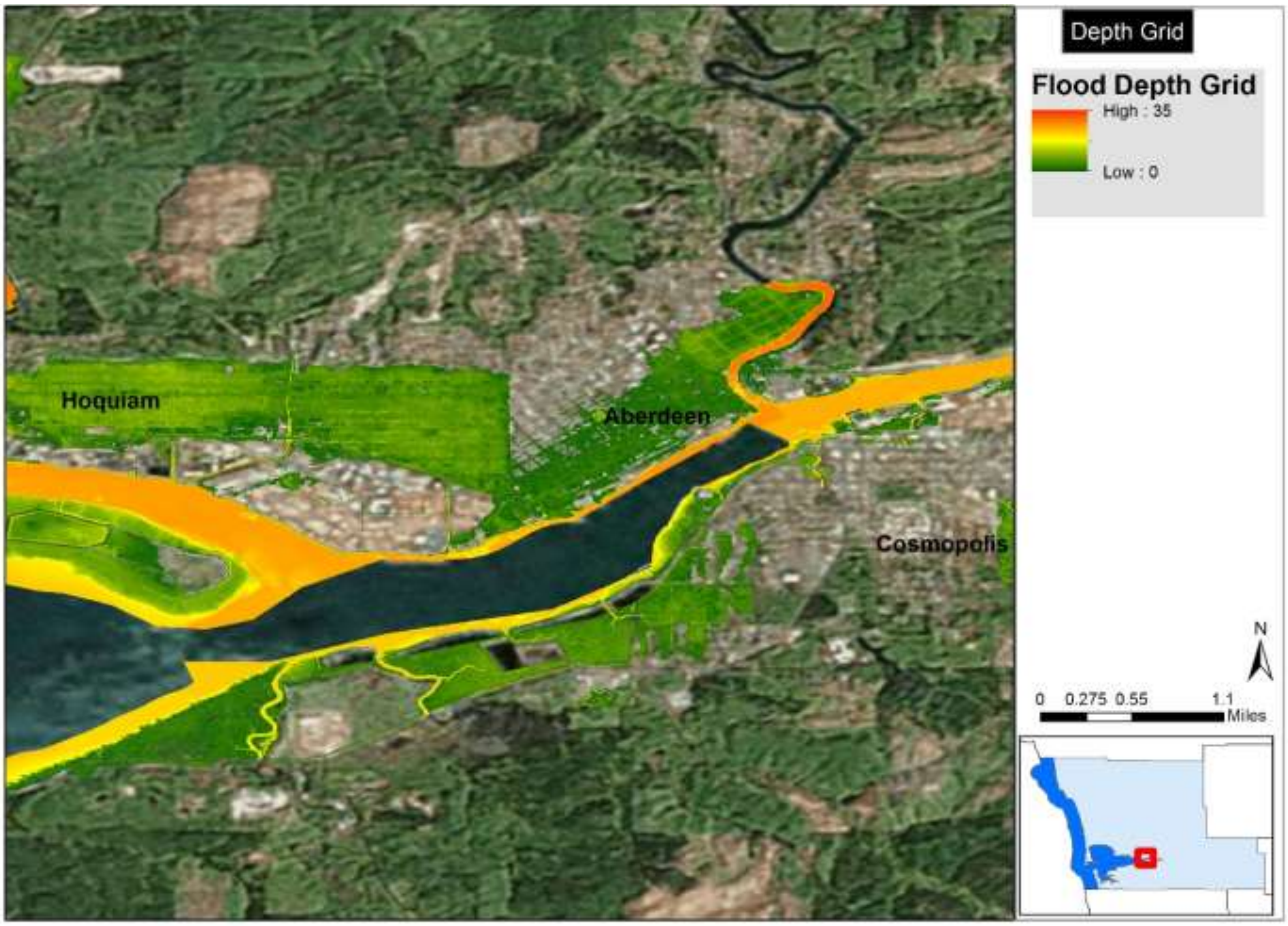


Figure 9-8 100-Year Flood Hazard Depth Grid for Aberdeen, Hoquiam and Cosmopolis (Source: FEMA 2015 RiskMAP)

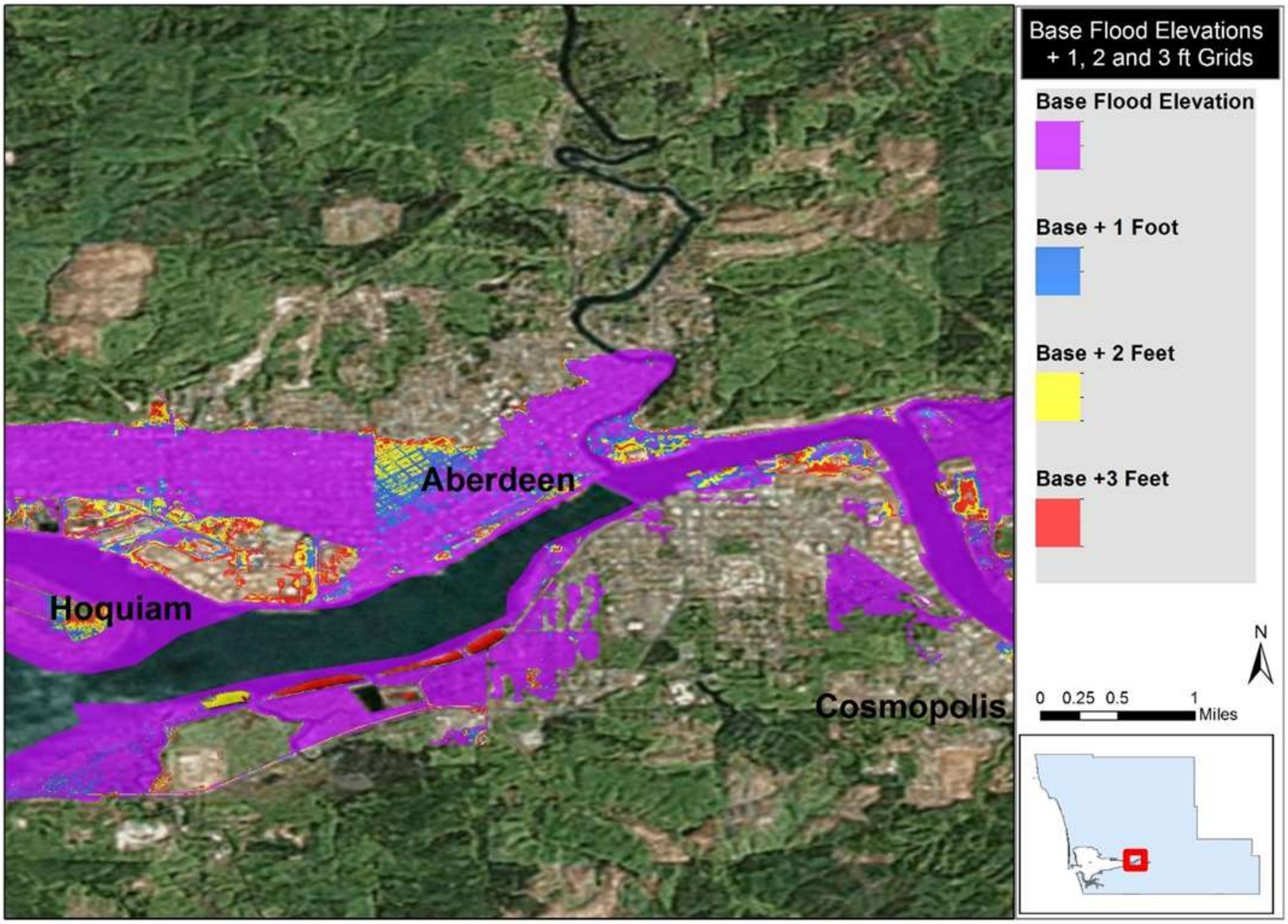


Figure 9-9 1% Flood Depth Grid (Base Flood Elevation) +1, 2, and 3 ft
(Source: FEMA RiskMap 2015)

In addition to the depth grid, a Base Flood Elevation (BFE)+ grid that was created shows increases of 1, 2, and 3 feet above the 1-percent-annual-chance BFE. This elevation grid represents events above the 1-percent-annual-chance flood, which includes projected sea level rise. This product is meant to inform local communities about possible future risk and is not a substitute for detailed sea level rise modeling. The BFE+ grid for the Aberdeen area is shown in Figure 9-9 (FEMA Risk Report 2015). Detailed information containing all data in the 2015 RiskMap Report is available for download from FEMA's website, or available for viewing from the County's Floodplain Manager or Emergency Manager.

As a result of the 2017 preliminary Chehalis and Wynoochee Rivers Study, FEMA also developed depth grids for the 1-percent-annual-chance flood for the riverine areas, as well as the 0.2-percent-annual-chance flood depth grids as shown in Figure 9-9. The various flood zones associated with the 2017 preliminary Chehalis Study are illustrated in Figure 9-10.

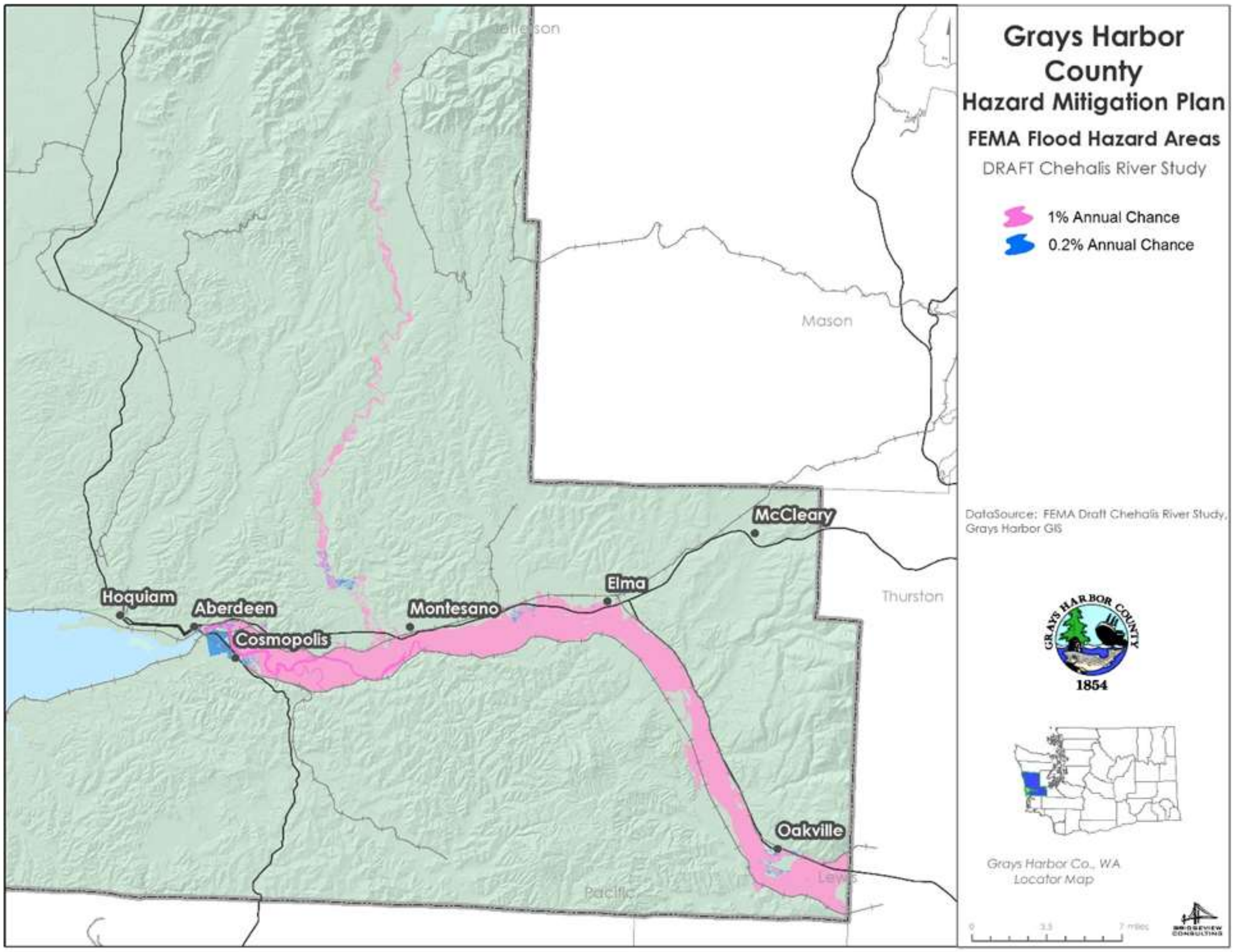


Figure 9-10 Draft 100- and 500-Year Chehalis River Flood Hazard Areas

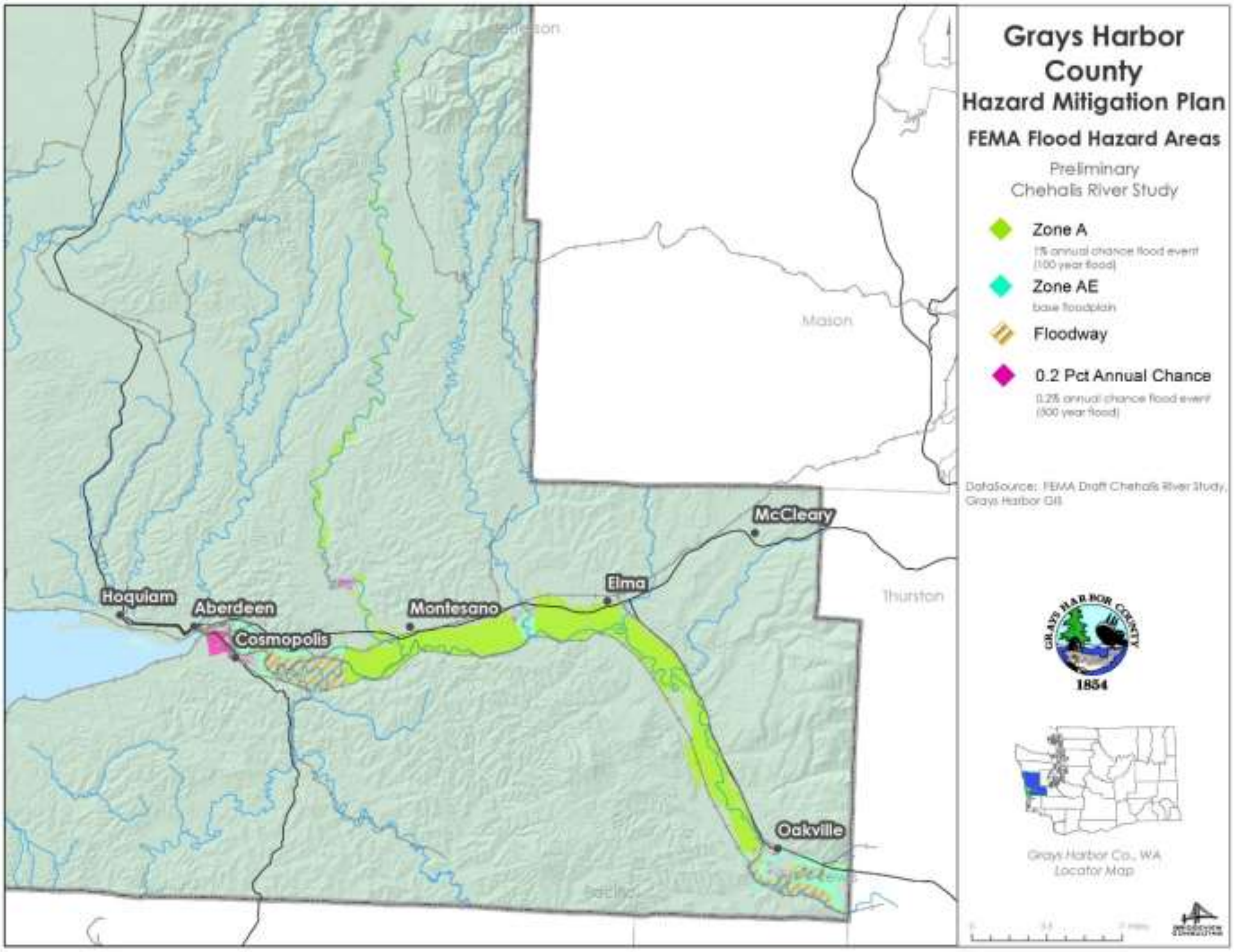


Figure 9-11 Preliminary Flood Hazard Zones on Chehalis and Wynoochee Rivers

While preliminary data and maps developed by FEMA for the 2017 Chehalis and Wynoochee Rivers RiskMap Study (hereafter referred to as the *2017 Preliminary Study*) has been utilized in this update, the maps are not and should not be considered final. *Viewers should confirm the data presented as it may change, and the County and any of its jurisdictions may elect to contest the maps prior to being finalized*. Once the final maps and Flood Insurance Study are adopted (currently anticipated for summer/fall 2019), the County may seek grant funding to update this flood hazard profile to incorporate any updated and new information which changes over the course of the RiskMap process. This has been identified as a strategy. Figure 9-12 illustrates the potential structures at risk based on the 2017 preliminary study.

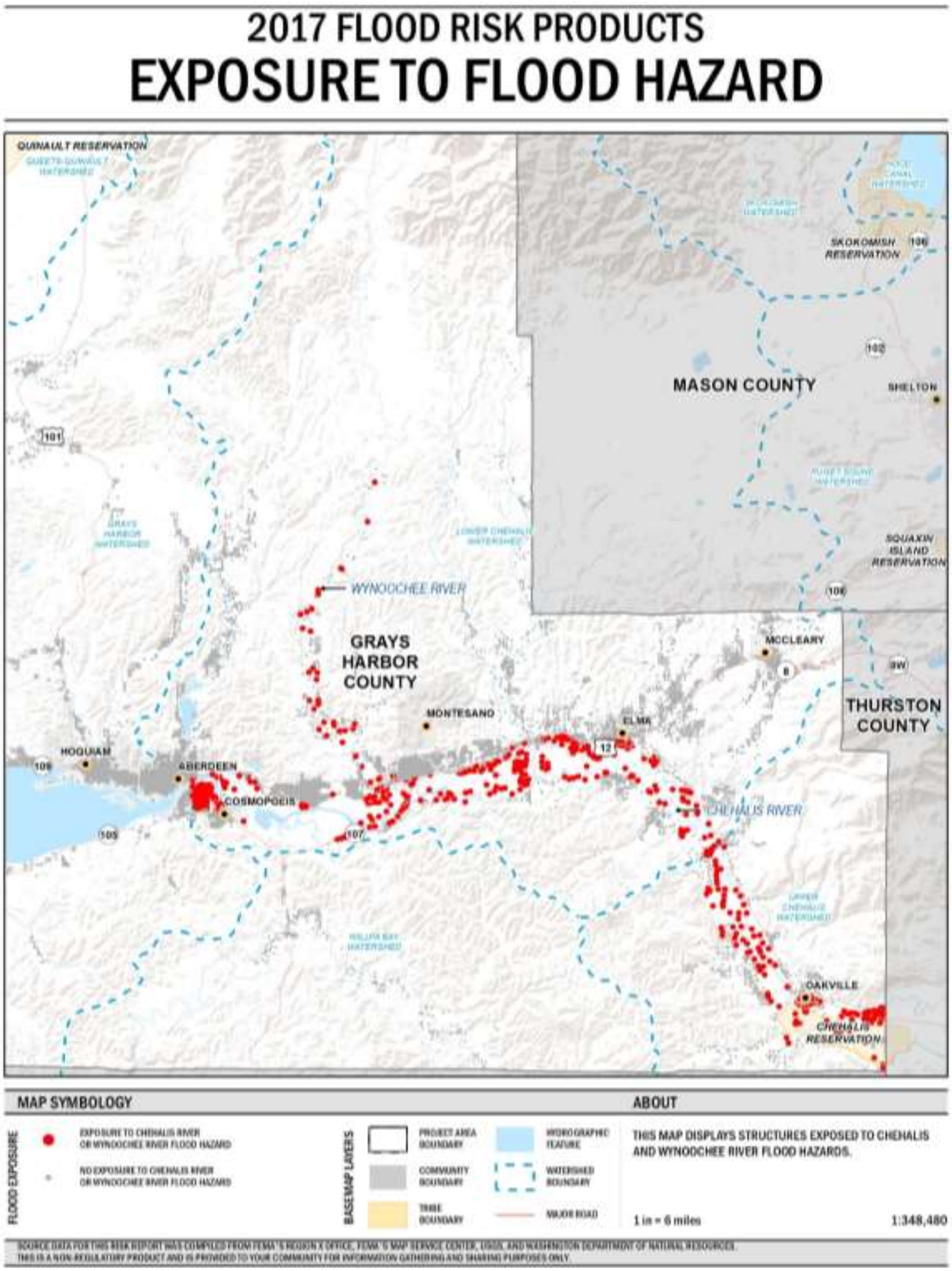


Figure 9-12 Exposed Structures Along Chehalis and Wynoochee Rivers (2017 Preliminary Maps)

The adjacent Pacific Ocean plays a significant role in influencing many hazards in the county by serving as a conduit for tsunamis, severe storms, coastal flooding, and hazardous material incidents.

There are six potential flooding sources in the area: Grays Harbor coastal flooding, and the Chehalis, Wishkah, Satsop, Wynoochee, Humptulips, and Hoquiam Rivers for riverine flooding. Ocean tides also significantly contribute to flooding in the Chehalis Basin and at the mouths of the larger tributaries in the county. Flooding associated with the tidal flooding include the Wishkah River, Hoquiam River, and Chehalis River. The low gradient of the Chehalis Basin and the mouths of major tributaries all contribute to flooding problems.

Each type of flooding usually happens simultaneously. For example, rivers in flood stage flowing into the Grays Harbor Estuary experience tidal flooding as well. Both types of flooding can influence each other during natural disaster events. Smaller, more localized flood events in the county result from intense rainfall within a short period, saturated soils, high water tables and heavy surface run-off.

Grays Harbor County has 7.5% of its uplands within floodplains, the second highest in the state. These extensive floodplains and wetlands contribute to the regional nature of flood events in the County. Riverine flooding is seen on all main rivers and tributaries in the rural portions of the county. Urban flooding generally occurs within the boundaries of the Montesano, Aberdeen, Hoquiam and Cosmopolis. The cities have extensive piped stormwater conveyance systems with outfalls at the rivers and harbor. Many of these systems' pumps used to prevent backflow through positive drainage are not sized for large 100-year rainfall events, offering little to no protection from riverine or coastal flooding. This is especially true in Hoquiam and Aberdeen (see Steepy/CLOMR 2017 Submittal for further details).

The Grays Harbor Estuary, the mouth of the Chehalis River, is a predominate feature that extends about 25 miles inland and covers 58,000 acres. The Chehalis River, a dominant factor in floods in the county, meanders east to west along a broad, flat river valley terminating in Grays Harbor. The largest tributaries of the Chehalis are the Satsop and Wynoochee Rivers originating on mountain slopes north of the river. Other significant rivers in Grays Harbor County include the Humptulips, Wishkah, and Hoquiam. Smaller rivers include the North River, Copalis, Moclips, the Johns, and Elk Rivers, which flow into the South Bay of the Grays Harbor estuary. All of these rivers terminate in the Grays Harbor estuary and are subject to serious flooding. Many smaller tributary streams associated with these rivers also contribute to flood events in the county.

Tidal changes from the Pacific Ocean, combined with increased runoff have produced a history of frequent flooding in Grays Harbor County. Coastal land areas in the county north and south of the mouth of Grays Harbor tend to be flat, low areas with an abundance of floodplains, wetlands, marshes, and dunes along ocean beaches. Lower elevation coastal areas adjacent to rivers are subject to tidal fluctuations. Storm tides, combined with storm surge and high tides, will cause backwater flooding in rivers. Tidal fluctuations can influence river flooding for a significant number of miles upstream. Lowland water tables, especially in winter months, tend to produce standing water that often floods roads.

9.2.2 Previous Occurrences

Major floods in the planning area have resulted from intense rainstorms customarily between October and April. Table 9-6 highlights historical flood events. It should be noted that due to the disaster typing which occurs at the FEMA level, there are other types of events which also include flooding, but due to the typing, those are not referenced within this chapter. Specific examples of this include Severe Weather events which include flooding as a hazard of impact. In some cases, those events are included in the Table 9-6, but highlighted in grey. Viewers should also review the Severe Weather hazard profile for additional information.

9.2.3 Severity

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

The principal factors affecting flood damage are flood depth and velocity. The deeper and faster flood flows become, the more damage they can cause. Shallow flooding with high velocities can cause as much damage as deep flooding with slow velocity. This is especially true when a channel migrates over a broad floodplain, redirecting high velocity flows and transporting debris and sediment. Flood severity is often evaluated by examining peak discharges.

Figure 9-13 illustrates floodwaters between Montesano and Elma resulting the December 3, 2007 Severe Storm event (DR-1734). Figure 9-14 is a map which illustrates areas where impact occurred during the 2015 Flood and Landslide event which was categorized as a Severe Weather Event.

There is little record of flooding in the 1800's and it was not until the 1900's that floods become an issue. Early flood management were local efforts such as the construction of dike and levee systems. As problems increased, the United State Army Corps of Engineers (USACE) began to play an important role in supporting the county with flood management activities. In the 1930's, the USACE assisted the county with flood control to help maintain shipping channels for navigation purposes.

Flooding has increased over the decades. According to records, 13 major flood events from 1960 to 1917 in Grays Harbor were included in Federal Disaster Declarations. As damages grew larger, flood management efforts accelerated. An example of this activity was the development of Wynoochee Dam by the USACE Project in 1972. Before the dam, the Wynoochee River received peak inflows of 22,500 cfs; the dam held outflows at 200 cfs, reducing the flood stage downstream by about 3 feet. A growing concern of county officials and citizens has been the growth in the frequency of floods since 2005. Some of this rise may be related to the fact that peak flows for the Lower Chehalis River Basin increased 15% from 1990 to 2004, and continues to increase.

9.2.4 Frequency

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

Grays Harbor County experiences some level of flooding on an annual basis. The Washington State Hazard Mitigation Plan identifies Grays Harbor County as being "Most Vulnerable and At-Risk to Flooding," with a frequency rate of one every three years (October 2010). However, what customarily constitutes the "normal" flood season of October through April in Western Washington does not necessarily apply to the Chehalis and Wynoochee Rivers, which have received flood warnings issued by the National Weather Service during the month of July.

Large floods that can cause property damage have occurred 13 times during the time period 1964 through 2017. Frequency for this calculation was based on the period covering 1964 to 2017, and the number of events averaged based on years and number of floods. Based on this method of assessment, the return interval for a flood event (not inclusive of FEMA's severe storm designation) is 4.08 years, or a 25 percent chance of some level of a flood event occurring every year. Such calculations do not reflect the scientific recurrence interval, as that calculation is specific on varying factors, such as the incident type, discharge rate, etc. Urban portions of the county annually experience nuisance flooding related to drainage issues.

TABLE 9-6
FLOOD EVENTS IMPACTING PLANNING AREA 1964-2016

Disaster Number	Declaration Date	Disaster Type	Incident Type	Title	Incident Begin Date	Incident End Date	PA Dollars Obligated or Losses (State)
4253	2/2/2016	DR	Flood	Severe Winter Storm, Straight-Line Winds, Flooding, Landslides, and Tornado	12/1/2015	12/14/2015	$3,166,346
Several days of heavy rain in December 2015 resulted in widespread flooding of roadways, homes, and property. On February 2, 2016, Federal disaster aid was made available to the State of Washington to supplement state, tribal, and local recovery efforts in the Grays Harbor County and other areas affected by the flooding.							
NA	1/4/2015	NA	Flood	Flood and Landslide	1/4/2015		
An atmospheric river passed over parts of western Washington. Over the following 48 hours, intense precipitation fell on much of the coast and interior of the state. The two-day storm total was 7.16 inches at Hoquiam Airport (based on WA State Climatologist reports). The county experienced many landslides, with the City of Hoquiam experiencing several slides which damaged (at least) eight houses. Historic flooding was experienced in Hoquiam and Aberdeen. Further information on the impacts to Hoquiam can be viewed in the 1/16/2017 report prepared by WA DRN Geologist S. Slaughter.							
1817	1/30/2009	DR	Flood	Severe Winter Storm, Landslides, Mudslides, & Flooding	1/6/2009	1/16/2009	
January 2009- Washington State was hit with severe winter storms that brought heavy rains and warmer temperatures, resulting in snow melting causing flooding, land- and mudslides. Grays Harbor County was virtually under water with every river in the county on flood watch. Melting snow saturated the soil, and drenching rain created extreme risk of landslides making some roads impassable and forcing school closures. High winds blew trees into power lines all over the county knocking out power to about 5,000 customers. The Sheriff's Dept. issued a Notice of Voluntary Emergency Evacuation to people living near any river. Deputies spent the night and early morning hours evacuating about 10 people near Copalis Crossing, Humptulips, and Montesano. On January 9th, many businesses were forced to close, including Grays Harbor County offices, Weyerhaeuser Sawmill in Aberdeen, and Grays Harbor College. Montesano residents and businesses reported flooding in their basements as the water rose throughout town; roads flooded in lower areas of town. Residents on Lund Road reported the worst flooding they had ever seen, with river currents flowing across roadways and basements filled to the ceiling with water. Neighbors rescued each other with boats. More than 2,000 sand bags were placed along the Chehalis at Oakville. Oakville High School served as shelter while Grays Harbor County Fairgrounds provided animal shelter. Landslides closed roads throughout the county including: Highway 12 near Devonshire Rd., SR 108 at Montesano, Hwy 101 outside Raymond in Pacific County, Wynoochee Road, Hicklin Underpass, North River Road, and the Wishkah Road.							
1734	12/8/2007	DR	Flood	Severe Storm, Landslides, Mudslides, & Flooding	12/1/2007	12/17/2007	~$7.98 M
Numerous injuries and one death were reported to Grays Harbor Emergency Services. A falling tree killed an Aberdeen man as he cleared downed trees. Two PUD workers were badly injured when they responded to downed trees and one of the workers fell 40 feet from the bucket from which he was working. Workers had to clear trees along Hwy 12 to clear a route for evacuation of the victim to Harborview. As workers cleared trees in front of the ambulance, more were falling behind. This was identified as the worst storm since the Columbus Day storm of 1963 to hit the region with hurricane force							

TABLE 9-6
FLOOD EVENTS IMPACTING PLANNING AREA 1964-2016

winds gusting to 81 mph, heavy rain, and power outages to virtually everyone in the county. During a 24-hour period, 45-55 mph winds battered western Grays Harbor, closing highways. Widespread flooding caused a section of I-5 to close for three days. The Chehalis River flooded into fields, side roads and buildings. Floodwaters in some neighborhoods were as high as the rooflines. Several shelters were opened throughout the county. Sheriff's deputies and National Guard units were dispatched to do welfare checks, concentrating on four areas (the Wynoochee Valley along Wishkah Rd, East Hoquiam Rd, Central Park, and the Ocosta-Grayland areas). Power outages numbered over 33,000 countywide, with wind gusts clocked at 81 mph. Almost $8 million was paid in aid to Grays Harbor County (GHC HMP, 2011).							
1671	12/12/2006	DR	Severe Storm	Severe Storms, Flooding, Landslides, Mudslides	11/02/2006	11/11/2006	
The Pineapple Express brought record-breaking rains to Grays Harbor County on November 6, 2006. Sustained coastal winds at 40 mph generated high coastal swells augmented by high tides. Wind and waves battered the marina and jetty at Westport with seawater flowing over the seawall, flooding an area of about five city blocks. The enormous amount of water caused animals to be stranded, put lowland residents on evacuation alert, and closed schools and roads around Grays Harbor County. Mud and rockslides blocked a number of highways and delayed trains. Hoquiam built a sand dike on Myrtle Street north of Simpson Avenue to divert floodwaters out of Fry Creek from an assisted living facility. The water rushed down Cherry Street in Aberdeen and flooded houses and other structures. Many of Aberdeen's streets were under up to a foot of water, including Oak Street, which is the only access to the Community Hospital. Lake Quinault received rainfall of 11" in 24 hours, while Aberdeen received 9.2" and Hoquiam received 5" in the same 12 hour period.							
1641	5/17/2006	DR	Severe Storm	Severe Storms, Flooding, Tidal Surge, Landslides, Mudslides	1/27/2006	2/2/2006	
January 2006 brought severe storms with record-breaking rainfall to Grays Harbor County. Heavy rains continued for 44 days in a 45-day period causing flooding of the Chehalis, Satsop, and Wynoochee Rivers. Rivers and retention ponds spilled over and flooded Aberdeen streets, farmland, houses, and other structures. The Grayland area experienced heavy rain, strong ocean currents, and unusually high tides. High water and landslides forced many city and rural roads and state highways to close. Power outages were reported in Quinault, the North River areas, and Central Park. Aberdeen experienced record rainfall of 26.81"; Hoquiam 24.21". Winds were sustained at 35 mph, with 59 mph gusts recorded.							
1499	1/17/2003	DR	Severe Storm	Severe Storms and Flooding	10/15/2003	10/23/2003	Unknown
Severe storms caused flooding throughout the County.							
1172	4/2/1997	DR	Flood	Heavy Rains, Flooding, Snow Melt, Land Slides	3/18/1997	3/28/1997	$50,889,413
A week of torrential rain in late March 1997 created flooding and landslides in multiple places in Washington State. In Grays Harbor County, multiple roads were closed over the five-day period of heavy rains..							
1100	2/9/1996	DR	Flood	High Winds, Severe Storms and Flooding	1/26/1996	2/23/1996	Unknown
Major flooding occurred along the Chehalis River.							
883	11/26/1990	DR	Flood	Severe Storms & Flooding	11/9/1990	12/20/1990	$2.9 million
Two deaths as a result of this incident statewide. Over the Thanksgiving weekend, between 8 and 15 inches of rain fell.							
852	1/18/1990	DR	Flood	Severe Storms and Flooding	1/6/1990	1/14/1990	
Flooding occurred throughout the Chehalis Valley.							
612	12/31/1979	DR	Flood	Storms, High Tides, Mudslides & Flooding	12/31/1979	12/31/1979	

TABLE 9-6
FLOOD EVENTS IMPACTING PLANNING AREA 1964-2016

Heavy rains and snowmelt caused floods, mudslides, and road washouts.						
545	12/10/1997	DR	Flood	Severe Storms and Flooding	12/13/1975	12/31/1975
Heavy rain and runoff from snowmelt caused flooding throughout the County.						
492	12/13/1975	DR	Flood	Severe Storms & Flooding	12/13/1975	12/13/1975
A five-year record for precipitation resulted from this event. Record rainfall and snow caused widespread flooding. Strong winds occurring with the event caused additional damages throughout the county.						
322*	2/1/1972	DR	Flood	Severe Storms and Flooding	2/1/1972	2/1/1972
Heavy rains fell throughout the area. (*Incident listed as DR 328 in 2011 GHC HMP.)						
300	2/9/1971	DR	Flood	Heavy Rains, Snowmelt, and Flooding	2/9/1971	2/9/1971
Snow followed by wind and rain caused widespread damages throughout the County.						
185	12/29/1964	DR	Flood	Heavy Rains & Flooding	12/29/1964	12/29/1964
In December 1964, snow and heavy rains caused flooding and slides throughout the area. Snow accumulations reached records in parts of the state, including to the east in Mason County. Falling branches and the weight of the snow caused numerous power outages. Numerous reports were received of roofs of barns, sheds, carports, and garages collapsing under the weight of the snow. The storm closed logging operations in hard-hit areas.						

Figure 9-13 Floodwaters between Montesano and Elma (DR 1734)
Source Unknown - Photo taken December 3, 2007

Figure 9-14 Flood Impact from December 2008 Flood Event (DR1817)

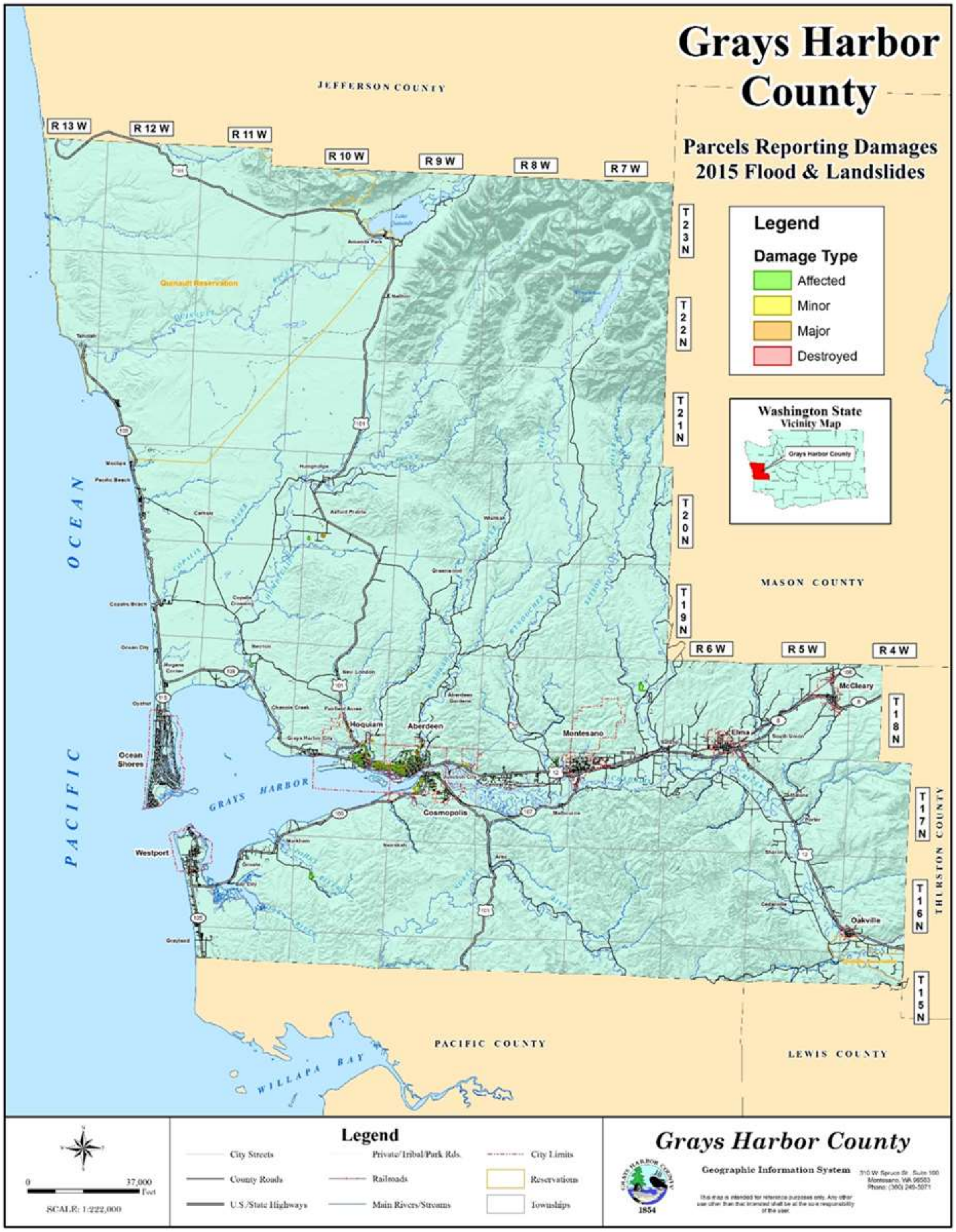


Figure 9-15 Flood Impacts from January 4-5, 2015 Flood and Landslide Event (Non-Declared)

9.3 VULNERABILITY ASSESSMENT

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

9.3.1 Overview

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

Methodology

In completing the analysis, a modified Level 1/Level 2 (for updated critical facilities and user defined facilities) Hazus protocol was used to assess exposure to flooding in the planning area. This type of analysis has a level of accuracy acceptable for planning purposes. Where possible, the Hazus default data was enhanced using critical infrastructure and building data provided by the County, as well as data from the state and federal sources.

As indicated, the County's effective FIRMs were adopted in February 2017 (dated 2015). As of this update, FEMA has also begun the process of updating the Chehalis and Wynoochee Rivers' area NFIP maps (2017 RiskMAP Preliminary Study); however, those have not yet been adopted. Both datasets were utilized within this hazard profile, with the data source referenced as utilized.

The project team completed the flood risk assessment using local parcel and assessors' data from Grays Harbor County, in addition to coastal and riverine flood depth grids derived from the RiskMAP (2017) project. For their assessment, FEMA used a new (2017) coastal flood depth grid for the coastal area. The team also completed an assessment for riverine areas, incorporating individual building data into Hazus, which allows losses to be reported at the building level.

During this HMP update, the HMP planning team also developed a new list of critical facilities, which was also loaded into Hazus and utilized throughout the various processes to identify potential exposure to those structures identified by the planning team members as critical facilities.

Warning Time

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

The potential warning time a community has to respond to a flooding threat is a function of the time between the first measurable rainfall and the first occurrence of flooding. The time it takes to recognize a flooding threat reduces the potential warning time to the time that a community has to take actions to protect lives and property. Another element that characterizes a community's flood threat is the length of time floodwaters remain above flood stage. The Grays Harbor County flood threat system consists of a network of precipitation gauges throughout the watershed and stream gauges at strategic locations in the county that constantly monitor and report stream levels (see Figure 9-16). This information is fed into a U.S. Geological Survey forecasting program, which assesses the flood threat based on the amount of flow in the stream (measured in cubic feet per second). In addition to this program, data and flood warning information is provided by the National Weather Service (NWS). All of this information is analyzed to evaluate the flood threat and possible evacuation needs.

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 9-17)[31], 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 9-16 USGS Gage Data on Upper Wynoochee Lake

The NWS issues watches and warnings when forecasts indicate rivers may approach bank-full levels. When a watch is issued, the public should prepare for the possibility of a flood. When a warning is issued, the

[31] The County provides a link on their Emergency Management Website to the various River Gauges maintained by USGS: http://water.weather.gov/ahps2/index.php?wfo=sew

public is advised to stay tuned to a local radio station for further information and be prepared to take quick action if needed. A warning means a flood is imminent, generally within 12 hours, or is occurring. Local media broadcast NWS warnings. The County utilizes its webpage and various social media to distribute this data to its citizens.

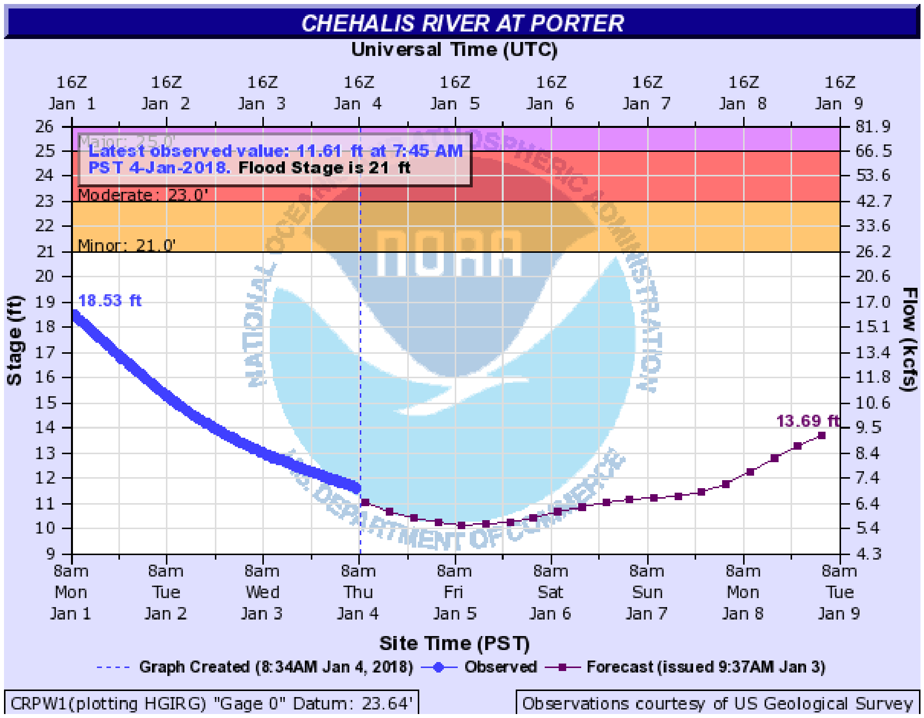


Figure 9-17 Chehalis River Hydrograph at Porter

9.3.2 Impact on Life, Health, and Safety

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

There are also residential structures in the path of potential waterflow with respect to the various dams throughout the County. While existing available data identifies some residential structures, there are also businesses in the area, including a hatchery. Therefore, consideration should also be given to employees working in those potential inundation areas who would also be at potential risk.

In order to estimate the population exposed to the 1 percent and 0.2 percent annual chance (100- and 500-year) flood events, the adopted DFIRM floodplain boundaries were intersected with residential parcels (based off of Grays Harbor County Assessor data) whose centers intersect the floodplain. Total population was estimated by multiplying the number of single-family residential structures by the average Grays Harbor County household size of 2.5 persons per household (based on Census data). Table 9-7 lists the estimated population located within these flood zones by municipality. It should be noted that the planning area also has many structures which have the designation of RES4 (hotel/motel-type structures) and RES5 (institutional dormitory). Due to the undetermined level of occupancy, calculations for those structures are not included in population impact totals as the variables are too great to determine (by day, season, number of units rented, number of individuals housed in the institutional dormitories per day, etc.).

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

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

Table 9-7
Populations Exposed within 100- and 500-Year Flood Hazard Areas (Adopted FIRM)

Jurisdiction	Number of Residential Structures 100-Year FIRM	Population Exposed (2.5/persons/ household)	Percent of Total Population in Planning Area	Number of Residential Structures 500-Year FIRM	Population Exposed (2.5/persons/ household)
Unincorporated Grays Harbor County	1,349	3,653	13.0%	55	138
Aberdeen, City of	1,488	4,125	24.6%	343	876
Cosmopolis, City of	10	25	1.5%	16	40
Elma, City of	3	8	0.2%	15	36
Hoquiam, City of	2,554	6,853	80.1%	0	0
McCleary, City of	21	63	3.7%	1	3
Montesano, City of	0	0	0.0%	0	0
Oakville, City of	1	3	0.4%	0	0
Ocean Shores, City of	82	215	3.6%	0	0
Westport, City of	48	120	5.7%	135	338
Other	278	703	NA	0	0
Total	5,834	15,765	21.6%	565	1,412

**Residential structures include both single and multi-family structures. Average single family residence within County is 2.5 persons per single residential household.*

9.3.3 Impact on Property

Table 9-8 summarizes the total number of structures and losses based on the existing 2017 FIRMS, inclusive of the 2017 coastal analysis. This table identifies those structures within Special Flood Hazard Areas (SFHAs). The SFHAs are the areas that would be inundated by the 1-percent-annual-chance flood.

For illustrative purposes, Figure 9-18 identifies the general building stock at risk as determined in FEMA's 2017 effective flood study, while Figure 9-19 and Figure 9-20 illustrate the 2017 Preliminary Study impact for the 100- and 500-year events, respectively.

Table 9-8 100-Year Potential Structures at Risk to Flood Hazard (2017 DFIRM Data)

Jurisdiction	Estimated Building Count (2)	Total Building Value (Structure and contents in $) (2)	FEMA Flood Hazard Exposure (3)									
			Buildings Exposed to 1% Annual Chance Flood Event (2)					Buildings Exposed 0.2% Annual Chance Flood Event (2)				
			Buildings Exposed (2)	Value Structure in $ Exposed (2)	Value Contents in $ Exposed (2)	Total Value (Structure and contents in $) Exposed (2)	% of Total Value	Buildings Exposed (2)	Value Structure in $ Exposed (2)	Value Contents in $ Exposed (2)	Total Value (Structure and contents in $) Exposed (2)	% of Total Value
City of Aberdeen	6,331	$1,558,813,283	2026	$304,134,378	$274,364,679	$578,499,056	37.11%	2405	$333,181,566	$291,064,435	$624,246,001	40.05%
City of Cosmopolis	740	$219,110,855	13	$1,423,410	$955,705	$2,379,115	1.09%	29	$2,915,635	$1,701,818	$4,617,453	2.11%
City of Elma	1,225	$345,049,384	4	$421,365	$368,800	$790,165	0.23%	20	$2,482,390	$1,449,313	$3,931,703	1.14%
City of Hoquiam	3,457	$668,170,030	2859	$245,427,550	$174,524,228	$419,951,778	62.85%	2859	$245,427,550	$174,524,228	$419,951,778	62.85%
City of Mccleary	664	$138,539,384	21	$2,923,895	$1,461,948	$4,385,843	3.17%	23	$3,049,705	$1,552,675	$4,602,380	3.32%
City of Montesano	1,554	$433,872,272	9	$4,961,120	$4,966,620	$9,927,740	2.29%	9	$4,961,120	$4,966,620	$9,927,740	2.29%
City of Oakville	331	$66,998,060	2	$178,190	$94,595	$272,785	0.41%	2	$178,190	$94,595	$272,785	0.41%
City of Ocean Shores	4,600	$1,156,337,793	88	$23,626,135	$11,965,515	$35,591,650	3.08%	88	$23,626,135	$11,965,515	$35,591,650	3.08%
City of Westport	1,291	$310,030,743	93	$21,584,022	$13,018,661	$34,602,683	11.16%	260	$38,369,542	$23,995,774	$62,365,316	20.12%
Unincorporated Grays Harbor County	12,816	$3,122,630,417	1507	$198,438,115	$153,107,655	$351,545,770	11.26%	1575	$262,720,324	$239,858,171	$502,578,495	16.09%
Other(4)	718	$177,559,756	295	$44,596,851	$30,280,300	$74,877,150	42.17%	295	$44,596,851	$30,280,300	$74,877,150	42.17%
Grays Harbor County	33,727	$8,197,111,976	6917	$847,715,030	$665,108,705	$1,512,823,735	18.46%	7565	$961,509,007	$781,453,442	$1,742,962,450	21.26%

Sources:

(1) 2017 Washington Office of Financial Management April 2017 Population Estimate

(2) Exposure numbers were estimated using FEMA Region X User Defined Facilities and Grays Harbor County Assessor data.

(3) FEMA Flood analysis based on the current Effective DFIRM

(4) "Other" includes Tribal, National Parks, and Military. Accurate population figures were not available at the time of this study.

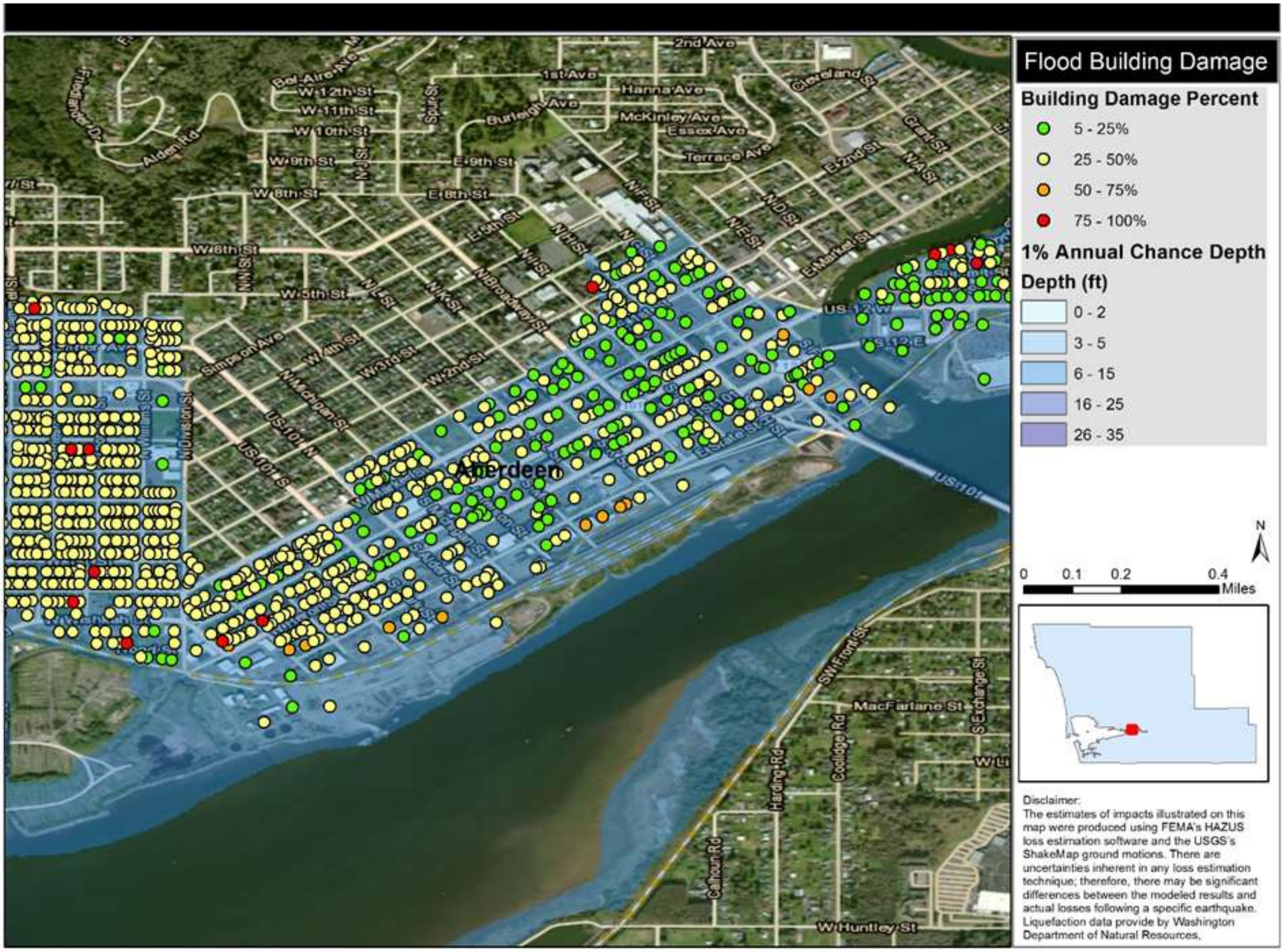


Figure 9-18 FEMA-Defined Flood Damage - Hoquiam and Aberdeen (2017 Adopted FIRMS)

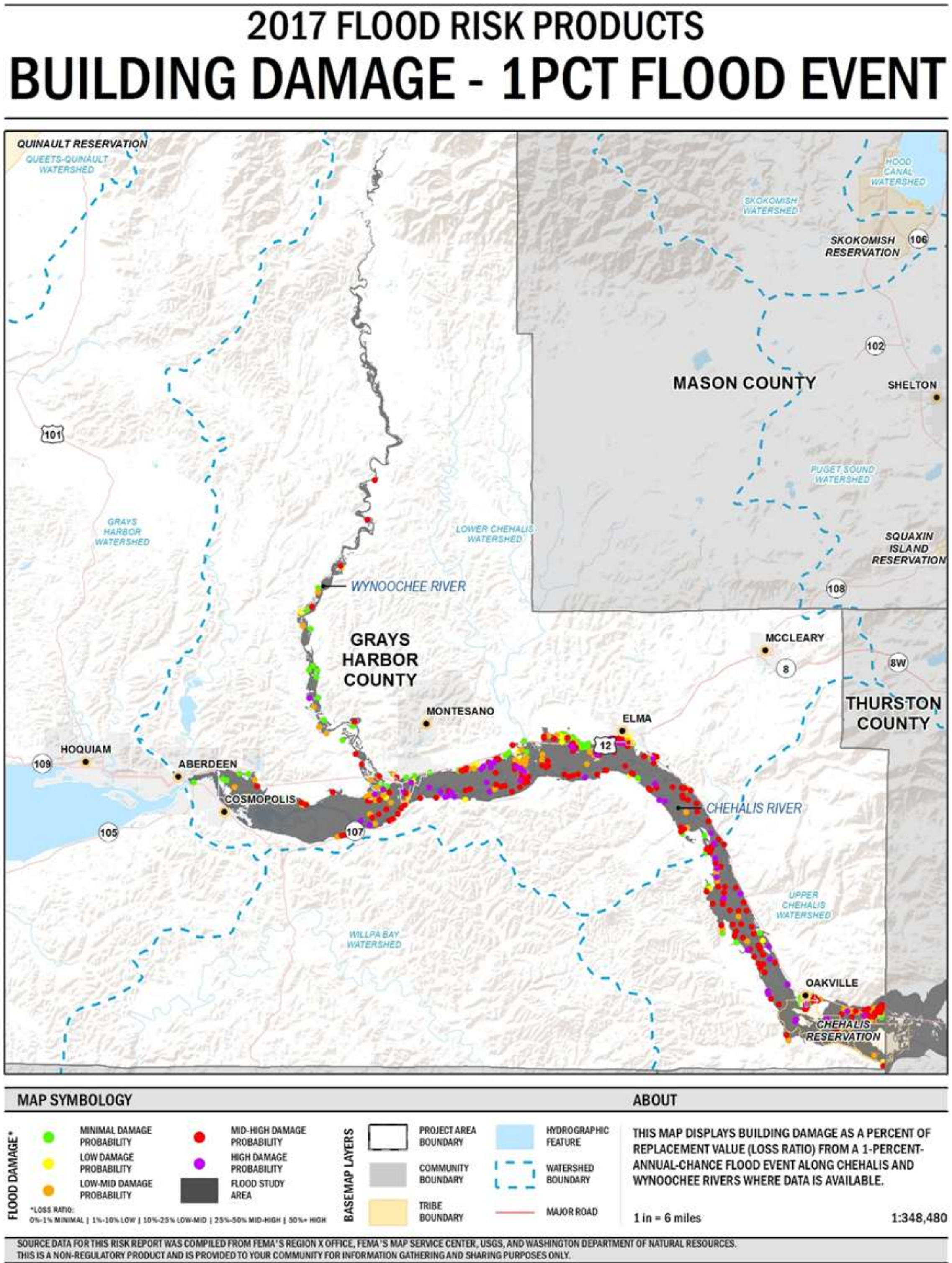


Figure 9-19 Building Impact 100-year Event Chehalis and Wynoochee Rivers (2017 Preliminary)

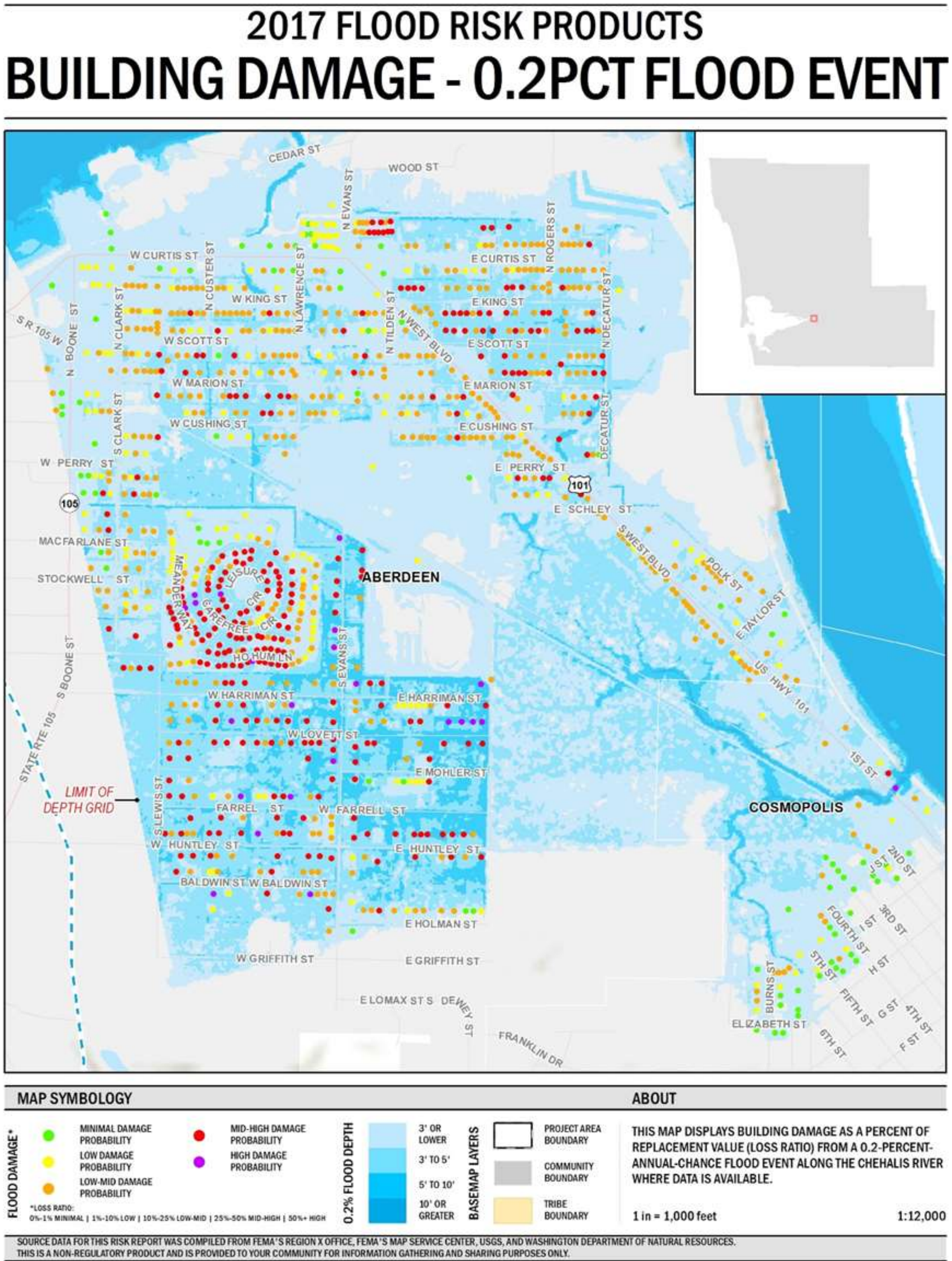


Figure 9-20 Building Impact 500-year Event Chehalis and Wynoochee Rivers (2017 Preliminary)

9.3.4 Impact on Critical Facilities and Infrastructure

In addition to considering general building stock at risk, the risk of flood to critical facilities and utilities was evaluated. Hazus-MH was used to estimate critical facilities exposed to the 100-year flood risk. This process was conducted outside of FEMA’s Risk Map process as part of the HMP development utilizing the critical facilities database and Hazus 3.2. Table 9-9 and Table 9-10 list critical facilities and infrastructure exposed in the FEMA 100-year flood hazard area (adopted FIRMS). Figure 9-21 illustrates the location of the critical facilities impacted by the adopted FIRMS.

Table 9-11 and Table 9-12 list the critical facilities and infrastructure inside the Chehalis and Wynoochee River 100-year flood hazard area (preliminary data). Figure 9-22 illustrates those facilities.

It should be noted that all facilities identified are listed based on geographic location, not on ownership. Therefore, as an example, Aberdeen lists six (6) government function structures within its boundary; not all six may be “owned” by Aberdeen.

Table 9-9
Critical Facilities in the (Effective) 100-year Floodplain

Jurisdiction	Medical and Health Services	Government Function	Protective	Hazardous Materials	School	Other	Total
Aberdeen	0	6	5	5	10	0	**26**
Cosmopolis	0	0	1	0	0	0	**1**
Elma	0	0	0	0	0	0	**0**
Hoquiam	1	4	5	2	8	0	**20**
McCleary	0	0	0	0	0	0	**0**
Montesano	0	0	0	1	0	0	**1**
Oakville	0	0	0	0	0	0	**0**
Ocean Shores	0	0	0	0	0	0	**0**
Westport	0	0	0	1	0	0	**1**
Unincorporated	0	2	2	5	1	0	**10**
Other	0	0	0	0	3	0	**3**
Total	**1**	**12**	**13**	**14**	**22**	**0**	**62**

Table 9-10 Critical Infrastructure in (Effective) 100-Year Floodplain							
Jurisdiction	**Water Supply**	**Wastewater**	**Power**	**Communications**	**Transportation**	**Other**	**Total**
Aberdeen	4	17	4	7	9	4	**45**
Cosmopolis	0	0	2	0	0	0	**2**
Elma	0	0	0	0	1	0	**1**
Hoquiam	2	10	2	5	8	2	**29**
McCleary	0	0	0	0	0	0	**0**
Montesano	1	1	0	0	6	0	**8**
Oakville	0	0	0	0	1	0	**1**
Ocean Shores	0	0	0	0	6	0	**6**
Westport	0	0	0	0	1	0	**1**
Unincorporated	4	1	1	0	134	0	**140**
Other	1	0	0	2	3	0	**6**
Total	**12**	**29**	**9**	**14**	**169**	**6**	**239**

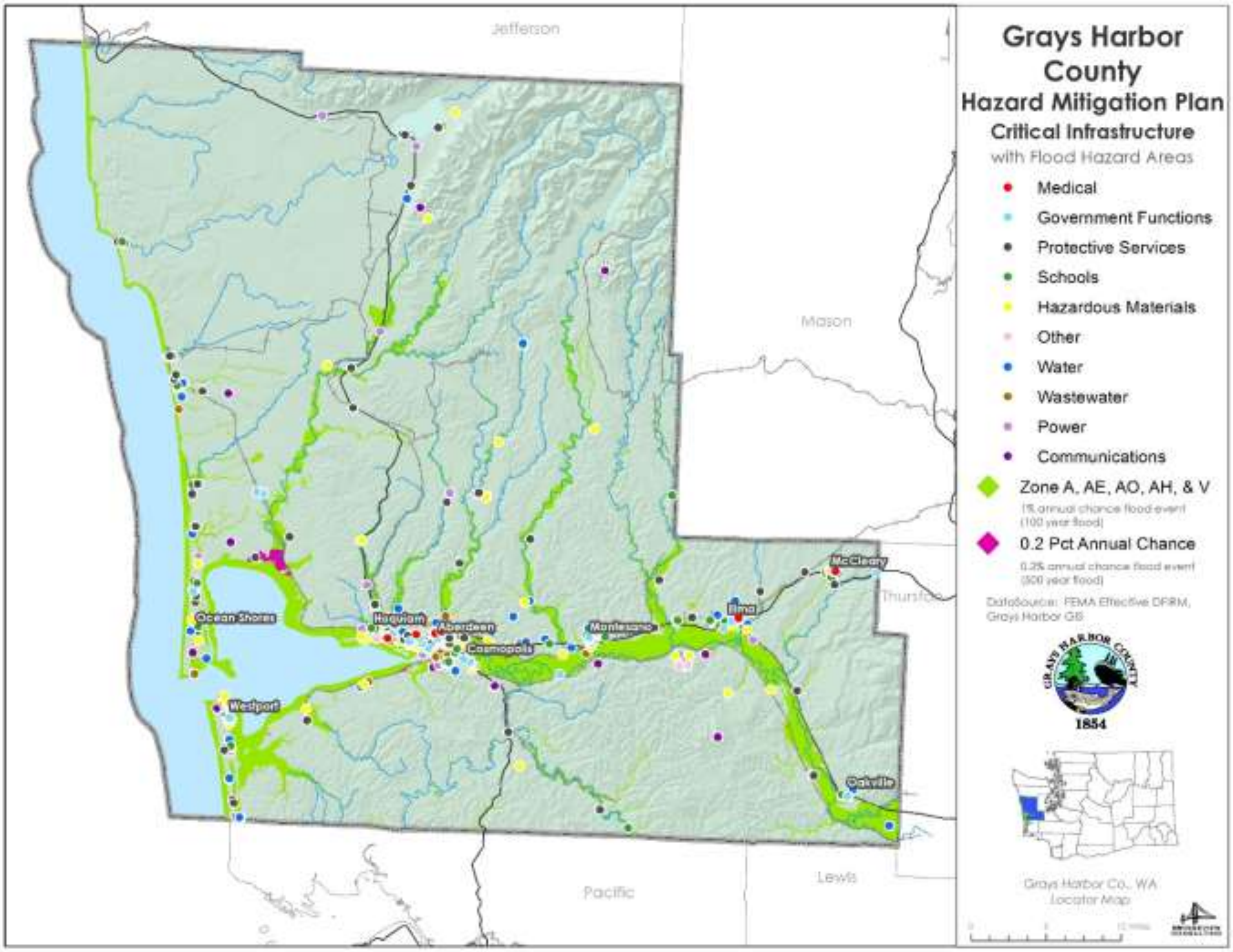


Figure 9-21 Critical Facilities Impacted in the 100- and 500-year Flood Hazard Areas

Table 9-11
Critical Facilities in the Chehalis & Wynoochee River Preliminary 100-Year Floodplain

Jurisdiction	Medical and Health Services	Government Function	Protective	Hazardous Materials	School	Other	Total
Aberdeen	0	0	0	0	0	0	**0**
Cosmopolis	0	0	0	0	0	0	**0**
Elma	0	0	0	0	0	0	**0**
Hoquiam	0	0	0	0	0	0	**0**
McCleary	0	0	0	0	0	0	**0**
Montesano	0	0	0	0	0	0	**0**

Table 9-11
Critical Facilities in the Chehalis & Wynoochee River Preliminary 100-Year Floodplain

Jurisdiction	Medical and Health Services	Government Function	Protective	Hazardous Materials	School	Other	Total
Oakville	0	0	0	0	0	0	**0**
Ocean Shores	0	0	0	0	0	0	**0**
Westport	0	0	0	0	0	0	**0**
Unincorporated	0	2	0	1	0	0	**3**
Other	0	0	0	0	0	0	**0**
Total	**0**	**2**	**0**	**1**	**0**	**0**	**3**

Table 9-12
Critical Infrastructure in the Chehalis and Wynoochee River Preliminary 100-Year Floodplain

Jurisdiction	Water Supply	Wastewater	Power	Communications	Transportation	Other	**Total**
Aberdeen	1	0	0	0	1	0	**2**
Cosmopolis	0	0	0	0	0	0	**0**
Elma	0	0	0	0	3	0	**3**
Hoquiam	0	0	0	0	0	0	**0**
McCleary	0	0	0	0	0	0	**0**
Montesano	1	0	0	0	3	0	**4**
Oakville	0	0	0	0	1	0	**1**
Ocean Shores	0	0	0	0	0	0	**0**
Westport	0	0	0	0	0	0	**0**
Unincorporated	0	0	0	0	38	0	**38**
Other	0	0	0	0	3	0	**3**
Total	**2**	**0**	**0**	**0**	**49**	**0**	**51**

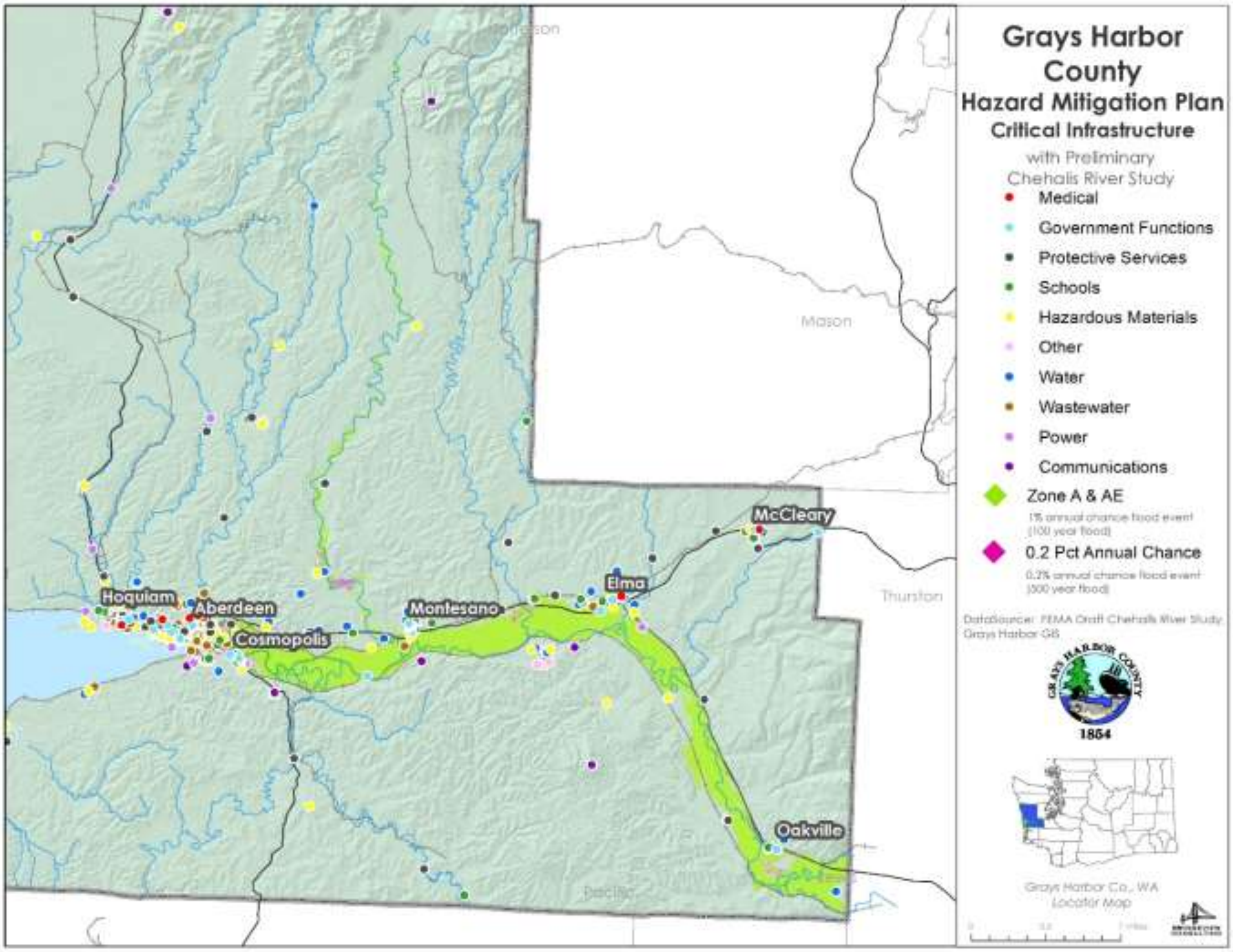


Figure 9-22 Critical Facilities Impacted in the Chehalis and Wynoochee River Preliminary Study

In cases where short-term functionality is impacted by a hazard, other facilities of neighboring municipalities may need to increase support response functions during a disaster event. Mitigation planning should consider means to reduce impact on critical facilities and ensure sufficient emergency and school services remain when a significant event occurs.

9.3.5 Impact on Economy

Impact on the economy related to a flood event in Grays Harbor County would include loss of property and associated tax revenue, as well as potential loss of businesses, including tourism. Depending on the duration between onset of the event and recovery, businesses within the area may not be able to sustain the economic loss of their business being disrupted for an extended period of time. Historical data has demonstrated that those businesses impacted by a disaster are less likely to reopen after an event. Flooding has impacts on agricultural and forestland. Agricultural land in the Chehalis River floodplain and cranberry bogs in Grayland are subject to flooding. Likewise, inundation frequently affects croplands in East County, something on which the County relies as a source of income. Forestland is also vulnerable to floods due to erosion when river and stream banks fail and overflow. Excessive historic logging within watersheds likely affected natural runoff patterns. All of these issues have the potential to impact the economy of the County and its planning partners.

9.3.6 Impact on Environment

Flooding is a natural event, and floodplains provide many natural and beneficial functions. Nonetheless, with human development factored in, flooding can impact the environment in negative ways.

Because they border water bodies, floodplains have historically been popular sites to establish settlements. Human activities tend to concentrate in floodplains for a number of reasons: water is readily available; land is fertile and suitable for farming; transportation by water is easily accessible; and land is flatter and easier to develop. But human activity in floodplains frequently interferes with the natural function of floodplains. It can affect the distribution and timing of drainage, thereby increasing flood problems. Human development can create local flooding problems by altering or confining drainage channels. This increases flood potential in two ways: it reduces the stream's capacity to contain flows, and it increases flow rates or velocities downstream during all stages of a flood event. Pollution from roads, such as oil, and hazardous materials can wash into rivers and streams. During floods, these can settle onto normally dry soils, polluting them for agricultural uses. Human development such as bridge abutments and levees, and logjams from timber harvesting can increase stream bank erosion, causing rivers and streams to migrate into non-natural courses.

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

9.4 FUTURE DEVELOPMENT TRENDS

Grays Harbor County and its planning partners are subject to the provisions of the Washington State Growth Management Act (GMA), which regulates identified critical areas. Chapter 18 of the Grays Harbor County Code identifies critical areas which are regulated by the County. Further, Article IV of the Grays Harbor County Critical Areas Protection Ordinance, which was updated in September 2017, includes regulatory authority concerning frequently flooded areas, which are defined as the FEMA 100-year mapped floodplain. The GMA establishes review and evaluation programs that monitor commercial, residential and industrial development and the densities at which this development has occurred under each jurisdiction's GMA comprehensive plan and development regulations. An evaluation is required at least every five years of the sufficiency of remaining land within urban growth areas to accommodate projected residential, commercial and industrial growth at development densities observed since the adoption of GMA plans. This buildable lands report compares planned versus actual urban densities in order to determine whether original plan assumptions were accurate. These plans exclude areas designated as "critical areas" from consideration as buildable lands due to the scope of regulations affecting them. Some floodplains in the planning area can be developed, but are subject to regulatory provisions in the codes of Grays Harbor County and its partner cities. The buildable lands analysis assumes that these regulations will discourage development from these areas. Section 3 of this plan discusses the County's land use designations, including identification of critical areas.

The floodplain portions of the planning area are regulated under the GMA and the NFIP. Development will occur in the floodplain; however, it will be regulated such that the degree of risk will be reduced through building standards and performance measures. As NFIP map updates have occurred, those updates will be utilized to further expand, modify and enhance planning efforts occurring within the County.

The County also has a separate Floodplain Management Plan (Grays Harbor County Comprehensive Zoning Ordinance No. 38, Chapter 13.07, Combining Districts), which addresses floodplain districts and floodplain management regulations, designed to control the use, alteration, modification and construction of and on lands subject to flooding.

9.5 ISSUES

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

Development has affected these natural features over time as the County developed from a wilderness to the present day. Along with development came land alternations that have been a factor in increasing the magnitude and frequency of floods in the County. Encroachment on floodplains by structures and fill material reduces carrying capacity and increases flood heights and velocities. Dams alter the hydrology of a watershed and stormwater runoff from impervious surfaces contributes to the volume and velocity of floodwater.

A worst-case scenario for a flood event within the County would be a series of storms that result in high accumulations of runoff surface water within a relatively short time period, especially when occurring simultaneous with a high-tide event. These types of events have occurred in Grays Harbor County, and have overwhelmed response capabilities within the County.

The results of such an event could again block major roads as has previously occurred, preventing critical access for residents and critical functions in portions of the planning region. High in-channel flows would cause watercourses to scour, possibly washing out roads or impacting bridges, creating more isolation problems, and further exacerbating erosion along the coastline. In the case of multi-basin flooding, repairs could not be made quickly enough to restore critical facilities and infrastructure. While human activities influence the impact of flooding events, human activities can also interface effectively with a floodplain as long as steps are taken to mitigate the activities' adverse impacts on floodplain functions.

The following flood-related issues are relevant to the planning area:

- The Wishkah, Hoquiam and Chehalis Rivers have strong tidal influences due to the low gradients and proximity to the Pacific Ocean.
- The previous lack of current flood hazard mapping was a difficult obstacle to overcome when attempting to develop a strategy for hazard prone areas in land use planning, the decision to pursue CRS, and for development of this mitigation plan. That issue, in part, was addressed when new flood maps were released and adopted by the planning area. Many of the jurisdictions also updated ordinances to address issues brought to light by the new NFIP maps.
- The risk associated with the flood hazard overlaps the risk associated with other hazards such as erosion, severe storm events, earthquake, and landslide. This provides an opportunity to seek mitigation goals with multiple objectives to reduce the risk of multiple hazards.
- Potential climate change may impact flood conditions throughout the County.

- More information is needed on flood risk with respect to structure type, year built, elevation, etc., 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 the county, cities, and the Washington Department of Transportation as it relates to flooding and flood induced issues and the potential for areas to experience isolation as a result of limited ingress and egress to certain areas of the County during storm/flooding events.
- Floodplain residents need to continue to be educated about flood preparedness, including insurance, and the resources available during and after floods. This should occur on an annual basis.
- The promotion of flood insurance as a means of protecting property from the economic impacts of frequent flood events should continue. Future outreach efforts should include the insurance industry in attendance to assist in determining the types of insurance available, and associated costs at the individual homeowner level.
- Existing floodplain-compatible uses such as agricultural and open space need to be maintained.

9.6 RESULTS

Based on review and analysis of the data, the Planning Team has determined that the probability for impact from Flood throughout the area is highly likely. The area experiences some level of flood annually, albeit not necessarily to the level of a disaster declaration. The cities of Aberdeen, Cosmopolis, and Hoquiam, and the Unincorporated Areas of Grays Harbor County have the largest percentage of buildings located in the SFHA. In addition, these three cities have the highest projected dollar losses associated with a flood event. While structural damage may vary due to flood depths and existing floodplain management regulations, there is a fairly high rate of property ownership that does not have flood insurance. Based on the potential impact, the Planning Team determined the CPRI score to be 3.1, with overall vulnerability determined to be a high level.

CHAPTER 10.
LANDSLIDE

10.1 GENERAL BACKGROUND

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

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

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

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

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

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

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

- Human activity.

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

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

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

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

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

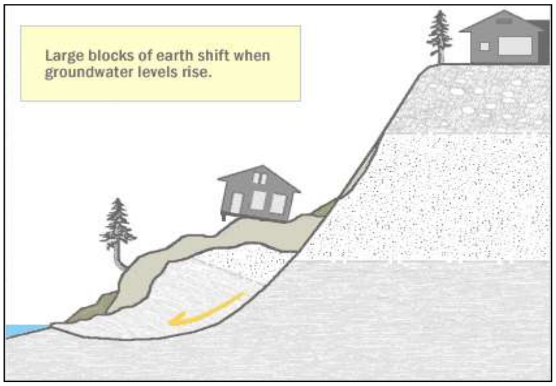


Figure 10-1 Deep Seated Slide

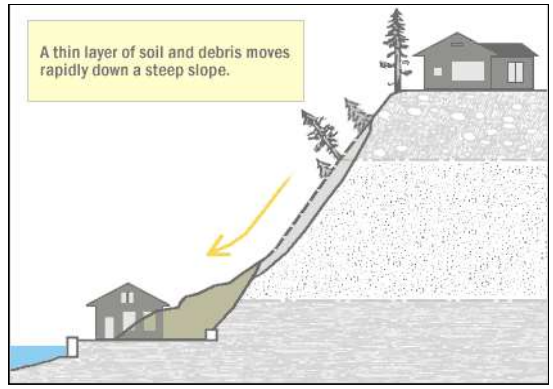


Figure 10-2 Shallow Colluvial Slide

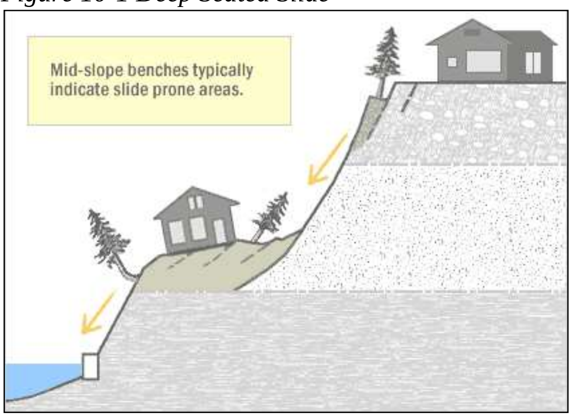


Figure 10-3 Bench Slide

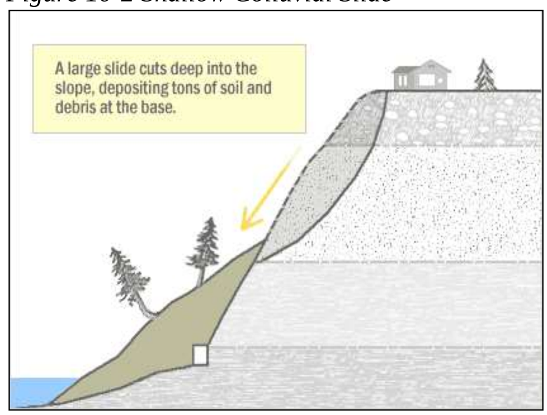


Figure 10-4 Large Slide

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

The primary types of landslides that occur in Grays Harbor County are debris flows and earth flows (GH HMP, 2011).

10.2 HAZARD PROFILE

10.2.1 Extent and Location

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

The areas most vulnerable to landslide in the County are the slopes of the Olympic range, the coastal shoreline, and Highways 101 and 12. However, landslides might occur on a moderate slope anywhere in the county if soils become saturated (GH HMP, 2011).

Generally, landslides in Grays Harbor County will develop at the base or top of a steep cut slope; on developed hillsides or coastal bluffs; from activities that disturb slopes such as construction, road building and logging; and on old existing landslides. Other factors inducing landslides can be poorly located septic systems that contribute to slope unsuitability, areas where surface water is channeled along roads and below culverts, water leakage from utilities, vegetation removal and paths or trails down a bluff leading to beach access.

The primary types of landslides that occur in the County are debris flows and earth flows. Debris flows are also called mudslides, mudflows, or debris avalanches. They are rivers of a combination of loose soil, rock, organic matter, water, and air that flow downhill. As they continue downhill they tend to grow in volume with the addition of water, soil, boulders and other materials. When the flow reaches flatter ground, it can spread over a large area. Earth flows usually occur in fine-grained materials or clay bearing rocks on moderate slopes. The slope's material liquefies and forms a bowl shape depression at the source area. Table 10-1 identifies the types and acres impacted by each landslide type as identified by WA DNR. Figure 10-5 illustrates the same information countywide.

TABLE 10-1
TYPES AND NUMBER OF LANDSLIDES AND IMPACTED AREA

LANDSLIDE TYPE	NUMBER OF RECORDED LANDSLIDES BY TYPE IN GRAYS HARBOR COUNTY	TOTAL AREA IMPACTED BY SLIDES
Debris Flow	242	291.4
Debris slide and avalanches	94	290.2
Deep-seated	939	12526.99
Deep-seated earthflow	682	2172.5
Shallow undifferentiated	2121	1479.65
Unknown	408	751.8

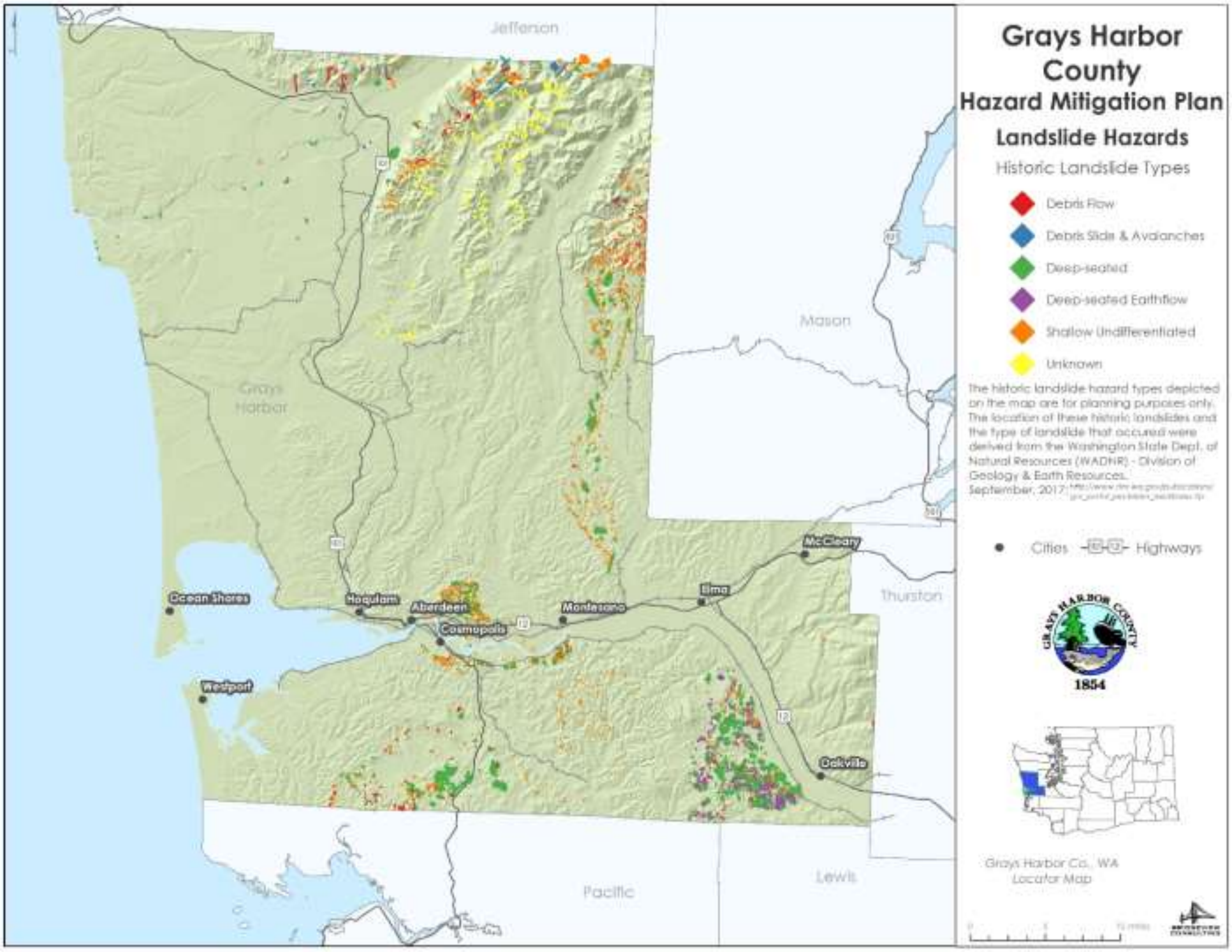


Figure 10-5 Landslide Types as Established by Washington State Department of Natural Resources

Grays Harbor has experienced significant slides in the past. Figure 10-6 through Figure 10-10 illustrate the impact on the City of Aberdeen which resulted from the January 2015 weather event causing significant landslides to occur within the city limits.

10.2.2 Previous Occurrences

Landslides within the planning area are common. Since 1964, a total of 11 weather events have included impact from landslides or mudslides. However, the County has never received a disaster declaration specifically typed *Landslide* by FEMA. Reviewers should examine the Disaster Event tables in both the Severe Weather and Flood Chapters to identify disaster-related landslide occurrences included with other hazards of concern.

There is no record of any fatality due to landslide in the County occurring, however, people have been evacuated from residences on several occasions as a result of landslides occurring. Highlights of a few of the declared events include:

- ✓ In December of 1977, there were several slides: a mudslide blocked Highway 107 south of Montesano; there was mud covering one lane on Highway 109 approximately one mile south of Pacific Beach; and small mudslides covered portions of Highway 101 south of Cosmopolis.
- ✓ In February 1982, several mudslides occurred when more than 10" of rain fell over a weekend: the Moclips Bridge on Highway 109 was damaged; and there was a massive slide blocking both lanes of Highway 12 just south of Porter. Another landslide completely blocked Highway 12 below the Aberdeen Bluff for one week in December 1996 during a period of intense snow and rainfall.
- ✓ In April 1997, a major slide blocked the flow of water at the north end of the West Fork of the Satsop River. On April 23, 1998, rain and wind caused a mudflow that blocked one lane of traffic on Highway 12 near Porter, and in November 1998 a mudslide blocked access to several homes at Lake Quinault.
- ✓ The 2006 Severe Storm event (DR1671), which caused mud and rockslides which delayed trains and blocked a number of highways in the area.
- ✓ The December 1-17, 2007 Severe Weather event which caused 12 landslides within days of the weather system starting. By December 5th, areas of the county were significantly impacted not only by flooding events, but also associated landslides, which restricted ingress and egress to the area, hampering first responders.
- ✓ The January 6-12, 2009 event caused road closures throughout the county as a result of landslides, including: Highway 12 near Devonshire Rd.

    - ➢ SR 108 at Montesano
    - ➢ Hwy 101 outside Raymond in Pacific County
    - ➢ Wynoochee Road
    - ➢ Hicklin Underpass
    - ➢ North River Road
    - ➢ Wishkah Road

One of the most significant events occurring in Grays Harbor County within recent years is associated with the January 2-5, 2015 severe storm event (not declared), which caused houses to be pushed off of their foundations and significant road closures in the City of Hoquiam (see Figures 10-6 through Figure 10-10). Utilizing the Washington State Department of Natural Resource's 2016 updated data, Figure 10-11 illustrates the areas of previous landslides, as well as areas of steep slopes of 40 percent or greater.

Figure 10-6 Highway 12 in Aberdeen at Junction City Road January 2015 Landslide
Photo taken by Jacky Spigler

Figure 10-7 Structure Impacted by January 2015 Landslide Event

Figure 10-8 Aerial image of January 2015 landslide blocking Beacon Hill Drive
Photo Source: Washington Department of Natural Resource

Figure 10-9 January 2015 Fly Over of Impact Area

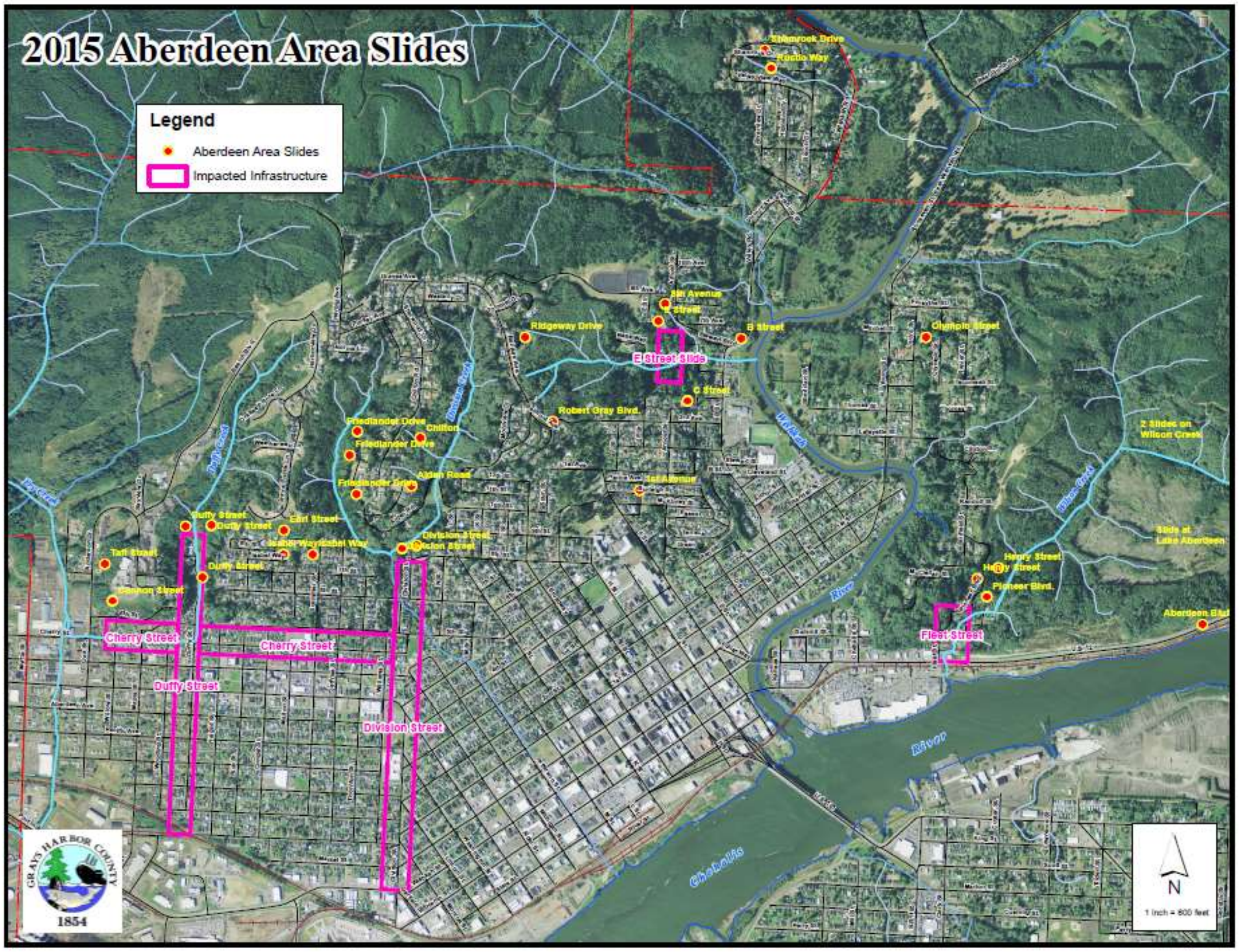


Figure 10-10 City of Aberdeen Landslide Impact January 2015

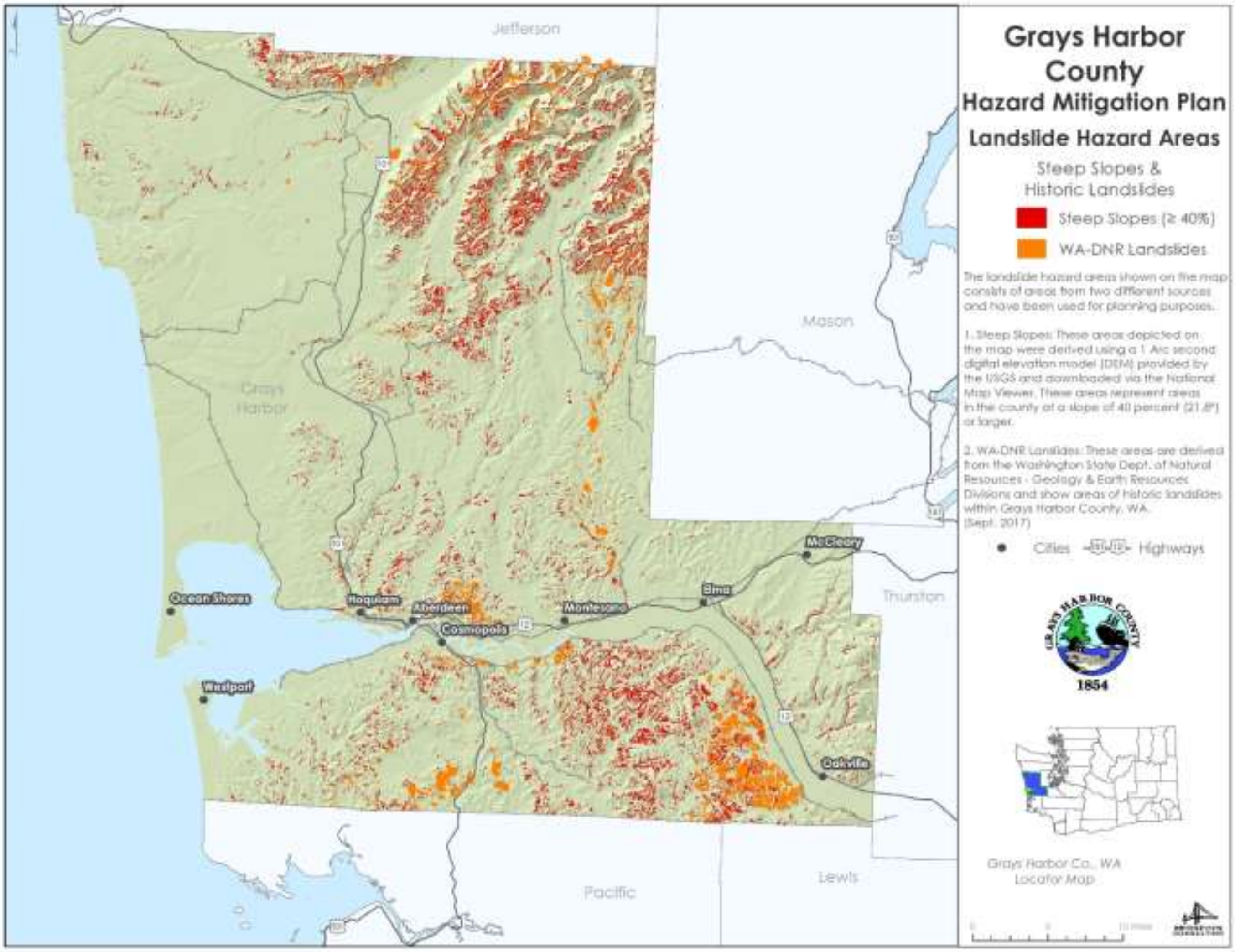


Figure 10-11 Landslide Hazard Areas

10.2.3 Severity

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

Washington is one of seven states listed by the Federal Emergency Management Agency as being especially vulnerable to severe land stability problems. Topographic and geologic factors cause certain areas of Grays Harbor County to be highly susceptible to landslides. Ground saturation and variability in rainfall patterns are also important factors affecting slope stability in area susceptible to landslides. Strong earthquake shaking can cause landslides on slopes that are otherwise stable. Figure 10-11 illustrates the Steep Slopes in Grays Harbor County which are identified with 40 percent or greater slopes – areas identified by Washington State Department of Natural Resources (WA DNR) as being more susceptible to landslide areas. This equates to approximately 27,207 acres of steep slopes within Grays Harbor County. Areas of historic landslides recorded by WA DNR equates to approximately 17,332 acres.

10.2.4 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. Landslides typically occur during and after major storms, so the potential for landslides largely coincides with the potential for sequential severe storms and flood events that saturate steep, vulnerable soils.

While the County has not received a disaster declaration specifically for a landslide, there have been 11 disaster declarations which have included mud- or land-slides which occurred in conjunction with severe storm (or flood) events over the course of the last 53 years. However, some type of landslide event occurs almost annually within the planning region. A specific recurrence interval has not been established by geologists, but historical data indicates several successive years of slide activities, followed by dormant periods.

Landslides are most likely to occur during periods of higher than average rainfall. The ground in many instances is already saturated prior to the onset of a major storm, which increases the likelihood of significant landslides to occur.

Precipitation influences the timing of landslides on three scales: total annual rainfall, monthly rainfall, and single precipitation events. 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. Studies conducted by the USGS have identified two precipitation thresholds to help identify when landslides are likely (USGS, 2007)[32]:

- Cumulative Precipitation Threshold (Figure 10-12)—A measure of precipitation over the last 18 days, indicating when the ground is wet enough to be susceptible to landslides. Rainfall of 3.5 to 5.3 inches is required to exceed this threshold, depending on how much rain falls in the last 3 days.
- Intensity Duration Threshold (Figure 10-13)—A measure of rainfall during a storm, indicating when it is raining hard enough to cause multiple landslides if the ground is already wet.

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

Review of existing data illustrates that slide events in the planning area most commonly occur from November through April, after water tables have risen. Review of historic disasters provides the following breakdown: January experienced four (4) landslides (three declared events, and the January 2015 landslides resulting from several days of rain); December historically has had the most landslide occurrences, with six (6) occurring since 1964 that have been included as an element of a disaster declaration in the county (e.g., severe weather or flood declaration which includes land- or mud-slides).

[32] USGS Landslide Hazards in the Seattle, Washington, Area. Accessed 20 Aug 2017. Available at: https://pubs.usgs.gov/fs/2007/3005/pdf/FS07-3005_508.pdf

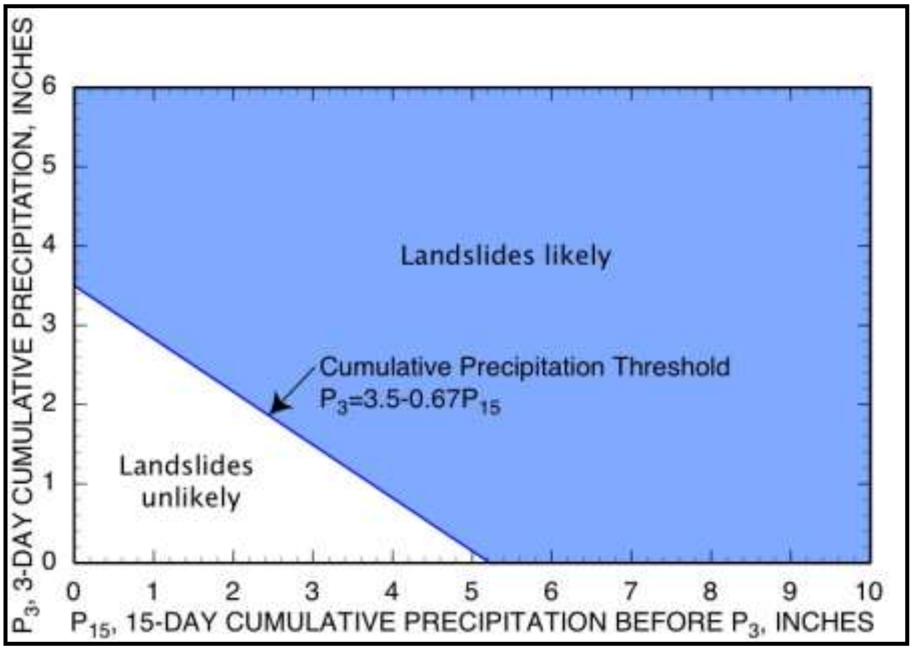


Figure 10-12 Cumulative Precipitation Threshold

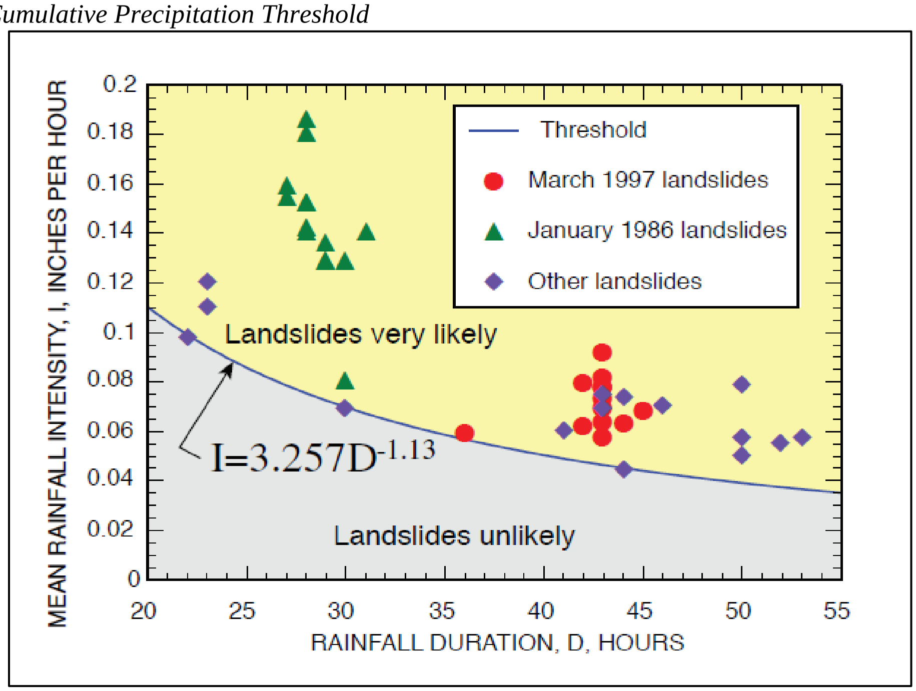


Figure 10-13 Landslide Intensity Duration Threshold

10.3 VULNERABILITY ASSESSMENT

10.3.1 Overview

Landslides have the potential to cause widespread damage throughout both rural and urban areas. While some landslides are more of a nuisance-type event, even the smallest of slides has the potential to injure or kill individuals and damage infrastructure. Given Grays Harbor County's relatively steep slopes in certain areas, its soil type, and its historical patterns of previous slide occurrences, the landslide hazard is a significant concern for the planning partners.

Review of the DNR data illustrates high areas of vulnerability in the northeastern portions of the county, which are much less urbanized. Areas within Hoquiam, Aberdeen, Cosmopolis, Montesano, and certain portions of the unincorporated areas of Grays Harbor County all have a high number of reported landslides.

Methodology

Historical occurrences, combined with analysis of the slope and the type of soil, are the most effective indicator of areas at risk to landslide. The Washington Department of Natural Resources collects data to use in determining historical events and landslide danger; however, because no damage figures have been developed for the landslide hazard, loss estimates were developed representing 10 percent, 30 percent and 50 percent of the assessed value of exposed structures.

Landslide hazard areas are those identified by Washington State DNR as having previous landslide events, and includes areas of slopes with a slope greater than or equal to 40 percent (or 21.8 degrees). This data is for mitigation planning purposes only, and should not be considered for life safety matters. No landslide hazard analysis was conducted, but rather, only reprojection of existing data. Additional landslide data is available at: http://www.dnr.wa.gov/programs-and-services/geology/geologic-hazards/landslides

Warning Time

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

Mass movements can occur suddenly or slowly. The velocity of movement may range from a slow creep of inches per year to many feet per second, depending on slope angle, material and water content. Generally accepted warning signs for landslide activity include:

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

- A faint rumbling sound that increases in volume as the landslide nears;
- Unusual sounds, such as trees cracking or boulders knocking together.

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

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

10.3.2 Impact on Life, Health, and Safety

A population estimate was made using the structure count of residential buildings within the landslide hazard areas, and applying the census value of 2.5 persons per household for Grays Harbor County. Using this approach, the population living in the landside risk area is identified in Table 10-2. It should be noted that areas identified within this document were based on existing data; no geotechnical or scientific analyses were conducted for development of this hazard mitigation plan as such analyses far exceed the intent of this document; therefore, no data should not be relied upon for life safety measures, or anything other than informing emergency managers of potential risk for planning purposes.

Table 10-2
Population and Residential Impact in Landslide Risk Area

Jurisdiction	Residential Building Count*	Population Exposed
Unincorporated Grays Harbor County	25	63
Aberdeen, City of	11	28
Cosmopolis, City of	0	0
Elma, City of	0	0
Hoquiam, City of	8	20
McCleary, City of	0	0
Montesano, City of	5	13
Oakville, City of	0	0
Ocean Shores, City of	0	0
Westport, City of	0	0
Total	**49**	**123**

For these planning purposes, risk area is defined as slopes 40% (21.8°) and above, and areas identified within WADNR mapped historic landslides. *Based on factor of 2.5 per person/household

Also to be taken into account when determining affected population are the area-wide impacts on transportation systems and the isolation of residents who may not be directly impacted but whose ability to ingress and egress is restricted, such as areas along major highways, which have a high transient population of tourists, especially during summertime months. In addition, Grays Harbor County's population of retirees may increase the level of first-responder requirements for residents whose structures were not directly impacted, but who were affected by power outages, lack of logistical support, etc. The increased level of population resulting from tourists in the area must also be considered for planning purposes by first responders. Landslides can also damage water treatment facilities, potentially harming water quality.

10.3.3 Impact on Property

Landslides affect private property and public infrastructure and facilities. The predominant land use in the planning area is single-family residential, much of it supporting multiple families. In addition, there are many small businesses in the area as well as large commercial industries and government facilities. Development in landslide hazard area is guided by building code and the critical area ordinance to prevent the acceleration of manmade and natural geological hazards, and to neutralize or reduce the risk to the property owner or adjacent properties from development activities.

For mitigation planning purposes only (not specific to the County's ordinance), the Washington State Department of Natural Resources Landslide Dataset was utilized to identify areas of historic events. In addition, slopes identified as being forty (40) percent or steeper were included in this analysis. The area and percent of the total planning area exposed to the landslide hazard in the planning area are summarized below. Data presented in these maps and tables are not a substitute for site-specific investigations by qualified practitioners. Table 10-3 identifies the area within the landslide risk, as well as the percent of the total planning area. Table 10-4 identifies dollar loss estimates based on exposed building values.

Table 10-3
Percent of Land Area in Landslide Risk Areas

Jurisdiction	Land Area in Landslide Risk (in Acres)	Percent of Total Planning Area
Unincorporated Grays Harbor County	43,332.2	3.51%
Aberdeen, City of	311.9	0.03%
Cosmopolis, City of	0.5	0.00%
Elma, City of	0	0
Hoquiam, City of	72.4	0.01%
McCleary, City of	0	0
Montesano, City of	151.1	0.01%
Oakville, City of	0	0
Ocean Shores, City of	0	0
Westport, City of	0	0
Total	43,867.6	3.56%

For these planning purposes, risk area is defined as slopes 40% (21.8°) and above, and areas identified within WADNR mapped historic landslides.

Table 10-4
Potential Building Losses in Landslide Risk Area

Jurisdiction	Estimated 2017 Population (1)	Estimated Building Count (2)	Total Building Value (Structure and contents in $) (2)	Buildings Exposed to Slopes 40% or Greater (3)				
				Buildings Exposed (2)				
				Buildings Exposed (2)	Value Structure in $ Exposed (2)	Value Contents in $ Exposed (2)	Total Value (Structure and contents in $) Exposed (2)	% of Total Value
City of Aberdeen	16,740	6,331	$1,558,813,283	96	$14,057,675	$9,595,453	$23,653,128	1.52%
City of Cosmopolis	1,660	740	$219,110,855	4	$492,540	$321,270	$813,810	0.37%
City of Elma	3,145	1,225	$345,049,384	1	$209,420	$104,710	$314,130	0.09%
City of Hoquiam	8,560	3,457	$668,170,030	40	$5,588,235	$3,903,850	$9,492,085	1.42%
City of Mccleary	1,695	664	$138,539,384	0	$0	$0	$0	0.00%
City of Montesano	4,120	1,554	$433,872,272	12	$2,035,350	$1,017,675	$3,053,025	0.70%
City of Oakville	690	331	$66,998,060	0	$0	$0	$0	0.00%
City of Ocean Shores	6,055	4,600	$1,156,337,793	0	$0	$0	$0	0.00%
City of Westport	2,115	1,291	$310,030,743	1	$185,565	$92,783	$278,348	0.09%
Unincorporated Grays Harbor County	28,190	12,816	$3,122,630,417	154	$18,798,677	$9,640,246	$28,438,923	0.91%
Other(4)	N/A	718	$177,559,756	3	$229,545	$114,773	$344,318	0.19%
Grays Harbor County	**72,970**	**33,727**	**$8,197,111,976**	**311**	**$41,597,007**	**$24,790,759**	**$66,387,766**	**0.81%**

10.3.4 Impact on Critical Facilities and Infrastructure

Figure 10-14 illustrates the proximity of the critical facilities and infrastructure to the established landslide areas. The number of identified critical facilities and infrastructure are listed in the following tables. No loss estimation of these facilities was performed due to the lack of established damage functions for the landslide hazard. Losses for the critical facilities and infrastructure exposed are included in the tables above, but not separately identified.

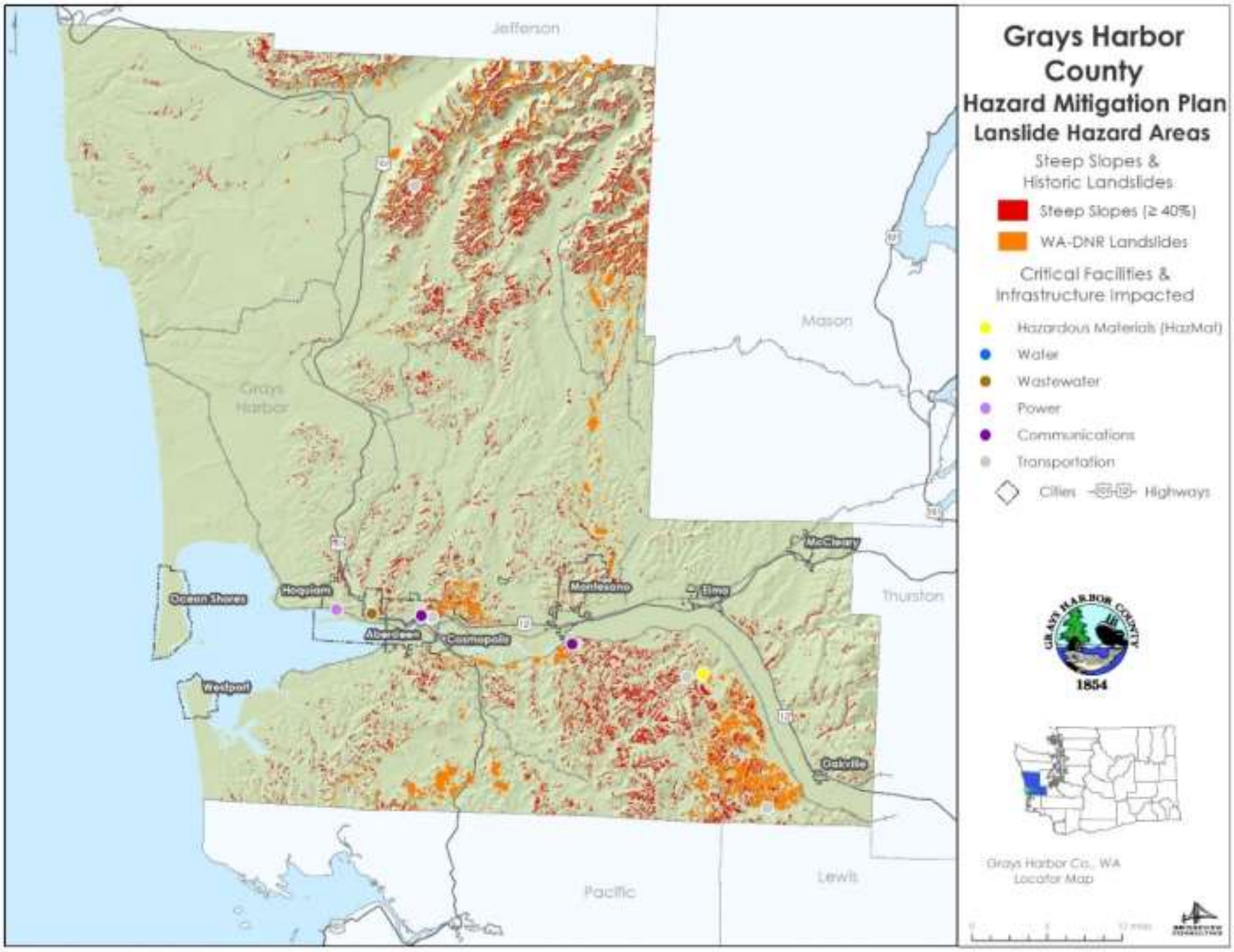


Figure 10-14 Critical Facilities and Infrastructure Exposed to Landslide Risk

Table 10-5
Critical Facilities in the Landslide Hazard Area

Jurisdiction	Medical and Health Services	Government Function	Protective	Hazardous Materials	Other	**Total**
Unincorporated	0	0	0	1	0	**1**
Aberdeen	0	0	0	0	0	**0**
Cosmopolis	0	0	0	0	0	**0**
Elma	0	0	0	0	0	**0**
Hoquiam	0	0	0	0	0	**0**
McCleary	0	0	0	0	0	**0**
Montesano	0	0	0	0	0	**0**
Oakville	0	0	0	0	0	**0**
Ocean Shores	0	0	0	0	0	**0**
Westport	0	0	0	0	0	**0**
Total	**0**	**0**	**0**	**1**	**0**	**1**

Table 10-6
Critical Infrastructure in the Landslide Hazard Area

Jurisdiction	Water Supply	Wastewater	Power	Communications	Other	**Total**
Unincorporated	0	0	0	1	3 (bridges)	**4**
Aberdeen	0	0	0	1	2 (bridges)	**3**
Cosmopolis	0	0	0	0	0	**0**
Elma	0	0	0	0	0	**0**
Hoquiam	0	1	1	0	0	**2**
McCleary	0	0	0	0	0	**0**
Montesano	0	0	0	0	0	**0**
Oakville	0	0	0	0	0	**0**
Ocean Shores	0	0	0	0	0	**0**
Westport	0	0	0	0	0	**0**
Total	**0**	**1**	**1**	**2**	**5**	**9**

Several types of infrastructure are exposed to mass movements, including transportation facilities, airports, bridges, and water, sewer and power infrastructure. Highly susceptible areas include mountain and coastal roads and transportation infrastructure. All infrastructure and transportation corridors identified as exposed to the landslide hazard are considered vulnerable until more information becomes available. Significant infrastructure in the planning region exposed to mass movements includes the following:

- **Roads**—Access to major roads is crucial to life-safety after a disaster event and to response and recovery operations. Landslides can block egress and ingress on roads, causing isolation for neighborhoods, traffic problems and delays for public and private transportation. This can result in economic losses for businesses.
- **Bridges, Marinas, and Boat/Ferry Docks**—Landslides can significantly impact road bridges, marinas, and boat/ ferry docks. Mass movements can knock out bridge and dock abutments, causing significant misalignment and restricting access and usages, as well as significantly weaken the soil supporting the structures, making them hazardous for use.
- **Power Lines**—Power lines are generally elevated above steep slopes, but the towers supporting them can be subject to landslides. A landslide could trigger failure of the soil beneath a tower, causing it to collapse and ripping down the lines. Power and communication failures due to landslides can create problems for vulnerable populations and businesses.

10.3.5 Impact on Economy

A landslide can have catastrophic impact on both the private sector and governmental agencies. Economic losses include damage costs as well as lost revenue and taxes. Damaged bridges, roadways, marinas, boat docks, municipal airports all can have a significant impact on the economy. Damages in this capacity could have a significant economic impact on not only Grays Harbor County, but also other areas of the state.

The impact on commodity flow from a significant landslide shutting down major access routes would not only limit the resources available for citizens' use, but also would cause economic impact on businesses in the area. Debris could impact cargo staging areas and lands needed for business operations. With highway 101 serving as a primary transportation route in the area, use of the highway reduces travel time between the inland Puget Sound area and the peninsula region, compared to requiring vehicles to travel much greater distances around the sound on land. Impacts would also significantly reduce the tourism industry within the County.

10.3.6 Impact on Environment

Environmental problems as a result of mass movements can be numerous. Landslides that fall into water bodies, wetlands or streams may significantly impact fish and wildlife habitat, as well as affecting water quality. Hillsides that provide wildlife habitat can be lost for prolonged periods of time due to landslides. With impact already occurring due to increased sediment loads in the floodplain, landslides could cause additional impact within the Skokomish River watersheds.

10.4 FUTURE DEVELOPMENT TRENDS

Under the Growth Management Act, the County is required to address geologic hazards within its Critical Areas Ordinance, which it does. Continued application of land use and zoning regulations, as well as implementation of the International Building Codes, will assist in reducing the risk of impact from landslide hazards.

Grays Harbor County has experienced minimal growth over the past 10 years, with some cities experiencing a decline. The region continues to attempt to expand its business base, which will increase economic vitality by providing businesses that stimulate retail sales and services and increased tourism. As a higher-than-average retirement and tourist destination for Washington, continued land use supported by regulatory authority which supports economic growth but practices smart planning will be vital. All planning partners are committed to assessing the landslide risk and developing mitigation efforts to reduce impact or enhance resiliency. There are four basic strategies to mitigate landslide risk:

- Stabilization
- Protection
- Avoidance
- Maintenance and monitoring.

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

Climate change may impact storm patterns, increasing the probability of more frequent, intense storms with varying duration which can saturate soils beyond capacity. Increase in global temperature could further exacerbate this by affecting the snowpack and its ability to hold and store water, further raising sea levels, and increasing beach erosion along the County's coastline. Warming temperatures also could increase the occurrence and duration of droughts, which would increase the probability of wildfire, reducing the vegetation that helps to support steep slopes. As parts of the County maintain fairly dense forested areas, such an incident would be significant. All of these factors would increase the probability of landslides.

10.5 ISSUES

Landslides throughout the 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 fall or early spring —months when the water tables are high. After heavy rains during October to April, soils become saturated with water. As water seeps downward through upper soils that may consist of permeable sands and gravels and accumulates on impermeable silt, it will cause weakness and destabilization in the slope. A short intense storm could cause saturated soil to move, resulting in landslides. As rains continue, the groundwater table rises, adding to the weakening of the slope. Gravity, a small tremor or earthquake, poor drainage, steep bank cutting, a rising groundwater table, and poor soil exacerbate hazardous conditions.

Mass movements are becoming more of a concern as development moves outside of urban centers and into areas less developed in terms of infrastructure. While most mass movements would be isolated events affecting specific areas, the areas impacted can be very large. It is probable that private and public property, including infrastructure, will be affected. Mass movements could affect bridges that pass over landslide prone ravines. Road obstructions caused by mass movements would create isolation problems for residents and businesses in sparsely developed areas, and impact commodity flows. Property 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; they may block ingress and egress to areas of the County, especially for areas with limited roadways.

Important issues associated with landslides throughout Grays Harbor 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 the structures were constructed to. Information to this level of detail is not currently available.
- Future development could lead to more homes in landslide risk areas.

- Portions of the County are surrounded by fairly steep banks and cliffs. Coastal erosion causes landslides as the ground washes away.
- Mapping and assessment of landslide hazards are constantly evolving. As new data and science become available, assessments of landslide risk should be re-evaluated. LiDAR data would greatly enhance the ability to determine landslide hazards, as well as other hazards.
- While the impact of climate change on landslides in general is uncertain, the impact of sea level rise caused by increased temperatures has already enhanced coastal erosion within the planning area. As climate change continues to impact atmospheric conditions, the exposure to landslide risks is likely to increase.
- Landslides cause many negative environmental consequences, including water quality degradation, degradation of fish spawning areas, and destruction of vegetation along waterways, ultimately impacting the flow of water bodies.
- 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 goals with multiple objectives that can reduce risk for multiple hazards.

10.6 RESULTS

Based on review and analysis of the data, the Planning Team has determined that the probability for impact from a landslide throughout the area is highly likely. The area experiences some level of landslides almost annually. The coastal bluff areas, and areas within the unincorporated areas of the County have identifiable landslide risk. While there are areas where no landslide risk areas are identified, landslides can nonetheless occur on fairly low slopes, and areas with no slopes can be impacted by slides at a distance. Construction in critical areas, which includes geologically sensitive areas such as landslide areas, is regulated; however, beyond the structural impact, secondary impact to infrastructure causing isolation or commodity shortages also has the potential to impact the region. Based on the potential impact, the Planning Team determined the CPRI score to be 2.95, with overall vulnerability determined to be a high level.

CHAPTER 11. SEVERE WEATHER

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

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

DEFINITIONS

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

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

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

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

Tornado— Most tornadoes have wind speeds less than 110 miles per hour are about 250 feet across, and travel a few miles before dissipating. The most extreme tornadoes can attain wind speeds of more than 300 miles per hour, stretch more than two miles across, and stay on the ground for dozens of miles They are measured using the Enhanced Fujita Scale, ranging from EF0 to EF5.

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

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

11.1 GENERAL BACKGROUND

Grays Harbor County has a predominantly maritime climate, influenced by the Pacific Ocean and the Olympic Mountain Range.

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

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

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

Thunderstorms occur up to 10 days each year over the lower elevations and up to 15 days over the mountains. Damaging hailstorms are rare in western Washington. During July and August, the driest months, two to four weeks can pass with only a few showers; however, in December and January, the wettest months, precipitation is frequently recorded on 25 days or more each month. Snowfall is light in the lower elevations and heavier in the mountains. During the wet season, rainfall is usually of light to moderate intensity and continuous over a long period rather than occurring in heavy downpours for brief periods; heavier intensities occur along the windward slopes of the mountains.

Within Grays Harbor County, severe storms hit Washington's coast during the winter, bringing heavy rains, strong winds, and high waves. Storms blow in about 70 to 100 inches of rain per year, the heaviest precipitation on the continent north of Guatemala.[33] Coastal storm winds regularly top 40 mph. The annual peak speed of 55 mph can topple chimneys, utility lines, and trees. The entire county is vulnerable to wind storms. High winds are commonplace along the coast, but not as frequently in East County (GH HMP, 2011).

11.1.2 Thunderstorms

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

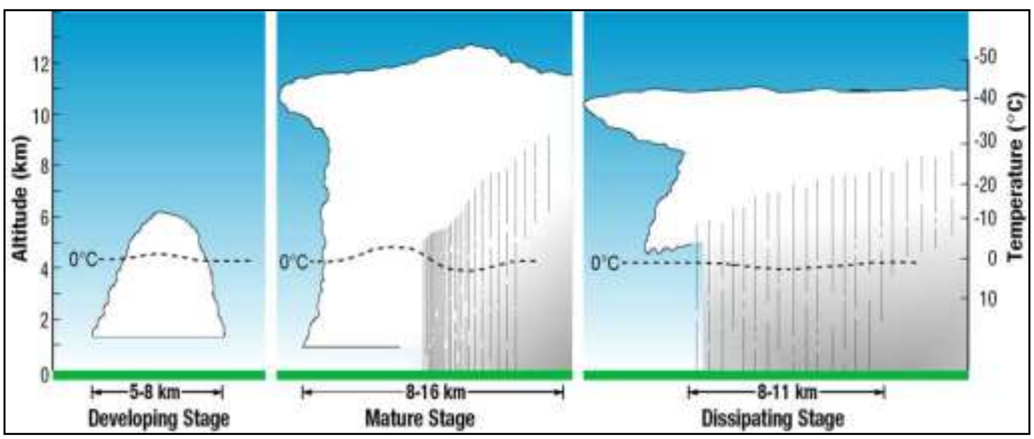


Figure 11-1 The Thunderstorm Life Cycle

[33] Washington State Department of Ecology. Accessed 10/31/2017. Available on-line at: http://www.ecy.wa.gov/programs/sea/coast/storms/weather.html

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

- **Single-Cell Thunderstorms—**Single-cell thunderstorms usually last 20 to 30 minutes. A true single-cell storm is rare, because the gust front of one cell often triggers the growth of another. Most single-cell storms are not usually severe, but a single-cell storm can produce a brief severe weather event. When this happens, it is called a pulse severe storm.
- **Multi-Cell Cluster Storm—**A multi-cell cluster is the most common type of thunderstorm. The multi-cell cluster consists of a group of cells, moving as one unit, with each cell in a different phase of the thunderstorm life cycle. Mature cells are usually found at the center of the cluster and dissipating cells at the downwind edge. Multi-cell cluster storms can produce moderate-size hail, flash floods and weak tornadoes. Each cell in a multi-cell cluster lasts only about 20 minutes; the multi-cell cluster itself may persist for several hours. This type of storm is usually more intense than a single cell storm.
- **Multi-Cell Squall Line—**A multi-cell line storm, or squall line, is a long line of storms with a continuous well-developed gust front at the leading edge. The storms can be solid, or have gaps and breaks in the line. Squall lines can produce hail up to golf-ball size, heavy rainfall, and weak tornadoes, but they are best known as the producers of strong downdrafts. Occasionally, a strong downburst will accelerate a portion of the squall line ahead of the rest of the line. This produces what is called a bow echo. Bow echoes can develop with isolated cells as well as squall lines. Bow echoes are easily detected on radar but are difficult to observe visually.
- **Super-Cell Storm—**A super-cell is a highly organized thunderstorm that poses a high threat to life and property. It is similar to a single-cell storm in that it has one main updraft, but the updraft is extremely strong, reaching speeds of 150 to 175 miles per hour. Super-cells are rare. The main characteristic that sets them apart from other thunderstorms is the presence of rotation. The rotating updraft of a super-cell (called a mesocyclone when visible on radar) helps the super-cell to produce extreme weather events, such as giant hail (more than 2 inches in diameter), strong downbursts of 80 miles an hour or more, and strong to violent tornadoes.

As Figure 11-2 illustrates, Washington ranks 50th nationwide in deaths associated with lightning strikes, having five deaths during the time period 1959-2016. Washington ranks 49th with respect to cloud-to-ground flash densities during the time period 2007-2016.[34] Annually, 30 percent of all power outages nationwide are lightning related, with total costs approaching $1 billion dollars (CoreLogic, 2015). Lightning starts approximately 4,400 house fires each year, with estimated losses exceeding $280 million.

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[34] NOAA Lightning Safety. Accessed 14 August 2017. http://www.lightningsafety.noaa.gov/stats/59-16_State_Ltg_Fatality+Fatality_Rate_Maps.pdf

Source: Vaisala, 2017

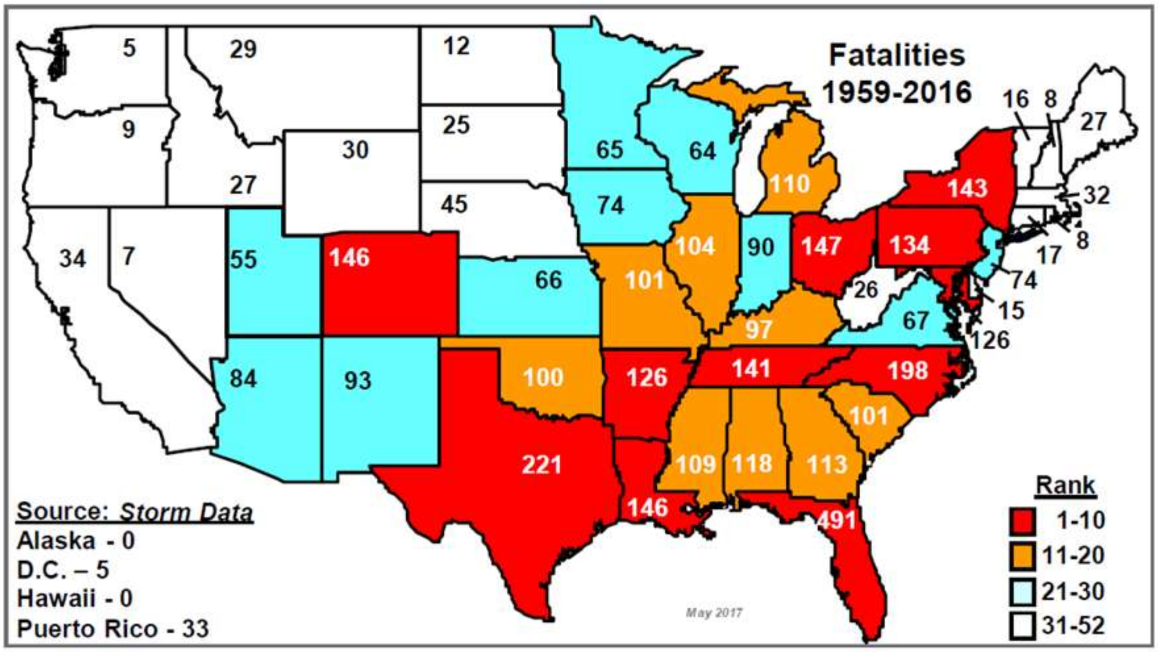


Figure 11-2 Lightening Fatalities by State, 1959-2016

11.1.3 Damaging Winds

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

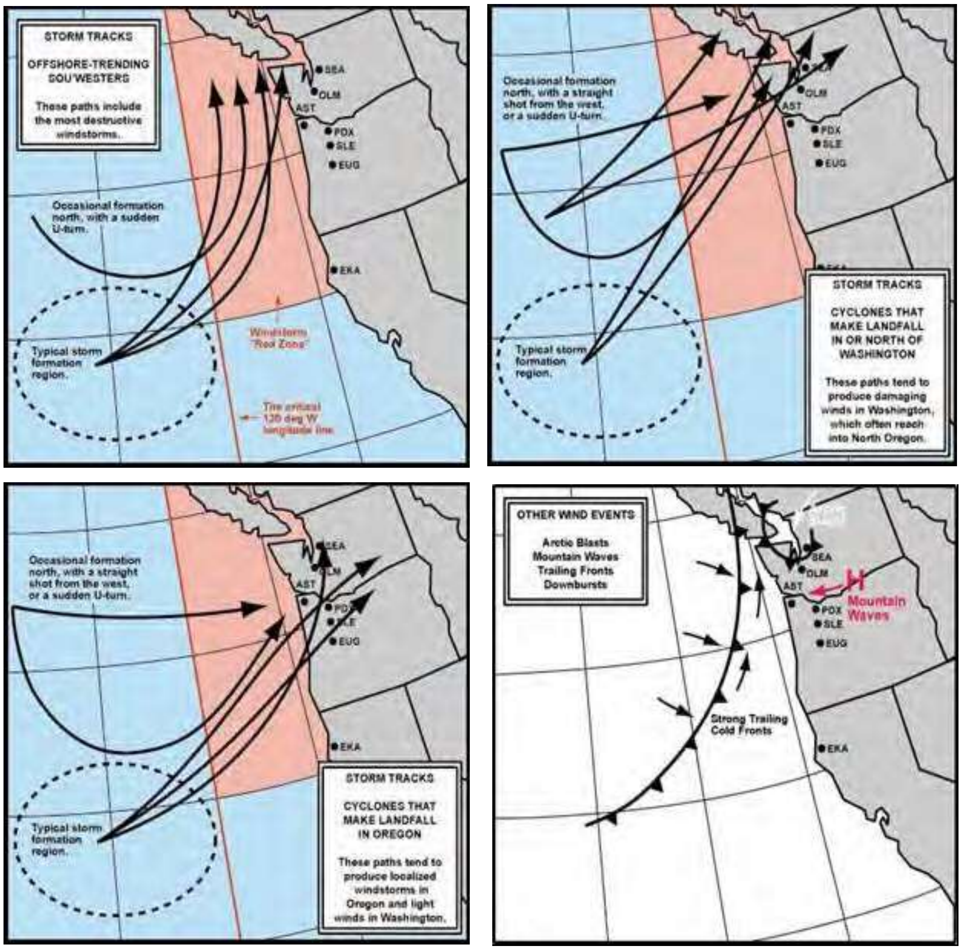
- **Straight-line winds** —Any thunderstorm wind that is not associated with rotation; this term is used mainly to differentiate from tornado winds. Most thunderstorms produce some straight-line winds as a result of outflow generated by the thunderstorm downdraft.
- **Downdrafts** —A small-scale column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

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

- **Derecho—**A derecho is a widespread thunderstorm wind caused when new thunderstorms form along the leading edge of an outflow boundary (the boundary formed by horizontal spreading of thunderstorm-cooled air). The word “derecho” is of Spanish origin and means “straight ahead.” Thunderstorms feed on the boundary and continue to reproduce. Derechos typically occur in summer when complexes of thunderstorms form over plains, producing heavy rain and severe wind. The damaging winds can last a long time and cover a large area.
- **Bow Echo—**A bow echo is a linear wind front bent outward in a bow shape. Damaging straight-line winds often occur near the center of a bow echo. Bow echoes can be 200 miles long, last for several hours, and produce extensive wind damage at the ground.

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

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



Source: Oregon Climate Service, 2015

Figure 11-3 Windstorm Tracks Impacting the Pacific Northwest

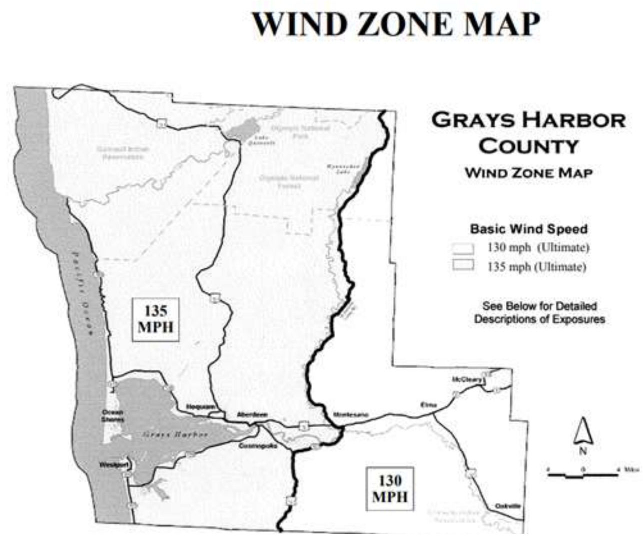


Figure 11-4 Grays Harbor County Wind Zone Map

Grays Harbor County's Wind Zone Map is featured in Figure 11-4.[35] These zones are utilized to guide structure development (2006 International Building Code). These exposure zones further identify areas that are at higher risk from impacts of high winds. The closer development is to open waters and on top of steep cliffs, the higher the design criteria that is required through building code.

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

- Surface Roughness B. Urban and suburban areas, wooded areas or other terrain with numerous closely spaced obstructions having the size of single-family dwellings or larger.
- Surface Roughness C. Open terrain with scattered obstructions having heights generally less than 30 feet (9144 mm). This category includes flat open country, grasslands, and all water surfaces in hurricane-prone regions.
- Surface Roughness D. Flat, unobstructed areas and water surfaces outside hurricane-prone regions. This category includes smooth mud flats, salt flats and unbroken ice.

11.1.4 Hail Storms

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

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

[35] http://www.co.grays-harbor.wa.us/docs/16ClimateGeographicDesignCriteria.pdf

11.1.5 Ice and Snow Storms

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

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

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

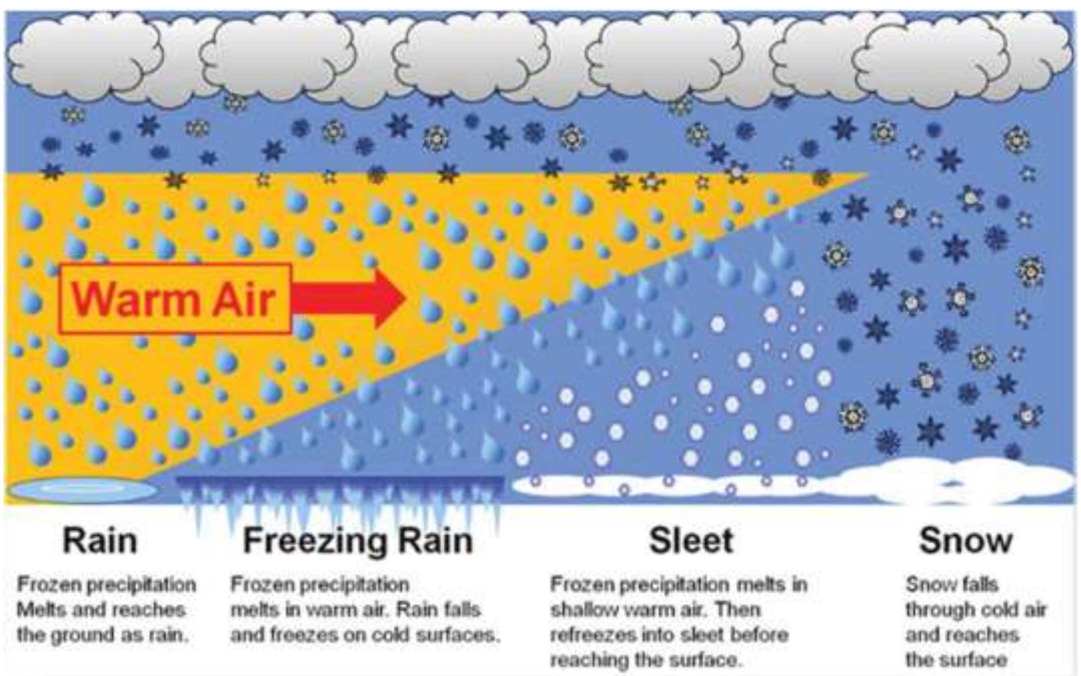


Figure 11-5 Types of Precipitation

11.1.6 Extreme Temperatures

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

Extreme Cold

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

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

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

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

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

Wind Chill (°F) $= 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$

Where, T= Air Temperature (°F) V= Wind Speed (mph) *Effective 11/01/01*

Figure 11-6 NWS Wind Chill Index

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

Extreme Heat[36]

Temperatures that hover 10 degrees or more above the average high temperature for the region and last for several days or weeks are defined as extreme heat (FEMA, 2006; CDC, 2006). An extended period of extreme heat of three or more consecutive days is typically called a heat wave and is often accompanied by high humidity (Ready America, Date Unknown; NWS, 2005). There is no universal definition of a heat wave because the term is relative to the usual weather in a particular area. The term heat wave is applied both to routine weather variations and to extraordinary spells of heat which may occur only once a century (Meehl and Tebaldi, 2004). A basic definition of a heat wave implies that it is an extended period of unusually high atmosphere-related heat stress, which causes temporary modifications in lifestyle and which may have adverse health consequences for the affected population (Robinson, 2000). Figure 11-8 identifies some of those consequences and associated temperatures. [37]

Figure 11-7 Order of St. Benedict Nuns Enjoying Summer Vacation at Grayland, Washington 1960
Photo by Tom Brownell, Courtesy MOHAI – Image 1986.6047

Certain populations are considered vulnerable or at greater risk during extreme heat events. These populations include, but are not limited to the following: the elderly age 65 and older, infants and young children under five years of age (see Figure 11-9), pregnant woman, the homeless or poor, the overweight, and people with mental illnesses, disabilities and chronic diseases (NYS HMP, 2008).

[36] Photo of Order of St. Benedict Nuns Accessed 30 Nov 2017. Available at: http://www.historylink.org/File/5630

[37] NCDC, 2000

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

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

Figure 11-8 Heat Stress Index

Wind-Chill Factor Chart (in Fahrenheit)

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

Comfortable for out door play — Caution — Danger

Heat Index Chart (in Fahrenheit %)

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

Figure 11-9 Temperature Index for Children

Figure 11-10 shows the number of weather fatalities based on 10-year and 30-year averages.[38] Extreme heat is the number one weather-related cause of death in the U.S. over the 30-year average. On average, more than 1,500 people die each year from excessive heat. Heat again ranked highest in causes of weather related deaths for the 30-year average; however, tornadoes ranked the highest for the 10-year average (2007-2016), while flood ranked the number one weather-related fatality for the year 2016.

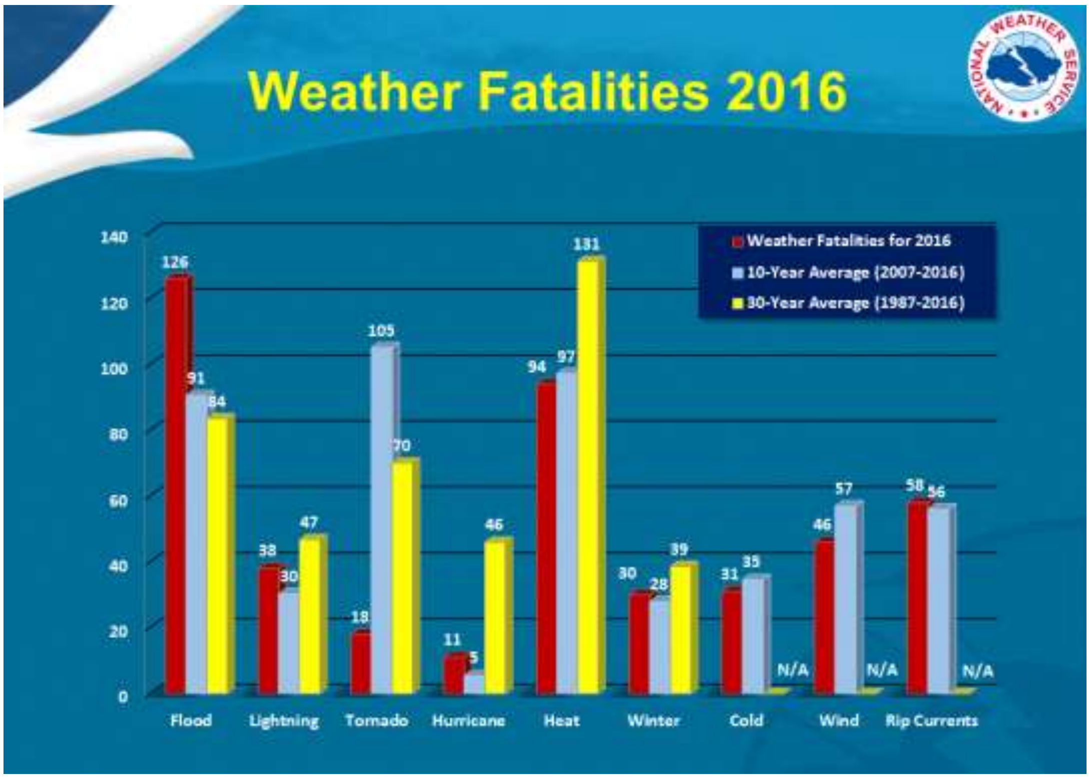


Figure 11-10 Average Number of Weather Related Fatalities in the U.S.

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

[38] NOAA, 2017 (http://www.nws.noaa.gov/om/hazstats.shtml) (Most recently available at time of update.)

11.2 HAZARD PROFILE

11.2.1 Extent and Location

The entire planning area is susceptible to the impacts of severe weather. Severe weather events customarily occur during the months of October to April, although they have occurred year round. The County has been impacted by tornadoes, strong winds (including storm surge), rain, snow (although limited), or other precipitation, and have experienced thunder or lightning storms, although rare. Considerable snowfall does not customarily occur throughout the region.

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

Severe storms and weather also affect transportation. Access across certain parts of the County is unpredictable as roads are vulnerable to damage from severe storms, storm surges, and landslide/erosion. Severe storms and storm surges can also cause flooding and channel migration.

The distribution of average weather conditions for Grays Harbor County are shown in Figure 11-11 through Figure 11-14.

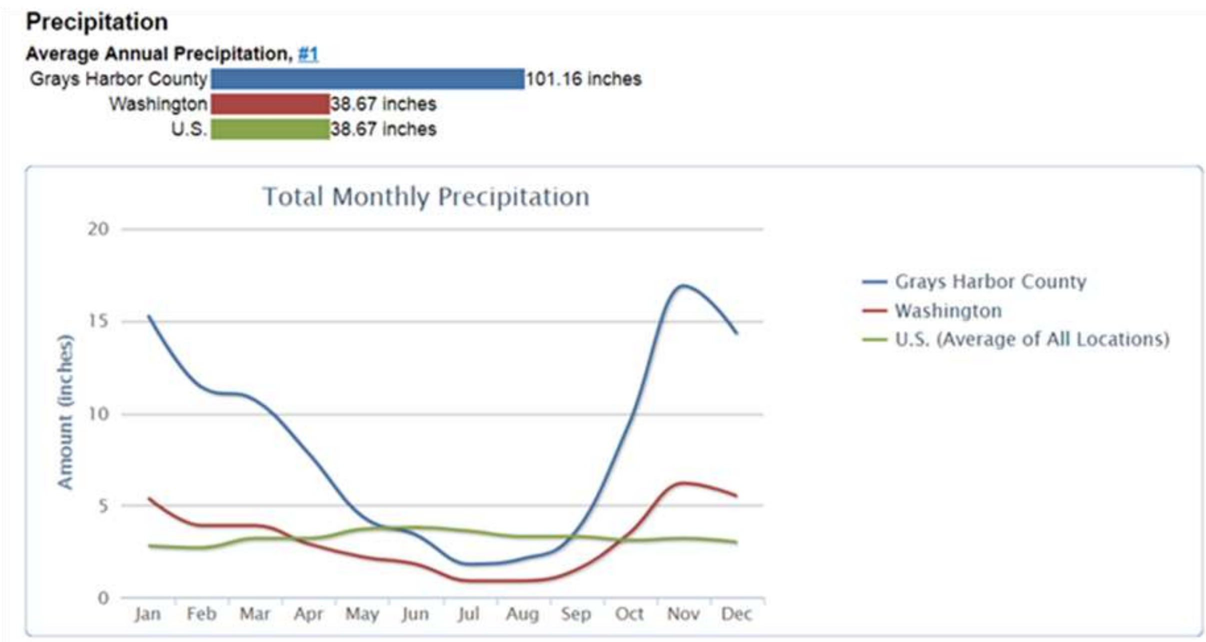


Figure 11-11 Grays Harbor County Average Annual Precipitation

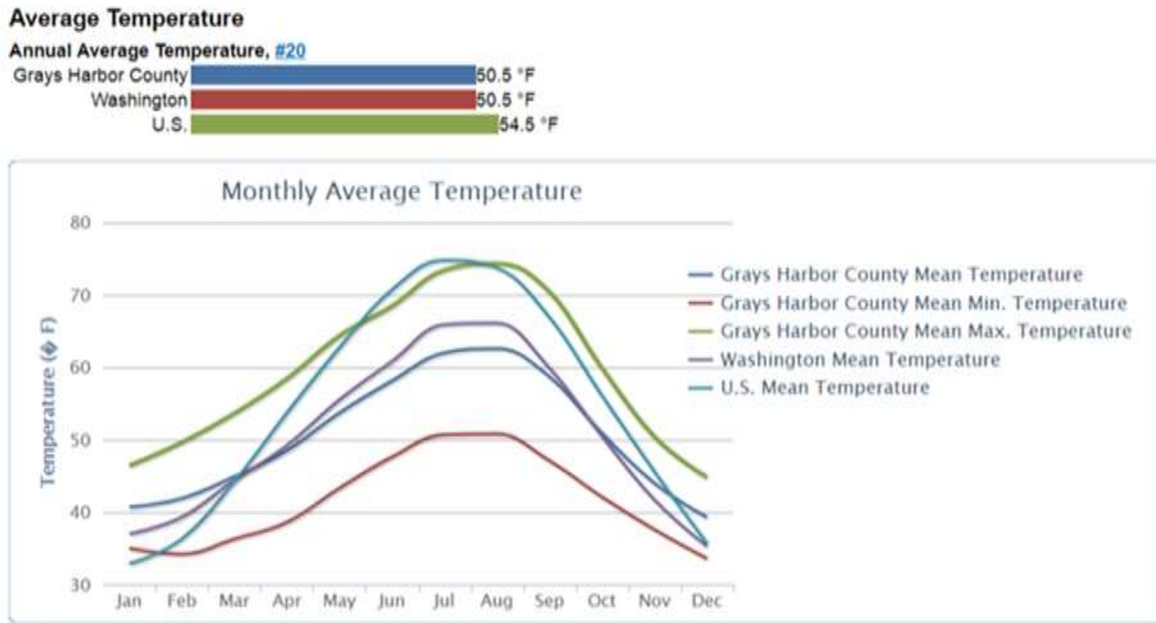


Figure 11-12 Grays Harbor County Average Temperature

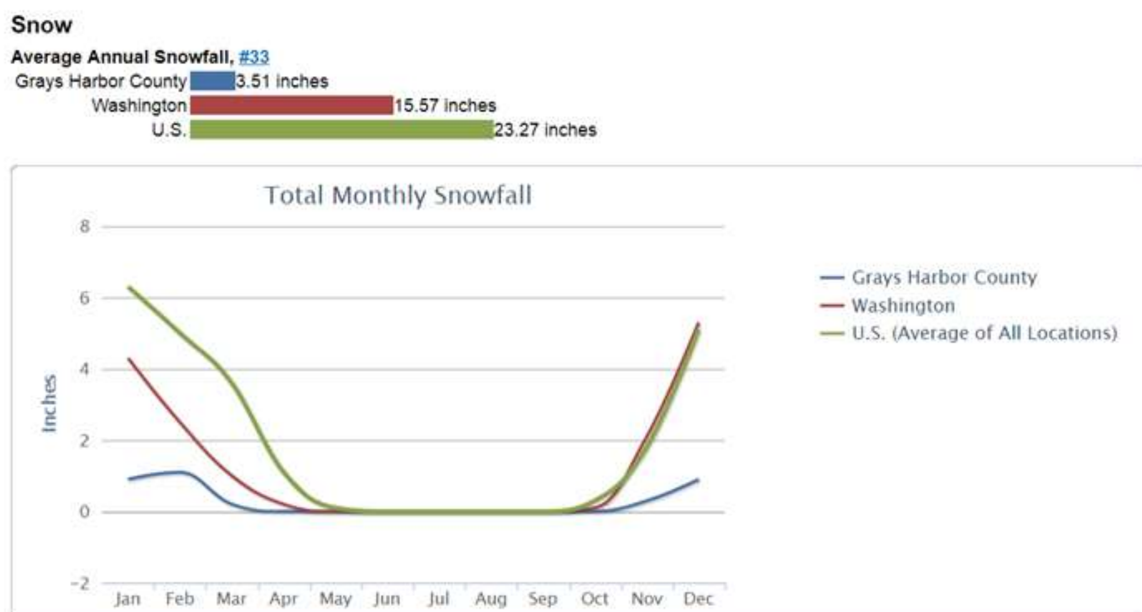


Figure 11-13 Grays Harbor County Average Snowfall

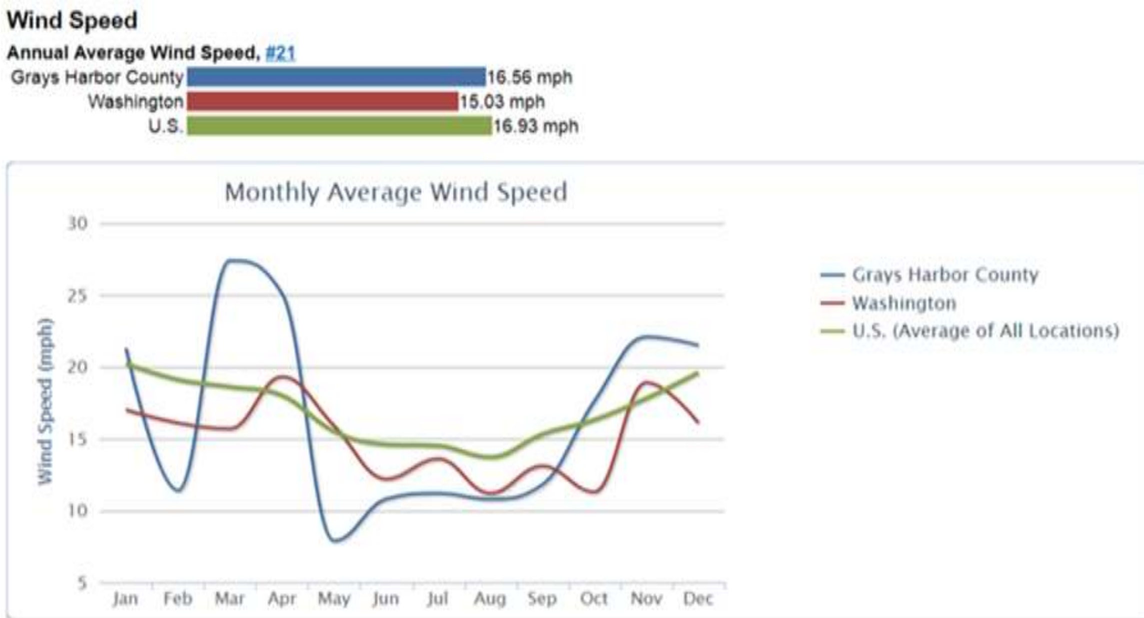


Figure 11-14 Grays Harbor County Monthly Average Wind Speed
Source: USA.com

11.2.2 Previous Occurrences

Table 11-1 summarizes severe weather events in Grays Harbor County since 1960, as recorded by the National Oceanic and Atmospheric Administration (NOAA), Spatial Hazard Events and Losses Database for the United States (SHELDUS), other local area plans, and FEMA websites.

SHELDUS utilizes a variety of NOAA data sources, and covers severe weather events from 1960 through 2000 that caused more than $50,000 in property and/or crop damage. Data obtained from the National Climatic Data Center include weather events causing more than $100,000 in property and/or crop damage from 1993 through 2003 (except June and July 1993, for which data is not available), with the following exceptions:

- Tornado information is from 1950 to 1992.
- Thunderstorm wind and hail information is from 1955 to 1992.

In addition to the federally declared events, Grays Harbor County regularly sustains impact from severe wind events which do not rise to the level of a declaration, but have significant impact on the region. Wind and associated storm effects impact a much greater area than incidents associated only with floods in most instances.

Table 11-1
Severe Weather Events Impacting Planning Area Since 1960

Date	Type	Deaths or Injuries	Property Damage
October 1962 DR 137	Wind storm	7 in Washington; 46—combined all state's impacted	$235 million in property damage; 15 billion board feet of timber valued at $750 million
Description: Most powerful non-tropical storm to impact lower 48 states. Impact felt in Washington, Oregon and California. Damaged over 50,000 buildings throughout regions impacted. Power in some areas out for 3+ weeks. Wind speeds ranged from 88 mph in Tacoma to 160 mph in Naselle, WA. There was extensive damage with power and telephone outages throughout the entire county. Trees were blown down in the North Beach area and the Markham Branch of the Northern Pacific Railroad was blocked. Many trees were blown down in Copalis beach and along the highway and the road was blocked from Montesano west to Grass Creek. An estimated 35 million board feet of timber was lost according to Wilton Vincent, Rayonier Land Department Manager. The Grays Harbor PUD facilities damage was $50,000 with total damages in the county reported to be approximately 2.5 million dollars.			
January 1993 (Disaster 981*)	(Listed as Flood Event) Severe storm and high wind	Five lives lost.	Unknown
Description: A powerful low-pressure system swept through central Western Washington, causing great destruction, numerous injuries and the loss of five lives. Winds averaging 50 miles per hour with gusts to over 100 miles per hour caused trees to fall and knocked out power to 965,000 customers. Wind gusts of 70 mph were reported at Twin Harbors. The framework for a new Washington State Dept. of Fisheries storage building at the Highway 12 and Devonshire Interchange collapsed, and a roof was torn off a mobile home in Satsop. There were widespread power outages. (*Grays Harbor County not included in declaration*.)			
November 1995 (Disaster 1079)	Flooding, severe storm, and high winds	Unknown	Unknown
Description: Heavy rains lead to flooding throughout the region.			
Dec. 1996—Jan. 1997 (Disaster 1159)	Severe winter storm, flooding, landslides and mudslides.	24 deaths statewide	Statewide: Stafford Act assistance $83 million; SBA $31.7 million; total losses $140 million statewide
Description: Saturated ground combined with snow, freezing rain, rain, rapid warming and high winds within a five-day period produced flooding and landslides. 37 counties were impacted, with large power outages throughout the impacted counties.			
October 2003 (Disaster 1499)	Severe Storm and Flooding	Unknown	Statewide losses PA >$9 million IA >$5.5 million
Description: Heavy rains, severe storms.			
January 2006 (Disaster 1641)	Severe winter storm, flood, landslide, mudslide, tidal surge	Unknown	Unknown
Description: Heavy rains			
December 2006 (Disaster 1671)	Severe winter storm, flood, landslide, mudslide, tidal surge	Unknown	Statewide PA >$29 million; IA >$5M
Description: Heavy rains from November 2 – 11, 2006 along with high tidal surge caused flooding in several Western Washington counties. Grays Harbor County was one of 11 counties to receive Individual Assistance as a result of the impact.			
December 2006 DR 1682	Severe winter storm, wind, landslides and mudslides	One fatality in McCleary	Unknown

Table 11-1
Severe Weather Events Impacting Planning Area Since 1960

Date	Type	Deaths or Injuries	Property Damage
Description: Severe winter storm caused landslides and mudslides throughout region. Grays Harbor County experienced hurricane-force winds and heavy rains on the coast causing 22,000 customers to lose power; a million were without power in the State. The "Hanukkah Eve Wind Storm of 2006" downed power lines, trees, and building debris which caused many road closures and left the county in a state of emergency. In Montesano, a roof that blew off a three-story building fell onto Pioneer Avenue, settling partially on a local bank and taking out a streetlight. Ocean Shores was also hit hard by the weather with power outages and trees across roads. A McCleary man was killed when the top of a tree snapped off in the wind and crashed into his home crushing him in his bed. A woman was injured when a gust blew a light pole down on the Chehalis River Bridge sending it crashing onto her windshield and trapping her inside her vehicle. Aberdeen's Finance Director stated damage caused by the storm could exceed $2 million; Hoquiam reported more than $400,000 in damage and another $1 million in downed trees on its watershed property.			
December 2007 (Disaster 1734)	Severe storm, flooding, landslides, and mudslides	Unknown	Unknown
Description: Severe winter storm, including record and near record snowfall and heavy rains and winds. the great Coastal Gale of December 1-3, 2007 impacted the entire western coastline from northern California to Canada. Over a period of three days, two separate storms lashed the area with hurricane-force gusts and heavy rain. The region between Newport, OR and Hoquiam, WA received the strongest gale since the great Columbus Day Storm of 1962. Figure 11-15 below compares winds speeds of the 1962 Columbus Day Storm to the 2007 event.[39]			
December 2008 (Disaster 1825)	Severe winter storm, record and near record snow	Unknown	Public Assistance to all declared counties was over $5.5 million
Description: Severe winter storm, including record and near record snowfall and heavy rains and winds.			
January 2012 (Disaster 4056)	Severe winter storm, flooding, landslides, and mudslides	Unknown	PA program only available >$30 million for impacted communities; no IA.
Description: Severe winter storm, including heavy rains, which caused flooding, landslides and mudslides.			
October 2015 (Disaster 4242)	Severe windstorm	Unknown	PA program only available >$6 million for impacted communities, no IA.
Description: A severe windstorm, including straight-line winds, impacted six counties in Western Washington on August 29, 2015.			
December 2015 (Disaster 4253)	(Listed as Flood) Severe winter storm, straight-line winds, flooding, landslides and mudslides	Unknown	PA program only available, no IA.
Description: Severe winter storm, including record and near record snowfall and heavy rains and winds.			

[39] http://www.climate.washington.edu/stormking/

Great Coastal Gale and Columbus Day Storm Events Comparison

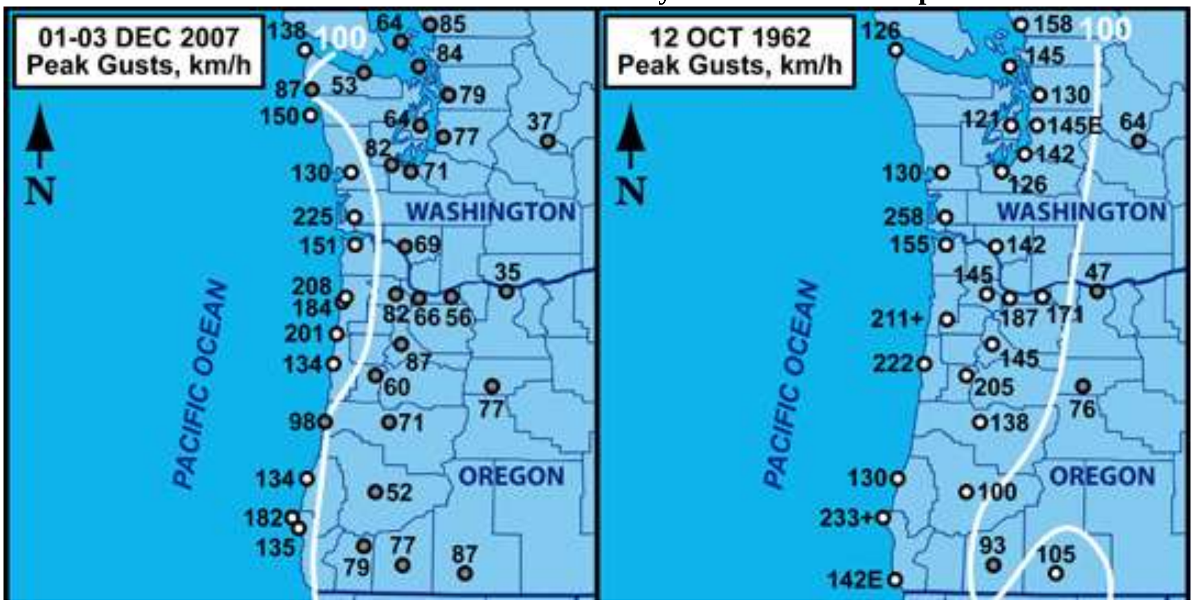


Figure 11-15 Peak Gust Comparison- 2007 Great Coastal Gale and 1962 Columbus Day Storm

Windstorms impact all of Grays Harbor County on a regular basis. The strongest winds are generally from the south or southwest and occur during fall and winter. Some are much more damaging than others.

For wind events like the Hanukkah Eve Windstorm of 2006 (see Figure 11-16), the impact on the public can be severe, and such was the case with Grays Harbor County when one of the strongest windstorms to impact the region occurred. The 1962 Columbus Day Storm has been identified as the strongest non-tropical windstorm to hit the lower 48 states. It traveled about 40 mph from Northern California to the Canadian border and east as far as Montana. The storm killed 46 people, destroyed more than 50,000 homes, left another 469,000 without power, caused $235 million in property damage and flattened 15 billion board feet of timber worth an estimated $750 million.

Figure 11-16 Hanukkah Eve Peak Wind Gusts

There was extensive damage with power and telephone outages throughout the entire county. Trees were blown down in the North Beach area and the Markham Branch of the Northern Pacific Railroad was blocked. Many trees were blown down in Copalis beach and along the highway and the road was blocked from Montesano west to Grass Creek. An estimated 35 million board feet of timber was lost according to Wilton Vincent, Rayonier Land Department Manager. The Grays Harbor PUD facilities damage was $50,000 with total damages in the county reported to be approximately 2.5 million dollars.

Severe winds also occurred during the Inauguration Day storm of 1993 (see Figure 11-17) . Five people were killed, state government was shut down, and at the height of the storm more than 750,000 residential and commercial customers were without power. Due to damages from the storm in the county, Grays Harbor was included in federal disaster declaration, #981 specified for this storm. Wind gusts of 70 mph were reported at Twin Harbors. The framework for a new Washington State Dept of Fisheries storage building at the Highway 12 and Devonshire Interchange collapsed, and a roof was torn off a mobile home in Satsop. There were widespread power outages.

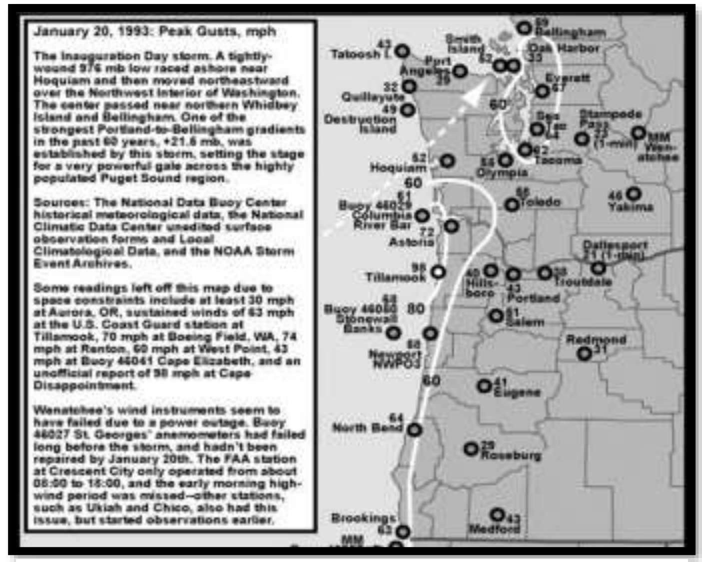


Figure 11-17 Inauguration Day Storm Peak Wind Gusts

Within Grays Harbor County, records of significant severe storm hazards date back as far as the early 1850s. For example, Henry Coonse, one of the county's early settlers, described hard wind with southerly gales together with rain, hail, snow, and ice during the winter of 1852. In 1855, Michael Luark recorded "rough, squally weather on Grays Harbor, very cold, wind blowing a gale from the northwest." P. W. Gilette claimed that the hardest wind storm in 10 years occurred late December 1862. On Christmas Day 1890 a gale blew down trees in Hoquiam (GH HMP, 2011).

Additional events which have impacted Grays Harbor County follow:

- ***The Great Blow Down***
  In January of 1921 there was a severe wind storm which became known as the "great blow down." Wind velocity on Grays Harbor was estimated at 100 mph. Ships and river craft broke loose of moorings, in some cases smashing into bridges, and whole sections of timber were blown down all along the west side of the Olympic peninsula.
- ***January 1950 Blizzard***
  The most momentous winter storm in Grays Harbor County began on December 29, 1949, and continued throughout the month of the January 1950. The winter of 1949 and 1950 is the coldest winter on record, with snow sweeping over the entire county New Year's Eve continuing throughout the next several days causing enormous damage and disruption. Snow depths ranged up to 4 inches throughout the county. Schools were closed, several Grays Harbor lumber mills were shut down, and ice flows in the south bay pounded the Elk River Bridge at Bay City. There was scattered power outage though out the county and dangerous road conditions.
- ***March 1999 Severe Weather and Storm Surge***
  On March 3, 1999, a storm surge of 4.6 feet, accompanied by 49.7 mile an hour winds, caused widespread coastal flooding. Wave heights exceeded 29.5 feet for over 5 hours, peaking at 34.8 feet. At Ocean Shores, several houses were damaged and a public restroom at North Beach was destroyed (see Figure 11-18 and Figure 11-19).[40] When wind blows toward the shore, water can pile up. Winds can raise water levels above predicted tides. Low atmospheric pressure can also cause the ocean to mound up, raising the water level.
- There have also been two tornado events, both EF 0's, and both occurring in 1997 (see Figure 11-20).

[40] http://www.ecy.wa.gov/programs/sea/coast/storms/weather.html

Figure 11-18 Restroom at North Beach Destroyed by Winter Storm Waves

Figure 11-19 March 1999 at Ocean Shores - 100 mph South Winds Combined with High Tide

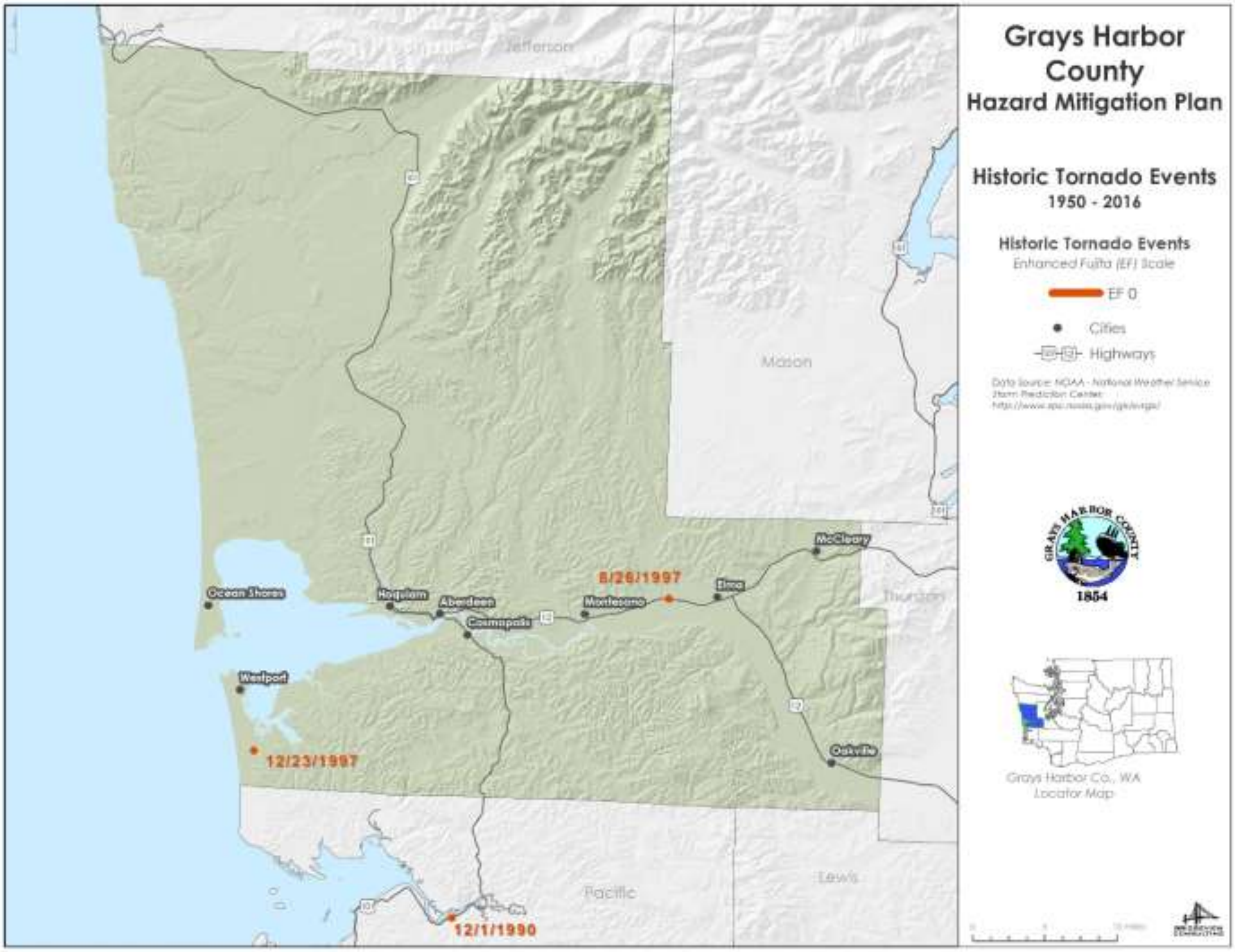


Figure 11-20 Tornado Events within Planning Region

11.2.3 Severity

The most common problems associated with severe storms are immobility and loss of utilities. Fatalities are uncommon, but have occurred. Roads become impassable due to flooding, downed trees, ice or snow, or a landslide. Power lines may be downed due to high winds, and services such as water or phone may not be able to operate without power. Lightning can cause severe damage and injury, although no such injuries have been reported within Grays Harbor County. Physical damage to homes and facilities caused by wind regularly occur. Due to the limited amount of snow customarily received in the region, even a small accumulation of ice or snow can, and has, caused havoc on transportation systems due to hilly terrain, the level of experience of drivers to maneuver in snow and ice conditions, and the lack of snow clearing equipment and resources within the region.

Ice storms, especially when accompanied by high winds, can have an especially destructive impact within the planning region, with both being able to close major transportation corridors and bridges, and also its impact on the densely wooded areas. Accumulation of ice on trees, power lines, communication towers and wiring, or other utility services can be crippling, and create additional hazards for residents, motorists and pedestrians. The County has received no disaster declarations for an ice storm event, however, the January 1950 Blizzard did create ice flows in the south bay, which impacted the Elk River Bridge at Bay City.

During the last 30 years, Western Washington has had an average annual snowfall of 11.4 inches per year, with the snowfall customarily occurring during November through March, although snow has fallen as late as April. As a coastal community, Grays Harbor County does not experience that amount of snowfall within the urban or coastal areas; however, areas within the Olympic National Forest do experience greater accumulations than in the coastal areas. Within Grays Harbor County, snowfall averages less than 1 inch, with approximately 0.4 days (averaged) per year with snow.[41] Snowfall (and rain) did contribute to a landslide event which occurred in 1996 due to increase in precipitation. Likewise, snow, followed by wind and rain, contributed to a January 1971 (DR 300) incident. Roadway conditions were impacted by the December 2008 snow/ice event.

Historical records in Western Washington are as follows:

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

Windstorms are common in the planning area, occurring many times throughout the year. The predicted wind speed given for wind warnings issued by the National Weather Service is for a one-minute average, during which gusts may be 25 to 30 percent higher. Windstorms are one of the greatest threats within the planning area, with several significant events identified.

Tornadoes are potentially the most dangerous of local storms, but they are not common in the planning area with two events occurring in 1997. If a major tornado were to strike within the planning area, damage could be widespread. As a result of building stock age, fatalities could be high, with many people homeless for an extended period of time. Routine services such as telephone or power could be disrupted. Businesses could be forced to close for an extended period, impacting commodities available for citizens. As a result of the heavily forested areas, debris accumulations would be high, causing additional difficulties with access along major arterials connecting the area to other parts of the state, further impacting logistical support and commodities.

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

On November 1, 2001, the NWS implemented a new wind chill temperature index. It was designed to more accurately calculate how cold air feels on human skin. Figure 11-6 (above) shows the new wind chill temperature index[42]. The Index includes a frostbite indicator, showing points where temperature, wind speed and exposure time will produce frostbite to humans. The chart shows three shaded areas of frostbite danger. Each shaded area shows how long a person can be exposed before frostbite develops (NWS, 2009).

[41] https://www.currentresults.com/Weather/Washington/annual-snowfall.php

[42] NWS, 2008

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

11.2.4 Frequency

The severe weather events for Grays Harbor County shown in Table 11-1 are often related to high winds and associated other winter storm-type events such as heavy rains and landslides, and to a much lesser extent, snow. The planning area can expect to experience exposure to some type of severe weather event at least annually.

Washington State Department of Ecology has estimated frequency intervals for wind speed as follows:

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

11.3 VULNERABILITY ASSESSMENT

11.3.1 Overview

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

Methodology

A lack of data separating severe weather damage from flooding, windstorms, and landslide damage prevented a detailed analysis for exposure and vulnerability. For planning purposes, it is assumed that the entire planning area is exposed to some extent to severe weather. Certain areas are more exposed due to geographic location and local weather patterns, as well as the response capabilities of local first responders.

Warning Time

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

11.3.2 Impact on Life, Health, and Safety

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

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

The National Severe Storms Laboratory states that of injuries related to ice and snow[43]:

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

A number of storm events have cut off primary access routes to areas of the County for days at a time – these storm events include both declared and non-declared incidents, as even minor incidents have the potential to impact ingress and egress. Such issues are of concern as a result of limited access for evacuation purposes by first responder if vital ALS is required, as well as for general evacuation purposes during a period where power is out, and individuals attempt to leave the area. Travel time can be increased significantly if alternate routes are used.

Power Loss

Grays Harbor PUD provides electricity to the planning area. Severe weather events can and have disrupted electricity in the planning area, on average though only a few times each year. When most power outages occur, they last for only a few hours, except in extreme outlying areas (see Figure 11-21).

Downed trees and wind storms continue to be the leading cause of power outages in Grays Harbor County, resulting in 152 service interruptions, or 77% of the utility outages in 2016. The most commonly impacted

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

areas included the north and south shores of Lake Quinault and the North River, Copalis Beach, Elma Gate and Elma McCleary Roads.

The total number of significant outages (50 or more customers) rose in 2016 to 369, but was still 19% under the five year average. Remarkably, the total customer outages fell from 83,755 in 2015 to 59,334 in 2016 while the total customer outage hours fell from 303,880 in 2015 to 171,220.

Grays Harbor PUDs have focused efforts on continued vegetation management, having established a tree trimming cycle which is assembled into the PUD's capital budget to help ensure that utility resources are directed where most needed (Dave Ward, PUD Website).

The fairly large population of retirees higher than other areas of the state, and the high rate of disabled individuals are of significant concern to the planning partners throughout the region when severe weather events occur due to the higher levels of vulnerable populations.

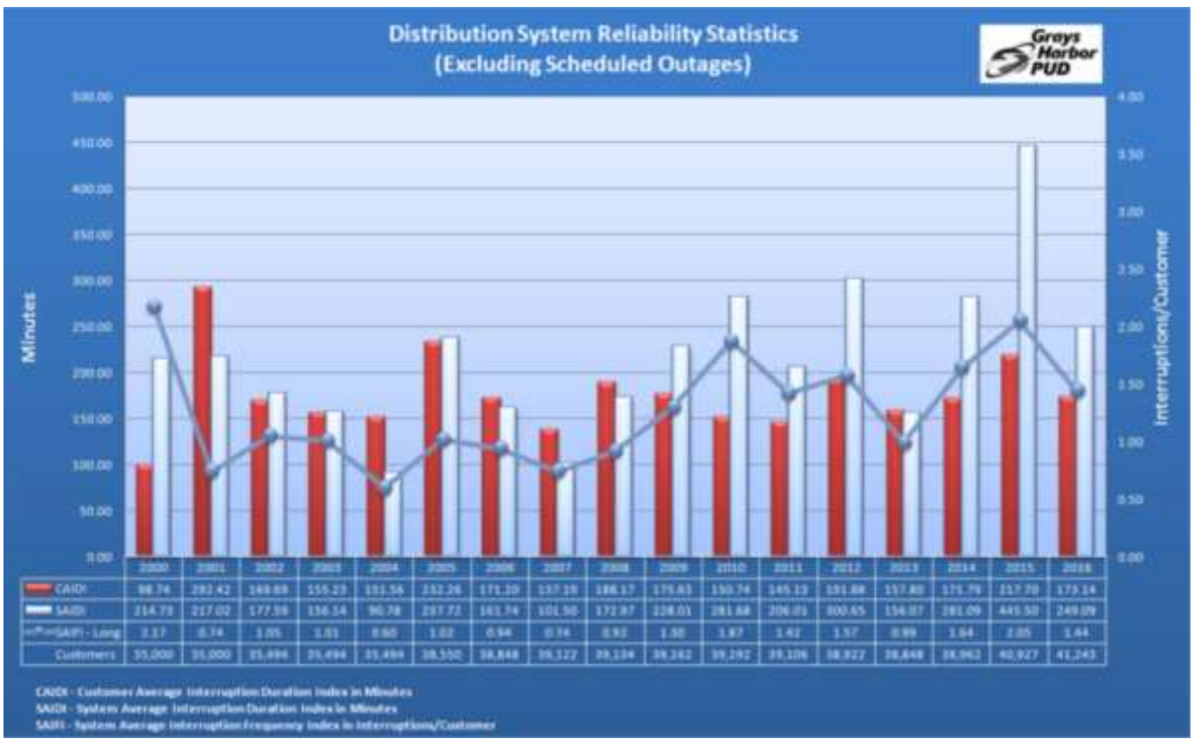


Figure 11-21 Grays Harbor PUD Annual Outage Data (2017 Annual Report)

11.3.3 Impact on Property

Currently data identifies that there are in excess of 33,000 buildings in the planning area. Most of these buildings are residential. Within Grays Harbor County, approximately 28 percent of structures were built pre-code, with the largest numbers in Aberdeen and Hoquiam, meaning a high percentage of structures in those areas could be impacted by significant weather events as many were built without the influence of a structural building code with provisions for wind loads. (See Section 3.8.2 for additional information on building stock age.)

For planning purposes, all properties and buildings within the planning area are considered to be exposed to the severe weather hazard, but structures in poor condition or in particularly vulnerable locations (hilltops or exposed open areas) may be at risk for the most damage. The frequency and degree of damage will depend on specific locations and severity of the weather pattern impacting the region. It is improbable to determine the exact number of structures susceptible to a weather event, and therefore emergency managers and public officials should establish a maximum threshold, or worst-case scenario, of susceptible structures.

Loss estimations for severe weather hazards are not based on modeling utilizing damage functions, as no such functions have been generated. Instead, loss estimates were developed representing 10 percent, 30 percent and 50 percent of the structure and content values 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 and associated inventory. Damage in excess of 50 percent is considered to be substantial by most building codes and typically requires total reconstruction of the structure. Table 11-2 shows loss estimates for potential severe weather risk by jurisdiction at the identified percent damages including both residential and non-residential structures.

Table 11-2
Potential Building Losses Due to Severe Weather Hazard

Jurisdiction	Estimated Building Count (2)	Total Exposed Value (Structure and Content)	Exposed Building and Content Values		
			10-, 30-, and 50 Percent		
			10 Percent	30 Percent	50 Percent
Aberdeen	6,331	$1,558,813,283	$155,881,328	$467,643,985.02	$779,406,641.71
Cosmopolis	740	$219,110,855	$21,911,085	$65,733,256.35	$109,555,427.25
Elma	1,225	$345,049,384	$34,504,938	$103,514,815.19	$172,524,691.98
Hoquiam	3,457	$668,170,030	$66,817,003	$200,451,009.05	$334,085,015.08
Mccleary	664	$138,539,384	$13,853,938	$41,561,815.05	$69,269,691.75
Montesano	1,554	$433,872,272	$43,387,227	$130,161,681.49	$216,936,135.82
Oakville	331	$66,998,060	$6,699,806	$20,099,418.00	$33,499,030.00
Ocean Shores	4,600	$1,156,337,793	$115,633,779	$346,901,337.97	$578,168,896.61
Westport	1,291	$310,030,743	$31,003,074	$93,009,222.99	$155,015,371.64
Unincorporated Grays Harbor County	12,816	$3,122,630,417	$312,263,042	$936,789,125.05	$1,561,315,208.42
Other (4)	718	$177,559,756	$17,755,976	$53,267,926.71	$88,779,877.85
Total	**33,727**	**$8,197,111,976**	**$819,711,198**	**$2,459,133,592.86**	**$4,098,555,988.11**

11.3.4 Impact on Critical Facilities and Infrastructure

No loss estimation of critical facilities was performed due to the lack of established damage functions for the severe weather hazard. Therefore, it should be assumed that all critical facilities are vulnerable to some degree. As many of the severe weather events include multiple hazards, information such as that identifying facilities exposed to flooding or landslides (see Flood and Landslide profiles) are also likely exposed to severe weather. Additionally, facilities on higher ground may also be exposed to wind damage or damage from falling trees. The most common problems associated with severe weather are loss of utilities. Downed power lines can cause blackouts, leaving large areas isolated. Grays Harbor PUD's annual report on the frequency and duration of power outages is identified in the graphic below.[44]

Within the planning region, Tacoma Public Utilities has one hydroelectric dam which produces a significant amount of power to areas well outside of the planning area. Major power lines travel from the Wynoochee Dam through a large swath of Grays Harbor County. As such, wind events occurring in Grays Harbor County also have the potential to impact power supplies in large metropolitan areas well outside of the county.

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

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

11.3.5 Impact on Economy

Prolonged obstruction of major routes due to severe weather can disrupt the shipment of goods and other commerce. Severe windstorms, downed trees, and ice can create serious impacts on power and above-ground communication lines. Freezing rain/snow on power and communication lines can cause them to break, disrupting electricity and communication, further impacting business within the region. Prolonged outages would impact consumer and tax base as a result of lost revenue, (food) spoilage, lack of production, etc. Large, prolonged storms can have negative economic impacts for an entire region. All severe weather events have the potential to also impact tourism, an industry on which much of the planning region is dependent.

Accommodation and food services account for 8.5 percent of the County's economy; transportation and warehousing accounts for 4.5 percent; agriculture, forestry, fishing and hunting account for 4.4 percent, while retail trade accounts for 11.3 percent (Census Data). Combined, these occupation categories account for almost 30% of the County's economy. Each of these occupation classes are highly vulnerable to impacts from severe weather events.

11.3.6 Impact on Environment

The environment is highly exposed to severe weather events. Natural habitats such as streams and trees are exposed to the elements during a severe storm and risk major damage and destruction. Prolonged rains can saturate soils and lead to slope failure. Flooding events caused by severe weather or snowmelt can produce river channel migration or damage riparian habitat, also impacting spawning grounds and fish populations for many years. Within the planning area, there are four fish hatcheries, which, if impacted, could result in

[44] Grays Harbor PUD Annual Outage Data. (2017). Accessed at: https://www.ghpud.org/outages/annual-outage-data

decreased numbers of salmon and trout in the area, as the hatcheries release the fish annually. Should this occur, this would impact the area for years to come due to the life-cycle of the returning salmon. Storm surges can erode beachfront bluffs and redistribute sediment loads. Extreme heat can raise temperatures of rivers, impacting oxygen levels in the water, threatening aquatic life.

11.4 FUTURE DEVELOPMENT TRENDS

All future development will be affected by severe storms. The ability to withstand impacts lies in sound land use practices and consistent enforcement of codes and regulations for new construction. The County does have land use regulations in place, which includes implementation of the International Building Codes as well as additional land use authority. These codes are equipped to deal with the impacts of severe weather incidents by identifying construction standards which address wind speed, roof load capacity, elevation and setback restrictions.

While under the Growth Management Act, public power utilities are required by law to supply safe, cost effective and equitable service to everyone in the service area requesting service, most lines in the area are above-ground, causing them to be more susceptible to high winds or other severe weather hazards. However, growth management is also a constraint, which could possibly lead to increased outages or even potential shortages, as while most new development expects access to electricity, they do not want to be in close proximity to sub stations. The political difficulty in sighting these sub-stations makes it difficult for the utility to keep up with regional growth.

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

11.5 ISSUES

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

- Older building stock in the planning area 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 and increased planning-region wide in order to more fully understand the vulnerabilities in this area.
- The capacity for backup power generation is limited and should be enhanced, especially in areas of potential isolation due to impact on major thoroughfares or evacuation routes.
- Isolated population centers exist.
- Climate change may increase the frequency and magnitude of winter flooding or storm surges, thus exacerbating severe winter events.
- Proximity to coastline enhances flooding potential through storm surges, as well as severe storms in general.

11.6 RESULTS

Based on review and analysis of the data, the Planning Team has determined that the probability for impact from a severe weather event throughout the area is highly likely, but the impact is more limited with respect to geographic extent when removing resulting flood and landslide events from the severe weather category. The area experiences some severe storm event annually. While snow and ice do occur, impact is somewhat limited. The more significant issue would be a severe storm which causes a landslide or flood event, isolating areas or blocking ingress and egress. Wind is a very significant factor, which can cause power outages. While the PUDs maintain excellent records for low incidents of long-term power outages, the possibility does exist. Based on the potential impact, the Planning Team determined the CPRI score to be 3.05, with overall vulnerability determined to be a high level.

CHAPTER 12.
TSUNAMI

A tsunami is a series of high-energy waves radiating outward from a disturbance. Earthquakes may produce displacements of the sea floor that can set the overlying column of water in motion, initiating a tsunami.

Tsunamis are classified as local or distant. Distant tsunamis may travel for hours before striking a coastline, giving a community a chance to implement evacuation plans. Local tsunamis have minimal warning times, leaving few options except to run to high ground. They may be accompanied by damage resulting from the triggering earthquake due to ground shaking, surface faulting, liquefaction or landslides. As a result of the high probability of a Cascadia Subduction Zone-type earthquake, occupants of many parts of Washington's coastlines have minimal time to reach high ground, in some areas only 20-30 minutes.

> **DEFINITIONS**
>
> **Tsunami—**A series of traveling ocean waves of extremely long wavelength usually caused by displacement of the ocean floor and typically generated by seismic or volcanic activity or by underwater landslides.
>
> **Tidal bore** – A tidal phenomenon in which the leading edge of the incoming tide forms a wave (or waves) of water that travel up a river or narrow bay against the direction of the river or bay's current.
>
> **Tsunami Advisory** - The purpose of a Tsunami Advisory is to keep people away from rivers, beaches, and harbors for their own personal safety. Tsunami waves during a Tsunami Advisory can also appear as "sneaker waves."
>
> **Sneaker wave –** A term used to describe disproportionately large coastal waves that can sometimes appear in a wave train without warning.

12.1 GENERAL BACKGROUND

12.1.1 Physical Characteristics of Tsunamis

All waves, including tsunamis, are defined by the following characteristics (see Figure 12-1; Earth Science, 2012):

- **Wavelength** is defined as the distance between two identical points on a wave (i.e., between wave crests or wave troughs). Normal ocean waves have wavelengths of about 300 feet. Tsunamis have much longer wavelengths, up to 300 miles.
- **Wave height** is the distance between the trough of a wave and its crest or peak.
- **Wave amplitude** is the height of the wave above the still water line; usually this is equal to 1/2 the wave height. Tsunamis can have variable wave height and amplitude that depends on water depth.
- **Wave frequency or period** is the amount of time it takes for one full wavelength to pass a stationary point.
- **Wave velocity** is the speed of a wave. It is equal to the wavelength divided by the wave period. Velocities of normal ocean waves are about 55 mph while tsunamis have velocities up to 600 mph (about as fast as jet airplanes).

Tsunamis are different from the waves most of us have observed on the beach, which are caused by the wind blowing across the ocean's surface. Wind-generated waves usually have periods of 5 to 20 seconds and a wavelength of 300 to 600 feet. A tsunami can have a period in the range of 10 minutes to 2 hours and wavelengths greater than 300 miles. Tsunamis are shallow-water waves, which are waves with very small ratios of water depth to wavelength.

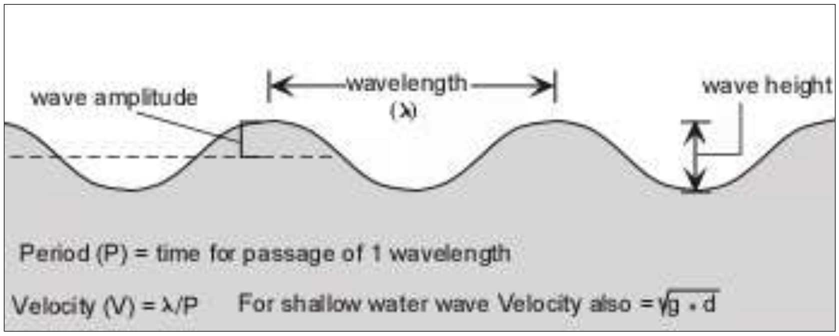


Figure 12-1 Physical Characteristics of Waves

The rate at which a wave loses its energy is inversely related to its wavelength. Since a tsunami has a very large wavelength, it loses little energy as it propagates. Thus, in very deep water, a tsunami will travel at high speeds with little loss of energy. For example, when the ocean is 20,000 feet deep, a tsunami will travel about 600 mph, and thus can travel across the Pacific Ocean in less than one day.

As a tsunami leaves the deep water of the open sea and arrives at shallow waters near the coast, it undergoes a transformation (see Figure 12-2; Earth Science, 2012). Since the velocity of the tsunami is also related to the water depth, as the depth of the water decreases, the velocity of the tsunami decreases. The change of total energy of the tsunami, however, remains constant. Furthermore, the period of the wave remains the same, so more water is forced between the wave crests, causing the height of the wave to increase.

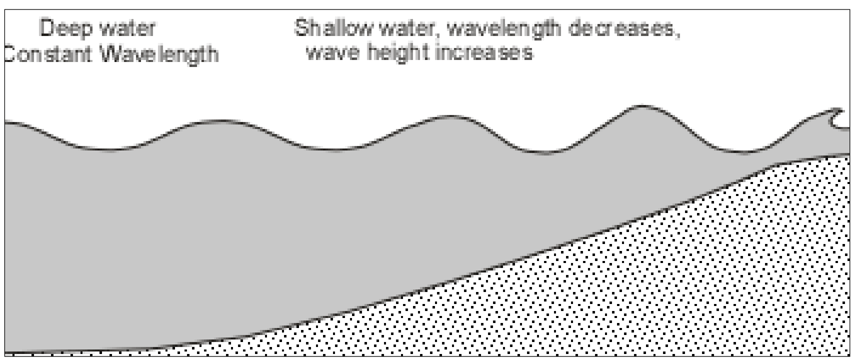


Figure 12-2 Change in Wave Behavior with Reduced Water Depth

Because of this "shoaling" effect, a tsunami that was imperceptible in deep water may grow to have wave heights of several meters. As a tsunami enters the shoaling waters near a coastline, its speed diminishes, its wavelength decreases, and its height increases greatly. The first wave usually is not the largest. Several larger and more destructive waves often follow. As tsunamis reach the shoreline, they may take the form of a fast-rising tide, a cresting wave, or a bore (a large, turbulent wall-like wave). The bore phenomenon resembles a step-like change in water level that advances rapidly (from 10 to 60 miles per hour).

The configuration of the coastline, the shape of the ocean floor, and the characteristics of advancing waves play roles in the destructiveness of tsunamis. Offshore canyons can focus tsunami wave energy and islands can filter the energy. The orientation of the coastline determines whether the waves strike head-on or are refracted from other parts of the coastline. A wave may be small at one point on a coast and much larger at other points. Bays, sounds, inlets, rivers, streams, offshore canyons, islands, and flood control channels may cause various effects that alter the level of damage. It has been estimated, for example, that a tsunami wave entering a flood control channel could reach a mile or more inland, especially if it enters at high tide.

The first indication of a tsunami to reach land may be a trough—called a drawdown—rather than a wave crest. The water along the shoreline recedes dramatically, exposing normally submerged areas. Drawdown is followed immediately by the crest of the wave, which can catch people observing the drawdown off guard. Rapid drawdown can create strong currents in harbor inlets and channels that can severely damage coastal structures due to erosive scour around piers and pilings. As the water's surface drops, piers can be damaged by boats or ships straining at or breaking their mooring lines. The vessels can overturn or sink due to strong currents, collisions with other objects, or impact with the harbor bottom.

Conversely, the first indication of a tsunami may be a rise in water level. The advancing tsunami may initially resemble a strong surge increasing the sea level like the rising tide, but the tsunami surge rises faster and does not stop at the shoreline. Even if the wave height appears to be small, 3 to 6 feet for example, the strength of the accompanying surge can be deadly. Waist-high surges can cause strong currents that float cars, small structures, and other debris. Boats and debris are often carried inland by the surge and left stranded when the water recedes.

When the crest of the wave hits, sea level rises (called run-up). Run-up is usually expressed in height above normal high tide. Run-ups from the same tsunami can vary with the shape of the coastline. One coastal area may see no damaging wave activity while in another area destructive waves can be large and violent. The flooding of an area can extend inland by 1,000 feet or more, covering large areas of land with water and debris. Tsunami waves tend to carry loose objects and people out to sea when they retreat. Tsunamis may reach a vertical height onshore above sea level, called a run-up height, of 100 feet.

At some locations, the advancing turbulent wave front will be the most destructive part of the wave. In other situations, the greatest damage will be caused by the outflow of water back to the sea between crests, sweeping all before it and undermining roads, buildings, bulkheads, and other structures. This outflow action can carry enormous amounts of highly damaging debris with it, resulting in further destruction. Ships and boats, unless moved away from shore, may be dashed against breakwaters, wharves, and other craft, or be washed ashore and left grounded after the withdrawal of the seawater.

Because the wavelengths and velocities of tsunamis are large, their period is also large. It may take several hours for successive crests to reach the shore. (For a tsunami with a wavelength of 125 miles traveling at 470 mph, the wave period is about 16 minutes). Thus people are not safe after the passage of the first large wave, but must wait several hours for all waves to pass. The first wave may not be the largest in the series of waves. For example, in several recent tsunamis, the first, third, and fifth waves were the largest.

12.2 HAZARD PROFILE

12.2.1 Extent and Location

Tsunamis affecting Washington may be induced by local geologic events or earthquakes at a considerable distance, such as in Alaska or South America. Approximately 80 percent of tsunamis originate in the Pacific Ocean and can strike distant coastal areas in a matter of hours, such as the 2011 earthquake and ensuing tsunami occurring in Japan which impacted Washington's coastlines, including within the planning area.

Most recorded tsunamis affecting the Pacific Northwest originated in the Gulf of Alaska. The landslide-generated tsunami in Lituya Bay, Alaska in 1958 produced a 200-foot-high wave. There is also geological evidence of significant impacts from tsunamis originating along the Cascadia subduction zone, which extends from Cape Mendocino, California to the Queen Charlotte Islands in British Columbia.

The Washington Department of Natural Resources (WDNR) mapped the tsunami risk zone in the vicinity of the Grays Harbor County, identifying the various depths shown on Figure 12-3 (WDNR, 2000). WDNR also prepared a series of evacuation maps illustrated in Figure 12-4. Due to the size of the map(s), details are difficult to read; therefore, a link to review the displayed data is provided: http://www.co.grays-harbor.wa.us/departments/emergency_management/tsunami_evacuation_maps.php

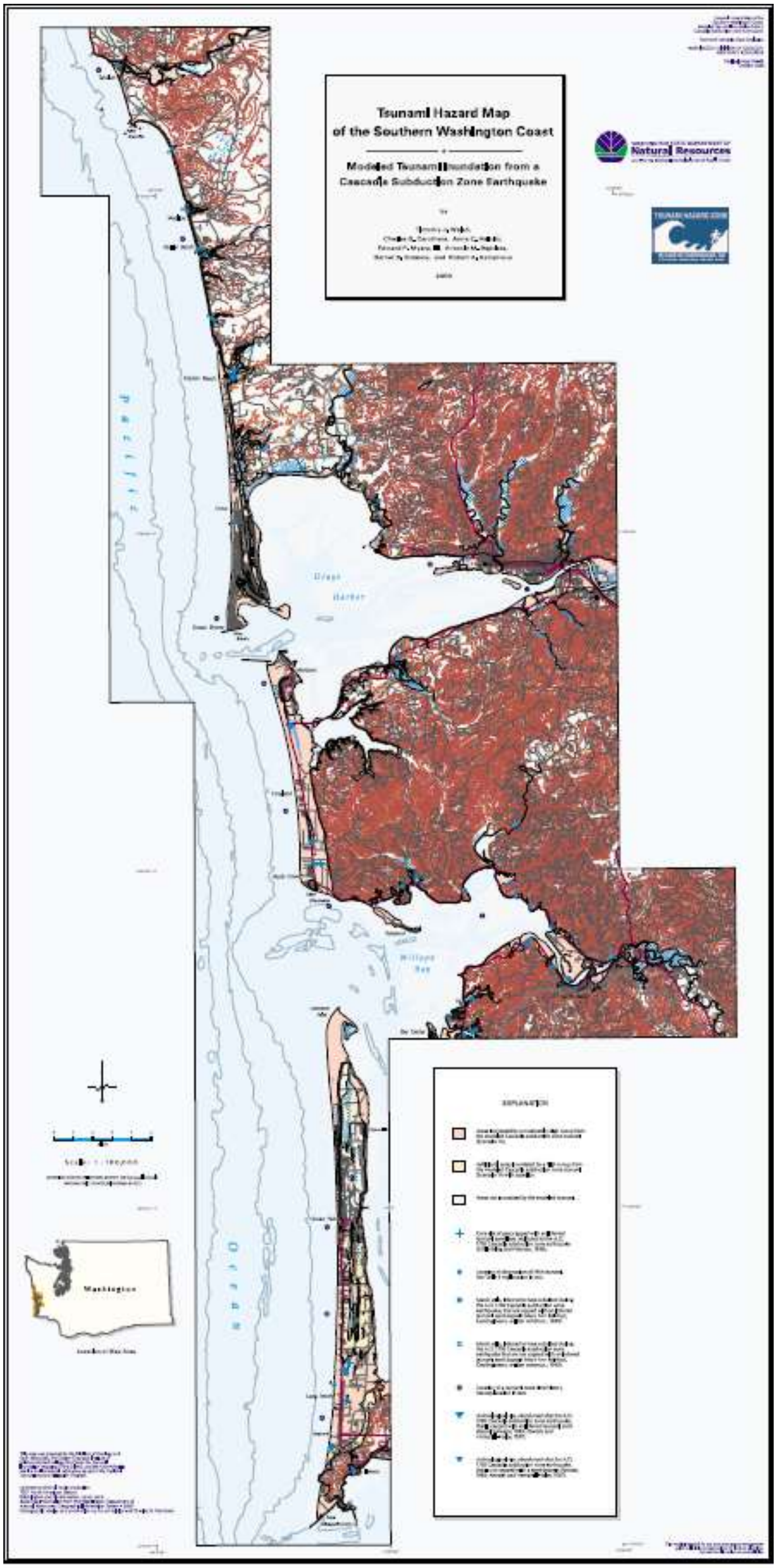
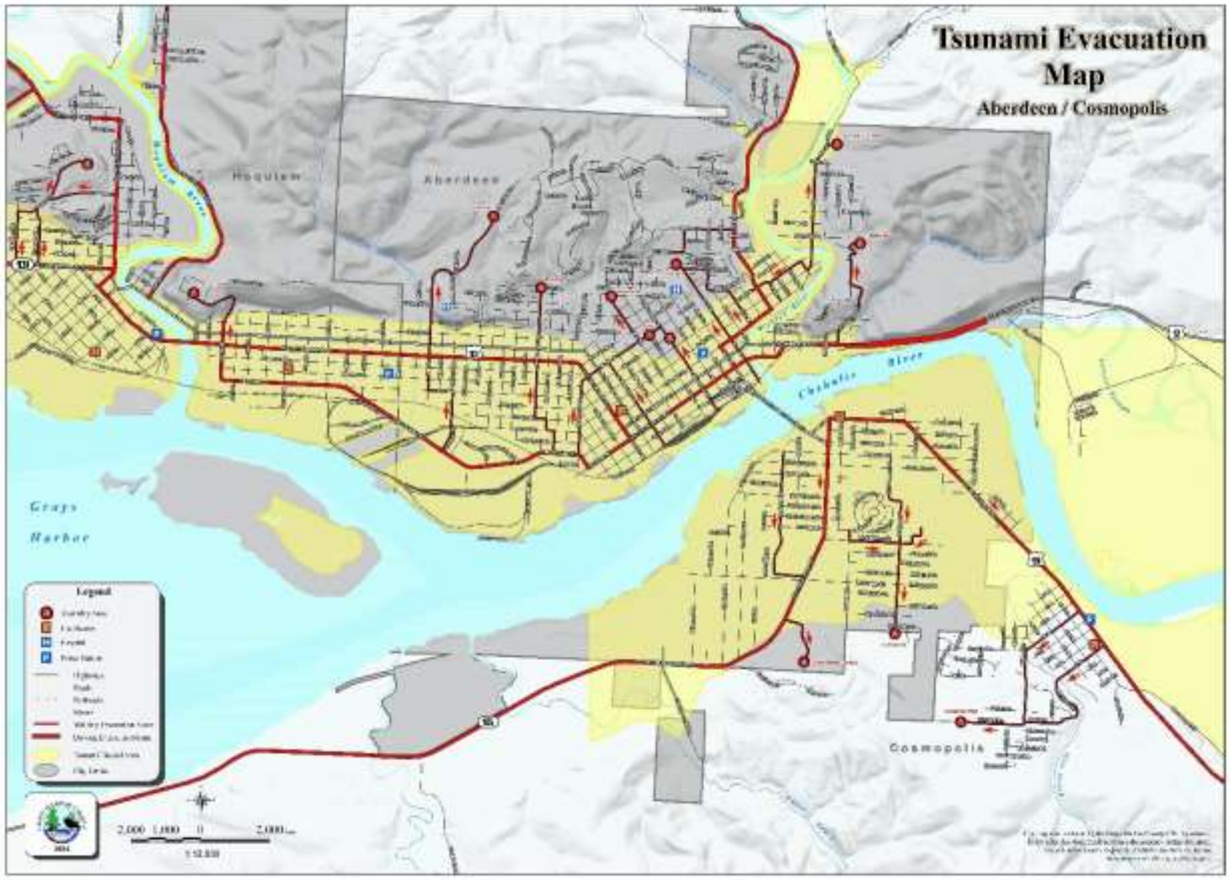
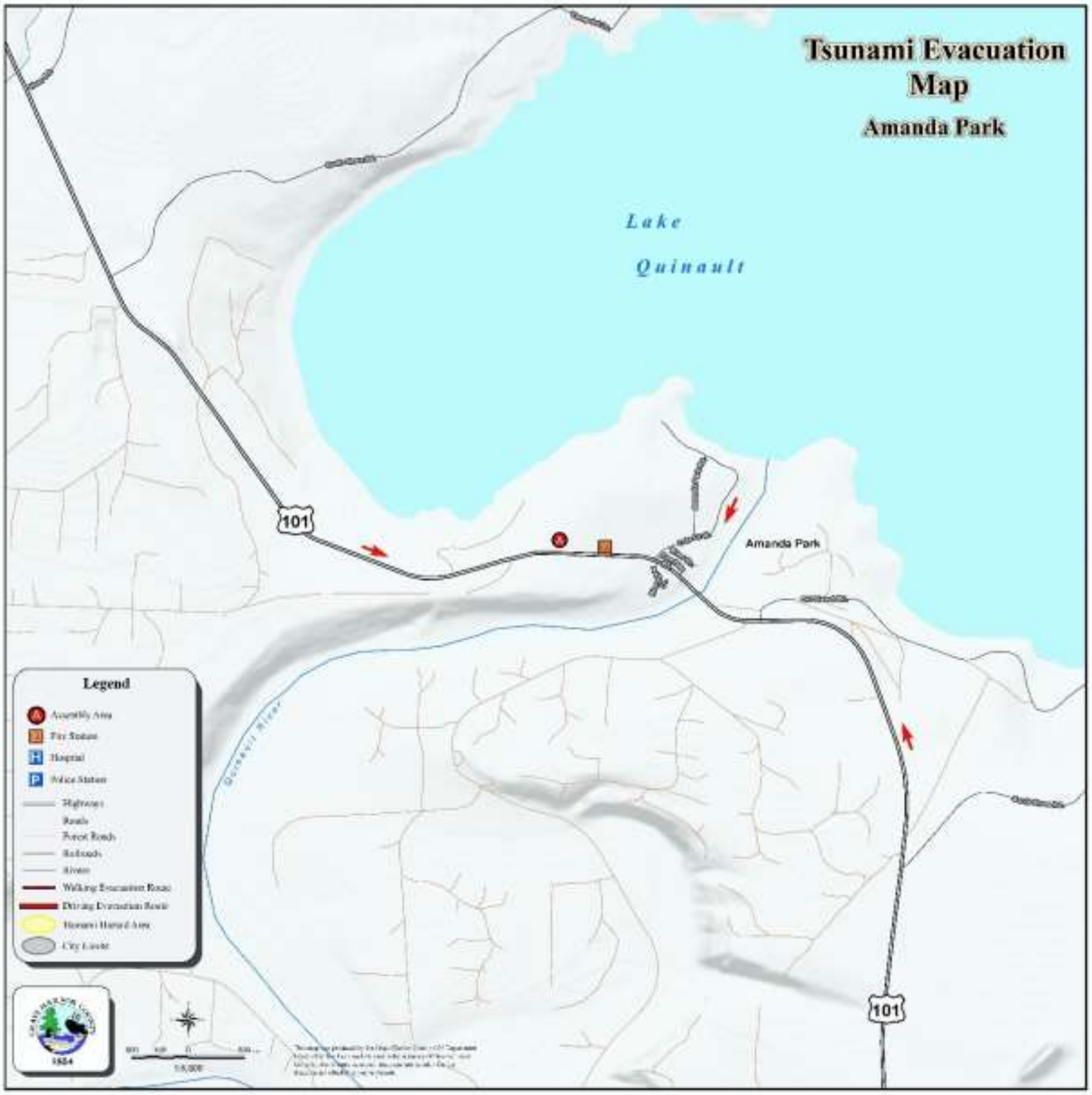


Figure 12-3WDNR Tsunami Hazard Map

Figure 12-4 Washington DNR Tsunami Evacuation Map Series for Grays Harbor County



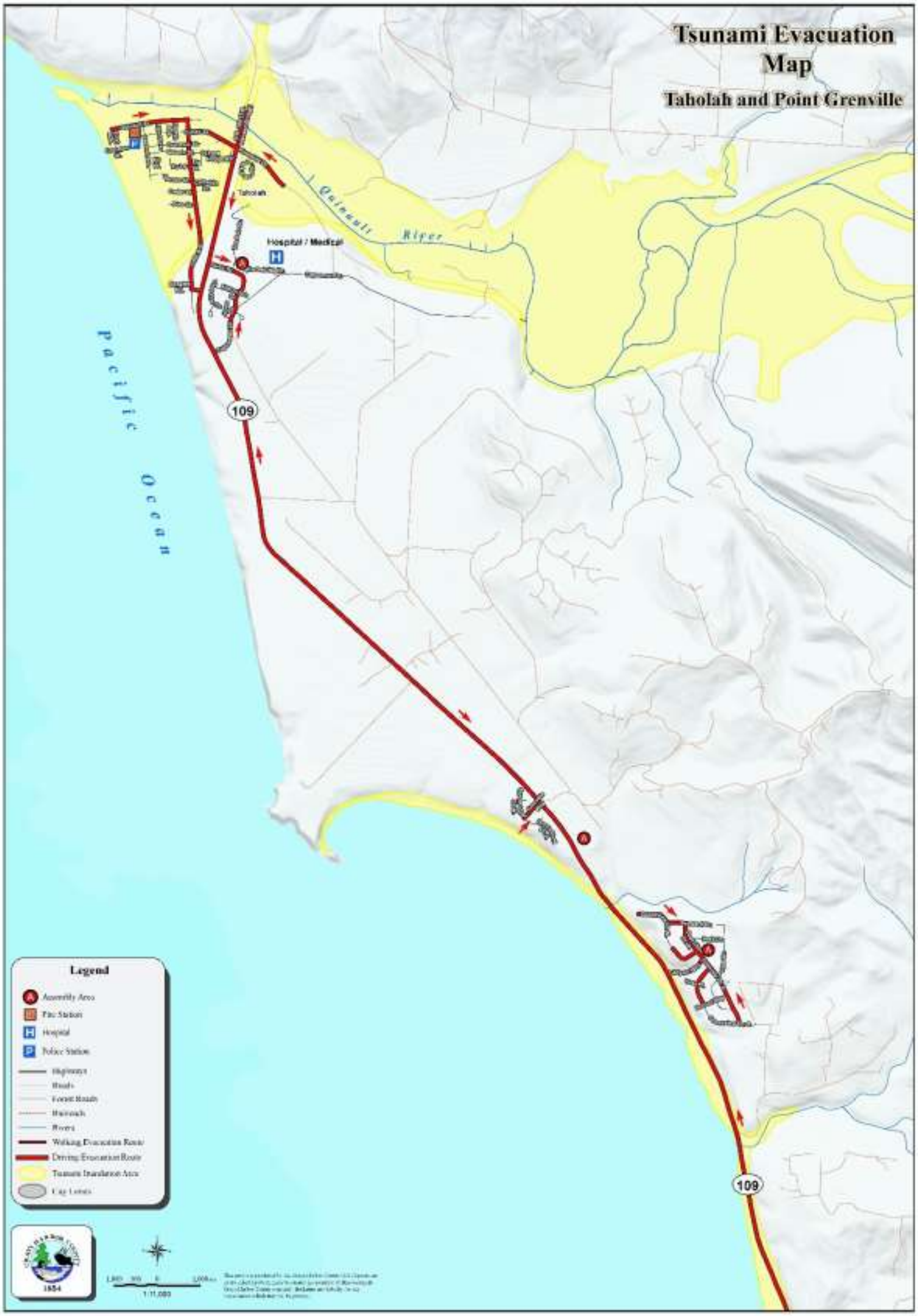

Tsunami Evacuation Map
Amanda Park
Lake Quinault
Amanda Park
101
101
Legend
Assembly Area
Fire Station
Hospital
Police Station
Highways
Roads
Forest Roads
Railroads
Rivers
Walking Evacuation Route
Driving Evacuation Route
Tsunami Hazard Area
City Limits

Tsunami Evacuation Map
Hoquiam
Hoquiam
Aberdeen
Grays
Harbor
Legend
2,000 1,000 0 2,000


Tsunami Evacuation Map
Ocean City, Copalis Beach, Pacific Beach, and Moclips
Moclips
old North Beach High School
Sunset Beach
Highland Heights
Pacific Beach Fire Station
Pacific Beach Naval Station
Pacific Beach
Seabrook Development
Aloha
Ocean Grove
Pacific Ocean
Oyehut
Iron Springs
Carlisle
Copalis Beach
Copalis Crossing
Camp Bethel
Newton
North Beach School District
Ocean City
Tulips
Burrows
Camp Bethel
Sampson
Legend


Tsunami Evacuation Map
Ocean Shores
North Bay
Oyhut
Pacific Ocean
Westport Airport
Grays Harbor
Ocean Shores
Oyhut Wildlife Area
Damon Point
Legend
2,000 1,000 0 2,000


Tsunami Evacuation Map
Taholah and Point Grenville
Pacific Ocean
Quinault River
Hospital / Medical
Taholah
109
Legend
Assembly Area
Fire Station
Hospital
Police Station
Highways
Roads
Forest Roads
Railroads
Rivers
Walking Evacuation Route
Driving Evacuation Route
Tsunami Hazard Area
1:11,000


Tsunami Evacuation Map
Taholah and Point Grenville
Hospital / Medical
Quinault River
Pacific Ocean
109
Legend
Assembly Area
Fire Station
Hospital
Police Station
Walking Evacuation Route
Driving Evacuation Route
Tsunami Inundation Area
1854


Tsunami Evacuation Map
Westport
Grays Harbor
Westhaven
Westport
Westport Airport
Ocosta
Ocosta Community Center
South Bay
Cohassett
Ocosta High School
Pacific Ocean
Legend
Fire Station
Hospital
Police Station
Highways
Roads
Railroads
Rivers
Walking Evacuation Route
Driving Evacuation Route
Tsunami Hazard Area
City Limits
Sahey Rd
2,000 1,000 0 2,000
1854

In addition to the WDNR data, FEMA also recently completed a Westport Study to pilot its Hazus 4.0 Tsunami Model, as well as conducting analysis in conjunction with the 2017 RiskMap Project Risk Report. That data is incorporated as referenced throughout this hazard profile.

Figure 12-5 illustrates the FEMA defined inundation areas as identified in the RiskMap Assessment (2015). Figure 12-6 and Figure 12-7 are illustrations of the inundation areas resulting from the 2017 Westport Study.

It should be noted that this data is in preliminary stages and may be changed. Readers should use this information for planning purposes only, and not life safety measures prior to verifying the information. This data may be updated as more information becomes available. There are also significant variations in the data. This is due to several factors, including:

1) Enhanced data sets with respect to structures in place. The Hazus program allows for the use of default data, or the development of an updated database, which can then be used. In the case of FEMA's 2015 Risk Report as well as the 2017 Westport Study, Assessor's data was utilized. Also, the age of the DNR study (2000) does not include population increases.
2) Topography data has been significantly enhanced since the 2000 data was completed, providing for much greater accuracy in the actual elevation of the land area.
3) Flood-prevention devices, such as levees, which previously had not been accounted for, or which did not previously exist.
4) Scientific data with respect to the earthquake hazard and its impact on Tsunami, as well as enhanced tsunami data with respect to waive height, arrival time, etc.
5) Modeling software has changed significantly since the 2000 DNR study was first completed. There have been several updates to FEMA's Hazus Software, with the newest edition used for the 2017 Westport Tsunami Study being a pilot project.

Figure 12-8 illustrates a single map panel containing all three studies completed for the region, illustrating the differences both in the inundation areas, as well as the areas of study.

Figure 12-5 Tsunami Inundation Zone - Cascadia M9.0 Earthquake (FEMA 2017a)

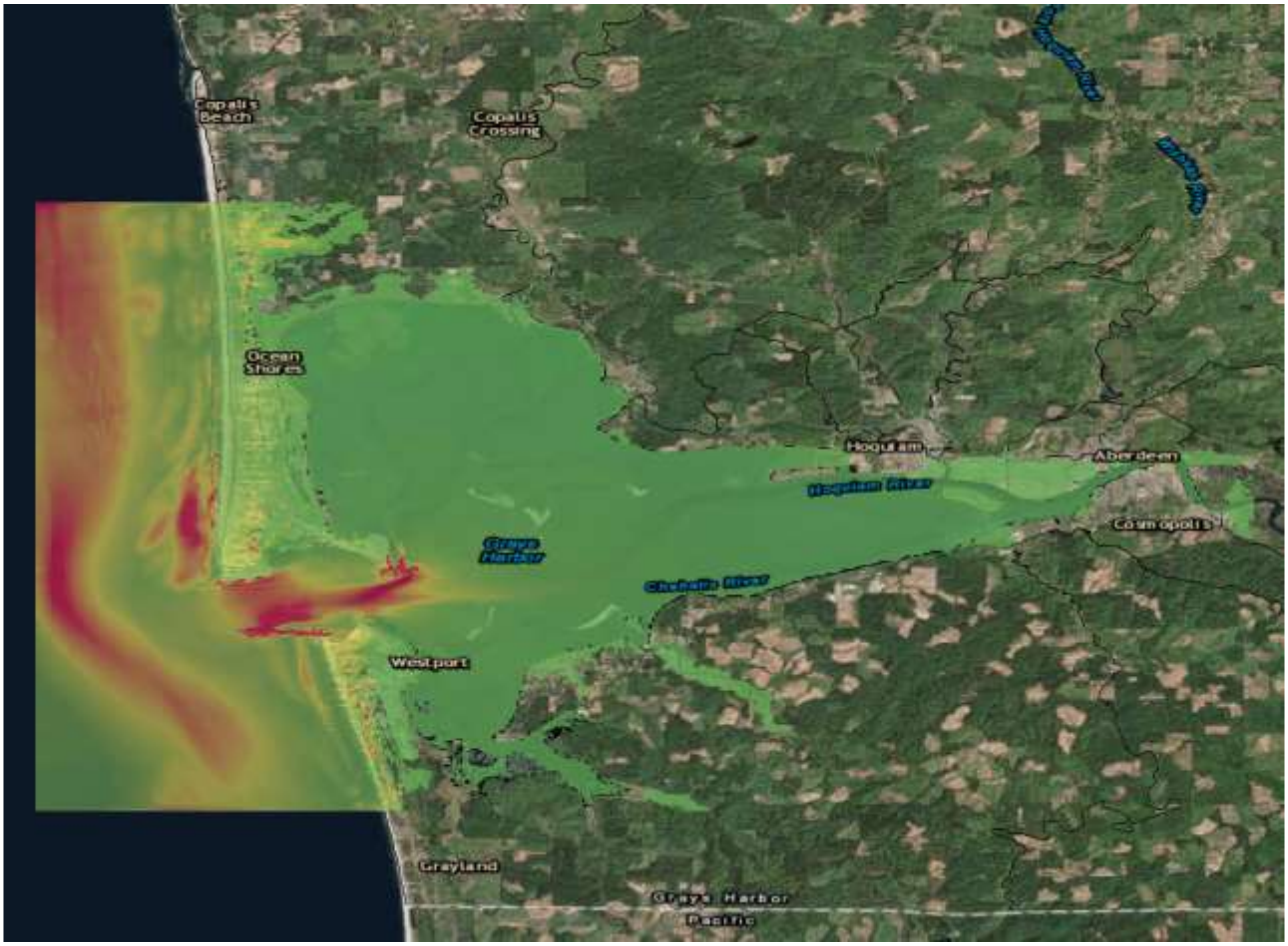


Figure 12-6 Grays Harbor County Inundation Area Based on 2017 Westport Study
Map Courtesy of Doug Bausch

Figure 12-7 South Aberdeen and Cosmopolis Inundation Area Based on 2017 Westport Study

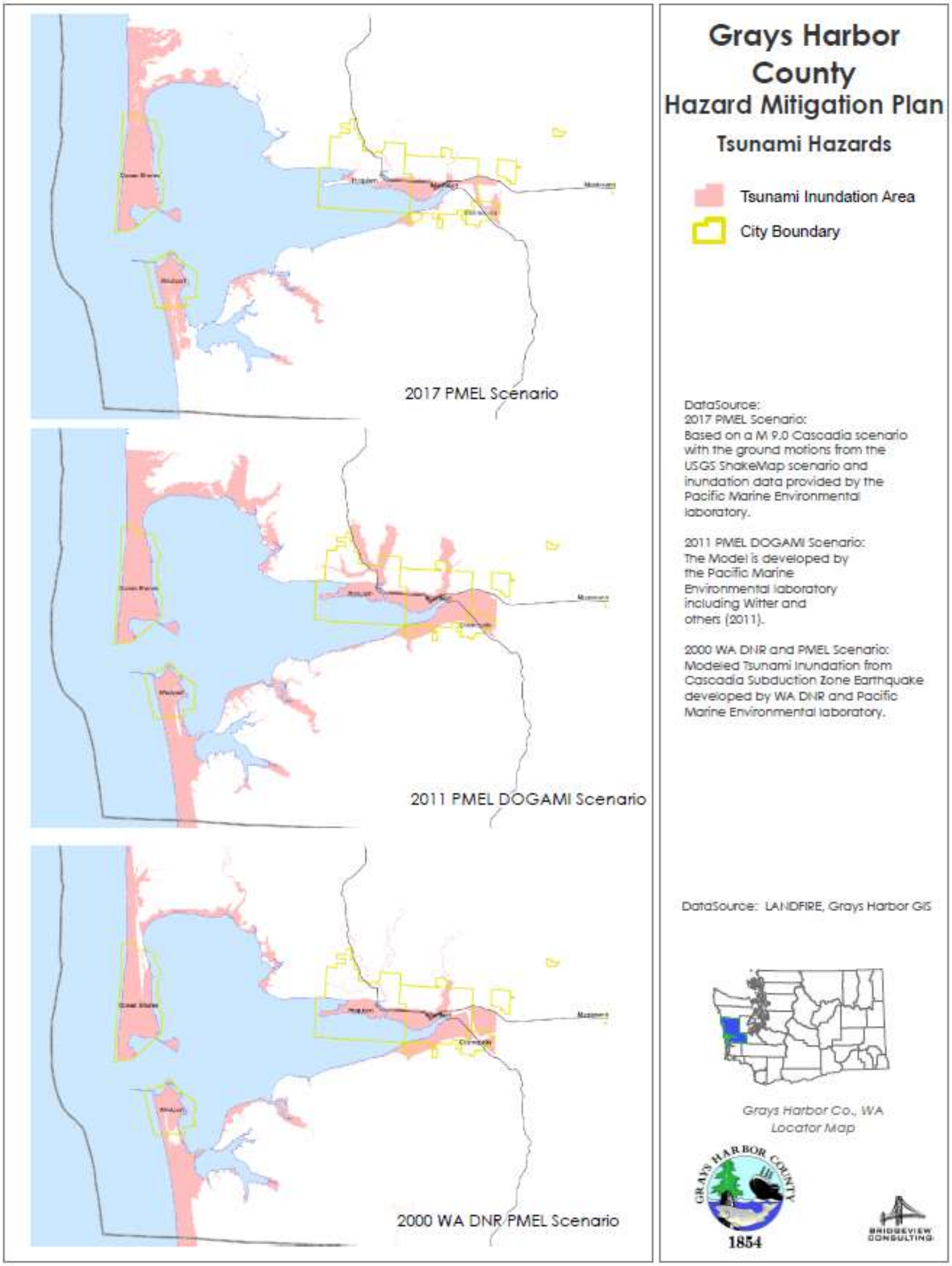


Figure 12-8 Completed Grays Harbor County Tsunami Inundation Studies 2000-2017

12.2.2 Previous Occurrences

According to data captured from NOAA, SHELDUS and historical records, Grays Harbor County has been impacted four times by tsunami wave events. The 1964 Magnitude-9.2 earthquake in Prince William Sound, Alaska caused a tsunami that struck Washington, Oregon and California, killing 139people, mostly in Alaska. There were no reported deaths in Washington, but there were reports of damaged roads, bridges, boats and houses along the coastline. Damages to roads and bridges alone were estimated at $80,000 (1964 figures). Wave heights along the Washington coastline were 1.5 feet at the mouth of the Hoh River; 5 feet in La Push; 10 feet in Ocean Shores; 23 feet in Tahola; 11 feet in Moclips, and 2 feet in Neah Bay (Sokolowski, undated). At Ocean City, 5- to 6-foot tsunami waves collapsed the bridge over the Copalis River. Wave heights at Moclips, Sea View, La Push and Wreck Creek reached an estimated 11, 12, 5, 7, and 15 feet, respectively.[45]

The Magnitude 8.3 earthquake which occurred near Kuril Island northeast of Japan caused Tsunami waves at Westport to rise to .16 feet.

The February 27, 2010 Chilean Magnitude-8.8 earthquake generated a small tsunami with no reported damage in Washington. NOAA reported increased wave heights above sea level as 5.5 inches in Westport, 7.5 inches in Port Angeles, 8.5 inches in La Push, and 9 inches in Neah Bay. (NOAA, 2011).

The March 2011 tsunami that resulted from a Magnitude-9.0 earthquake in Japan caused increased wave heights along the California, Oregon and Washington coastlines. Major declarations were issued in California and Oregon, but Washington sustained much less damage. Washington coastline wave heights above sea level were reported at La Push at 28 inches; Port Angeles at 23 inches; Westport at 18 inches; Toke Point at 13 inches; Port Townsend at 6 inches; and Neah Bay at 17 inches. No significant damage was reported, but this incident had the potential to be much worse. The County and its jurisdictions worked closely with the Pacific Marine Environmental Laboratory and the West Coast and Alaska Tsunami Warning Center, who provided wave predictions for coastal areas.

As a result of the Queen Charlotte Island M7.7 Earthquake which occurred on October 28, 2012 Toke Point and Westport experienced a tsunami, with maximum water height at Toke Point .04 and Westport .08.[46]

12.2.3 Severity

Tsunamis are a threat to life and property to anyone living near the ocean. According to the National Centers for Environmental Information (NCEI), tsunamis took the lives of more than 290,000 million people in the past 100 years.[47] From 1950 to 2007 alone, 478 tsunamis were recorded globally. Fifty-one events caused fatalities, to a total of over 308,000 coastal residents. The overwhelming majority of these events occurred in the Pacific basin. Recent tsunamis have struck Nicaragua, Indonesia, Thailand, and Japan, killing several hundred thousand people. Property damage due to these waves was nearly $1 billion. Historically, tsunamis originating in the northern Pacific and along the west coast of South America have caused more damage on the west coast of the United States than tsunamis originating in Japan and the Southwest Pacific.

[45] USC Tsunami Research Group http://cwis.usc.edu/dept/tsunamis/alaska/1964/webpages/index.html

[46] NOAA National Centers for Environmental Information Accessed 11/1/2017 Available online at: https://www.ngdc.noaa.gov/nndc/struts/form?t=101650&s=167&d=166

[47] https://www.ncei.noaa.gov/news/november-5-world-tsunami-awareness-day

The Cascadia subduction zone will produce the state's largest tsunami. The Cascadia subduction zone is similar to the Alaska-Aleutian trench that generated the Magnitude-9.2 1964 Alaska earthquake and the Sunda trench in Indonesia that produced the Magnitude-9.3 December 2004 Sumatra earthquake. Native American accounts of past Cascadia earthquakes suggest tsunami wave heights on the order of 60 feet, comparable to water levels in Aceh Province Indonesia during the December 2004 tsunami there. The Cascadia subduction zone last ruptured on January 26, 1700, creating a tsunami that left markers in the geologic record from Humboldt County, California, to Vancouver Island in Canada and is noted in written records in Japan. Water heights in Japan produced by the 1700 Cascadia earthquake were over 15 feet, comparable to tsunami heights on the African coast after the Sumatra earthquake. At least seven ruptures of the Cascadia subduction zone have been observed in the geologic record.

A Cascadia Subduction Zone earthquake is expected to lower the ground surface along the coast of Washington. Flooding of areas less than six (6) feet (1.8 m) above tide stage is expected shortly after the earthquake, rendering evacuation time even shorter for people on beaches (discussed further below). Maximum flooding depth, velocity, and extent will depend greatly on the tide height at the time of the tsunami arrival.

12.2.4 Frequency

Unlike many natural hazards, the number of tsunamis is low. In the last 100 years, slightly over 100 fatal tsunamis struck coastlines around the globe.[48] Generally four or five tsunamis occur every year in the Pacific Basin, and those that are most damaging are generated off South America rather than in the northern Pacific. Pacific-wide tsunamis are rare, occurring every 10 to 12 years on average. Most of these tsunamis are generated by earthquakes that cause displacement of the seafloor, but a tsunami can also be generated by volcanic eruptions, landslides, underwater explosions, and meteorite impacts (Nelson, undated). The frequency of tsunamis is related to the frequency of the event that causes them, which would include seismic, volcanic, or landslide events.

12.3 VULNERABILITY ASSESSMENT

12.3.1 Overview

Results from several studies conducted over the course of the last several years vary in some degree to impact; however, most reports are consistent in several factors. Due to the close proximity to the earthquake source, subsidence which is expected to occur in Grays Harbor County will result in long-term inundation (Gica, 2014). Short-term inundation is expected to be caused by the generated tsunami waves. The long-term inundation is generated by co-seismic displacement.

Studies based on scenarios developed by PMEL and NOAA have illustrated in extensive inundation in the Ocean Shores and Westport peninsulas. Extensive flooding is primarily caused by the initial and largest tsunami wave that hits the coasts. Later waves are also deemed damaging, with some amplitudes almost matching the initial one and occurring hours after the earthquake. Results indicate that not only are the tsunami waves high, but maximum current speed values are also high. As a result of the offshore continental shelf margin and wave refractions and reflections along the coast, tsunami time series models indicate that it will take several hours before the generated tsunami waves die out (Gica, 2014). Wave height also varies

[48] https://www.ncei.noaa.gov/news/november-5-world-tsunami-awareness-day

by study, with some indicating the first waves measuring in excess of 11 m in elevation, traveling at speeds from 3 m/second to 8 m/second, with maximum speeds reaching 12 m/second (Gica, 2014).

Aside from the tremendous hydraulic force of the tsunami waves themselves, floating debris carried by a tsunami can endanger human lives and batter inland structures. Ships moored at piers and in harbors often are swamped and sunk or are left battered and stranded high on the shore. Breakwaters and piers collapse, sometimes because of scouring actions that sweep away their foundation material and sometimes because of the sheer impact of the waves. Railroad yards and oil tanks situated near the waterfront are particularly vulnerable. Oil fires frequently result and are spread by the waves.

Methodology

The majority of data utilized within this process is the result of FEMA's on-going RiskMap project and Tsunami inundation modeling utilizing Hazus 4.0 and the Westport Tsunami Study model released March 2017, as well as Washington State Department of Natural Resources various inundation studies (2000). Data presented is primarily from those sources unless otherwise identified. It should be noted that discrepancies in data results will exist due to the variations in the methods used (different Hazus models), as well as different data sources, such as topography, tidal state, and the use of the various water tables (e.g., Mean High Water, wave height, source of the tsunami, etc.).

As information and the Hazus program is refined, outputs may change. Readers requiring additional data on the methodology utilized should obtain such information from FEMA Region X, or from Grays Harbor County Emergency Management for a full copy of the findings. Information presented is for hazard mitigation planning purposes only, and should not be considered for life-safety measures.

In addition to the above, a Level 2/3 Hazus-MH flood protocol was used to assess the risk and vulnerability to the tsunami inundation area. A user-defined facility model was developed, incorporating a depth grid developed in GIS, which has a level of accuracy acceptable for planning purposes. Where possible, the Hazus-MH default data was enhanced using local GIS data from the County, state and federal sources, as well as a comprehensive data management system update for critical facilities. Exposure analysis was also conducted during this update process, utilizing the critical facilities identified by the HMP Planning Team during this update process.

Warning Time

Typical signs of a tsunami hazard are earthquakes and/or sudden and unexpected rise or fall in coastal water. The large waves are often preceded by coastal flooding and followed by a quick recession of the water. Tsunamis are difficult to detect in the open ocean, with waves less than 3 feet high. The tsunami's size and speed, as well as the coastal area's form and depth, affect the impact of a tsunami. In general, scientists believe it requires an earthquake of at least a magnitude 7 to produce a tsunami. Figure 12-9 shows typical time for a tsunami to travel across the Pacific Ocean, based on the 1964 Alaska and 1960 Chile earthquakes and resulting tsunamis.

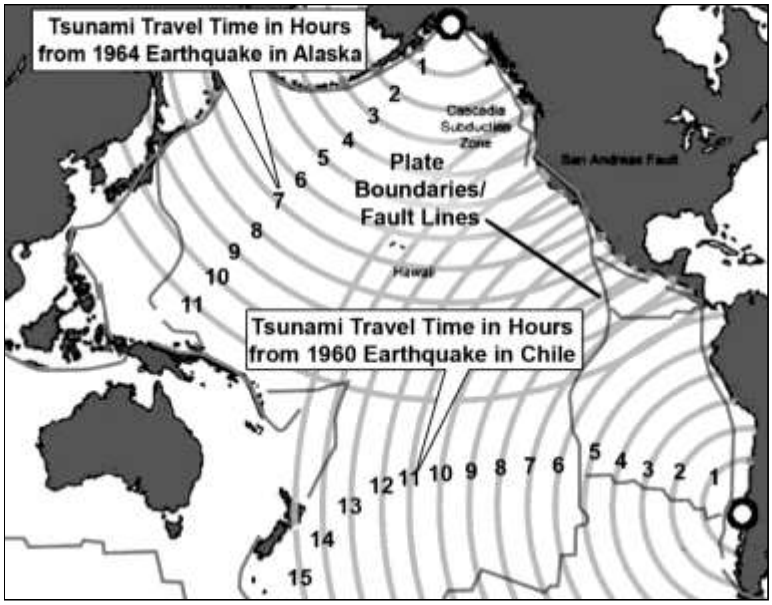


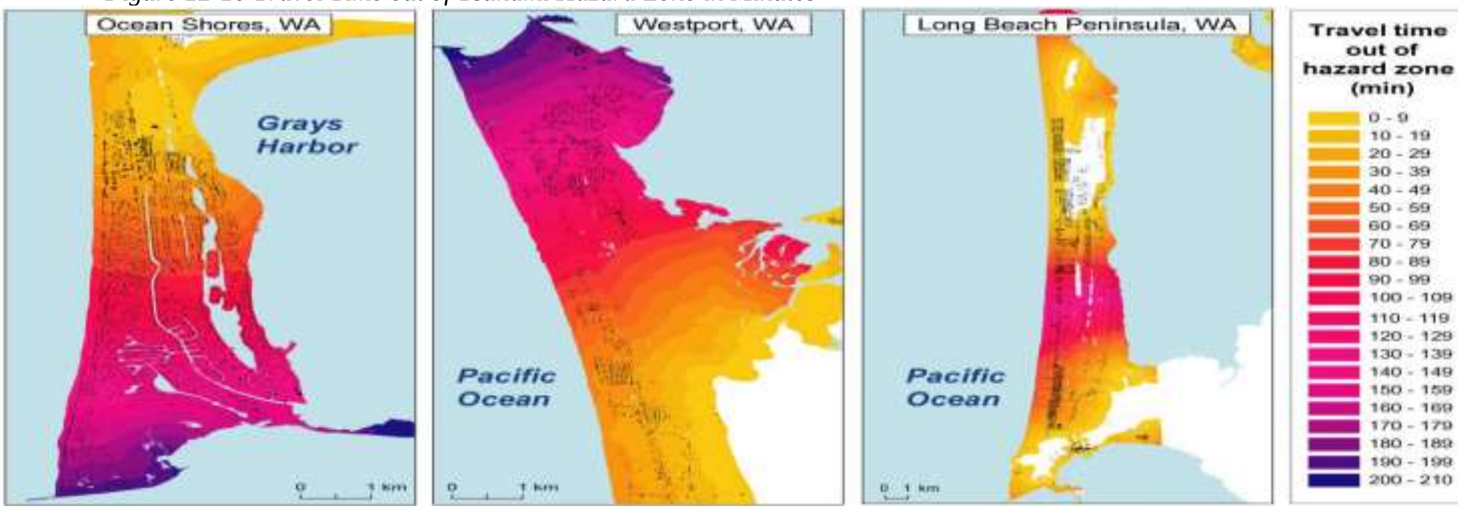
Figure 12-9 Tsunami Travel Times in the Pacific Ocean

According to Washington State's Hazard Mitigation Plan (2013) at least thirteen (13) of Washington State's Pacific Ocean coastal communities and tribal reservations lack natural high ground that is of sufficient elevation to escape a 30+ foot tsunami triggered by a Cascadia Subduction Zone earthquake. The lack of natural high ground coupled with preceding earthquake damage, close proximity to the fault (~50-100 miles), and limited time for evacuation (15-30 minutes) preclude the use of traditional horizontal or vehicular evacuation strategies. These limiting factors make 13 outer coastal communities in Washington extremely vulnerable to significant loss of life from such an incident. This situation is not unique to Washington State, as many low-lying coastal areas within U.S. states, commonwealths, and territories are also constrained by similar geographic factors.

To address this unique challenge, the concept of vertical evacuation was established. This evacuation strategy allows residents and visitors to move upwards to safety in man-made structures (buildings, towers, or berms) and is particularly important on peninsulas where traditional evacuation measures are not viable options for life safety. In 2008, FEMA collaborated with the National Oceanic and Atmospheric Association and published engineering guidance entitled "*Guidelines for Design of Structures for Vertical Evacuation from Tsunamis*" to promote the planning and development of life safety refuges in the United States (FEMA P646). In 2011, the vertical evacuation concept was tested to its fullest extent and successfully saved thousands of lives in Japan during the March 11, 2011 tsunami. Grays Harbor County was successful in constructing our nation's first vertical evacuation at the Ocosta School – Project Safe Haven. Additional information on the project is available in Section 15.9 of this document, as well as the community-developed Facebook account: https://www.facebook.com/ProjectSafeHaven.

The arrival time and duration of flooding are key factors to be considered in evacuation strategies. For locations on the outer coast, the first wave crest is generally predicted to arrive between 25 and 40 minutes after the earthquake (Gica, 2014). However, significant flooding can occur before the first crest arrives because a Cascadia Subduction Zone earthquake is expected to lower the ground surface along the coast, with some models predicting a 3.0 meter (~9.8 feet) subsidence. Flooding of areas less than six (6) feet above tide stage is expected a short time after the initial earthquake. This will effectively render evacuation times short not only for people on the beach, but also along coastal roadways, including major highways traversing the coastline. Figure 12-10 illustrates travel times out of hazards zones along the areas of the planning region. Some recent studies indicate that resulting tsunami waves from a Cascadia event could reach the coastline in as little as 25 minutes.

Figure 12-10 Travel Time out of Tsunami Hazard Zone in Minutes



Source: Wood, N.; Schmidtlein, M.; and Schelling, J.; *Preparing for catastrophic tsunamis in the U.S. Pacific Northwest --- the use of pedestrian-evacuation modeling to target mitigation and education*; *Paper #NH-38, American Geophysical Union (AGU) Science Policy Conference.*

As part of the Westport Study (2017), an analysis was conducted utilizing Hazus to help determine evacuation travel times. Hazus incorporates an estimate of pedestrian travel time based on either input from the USGS Pedestrian Evacuation Analyst (Level 2) or a streamlined analysis based on the local road network based on the USGS methodology (Level 1). The model incorporates standard walking speeds and reduction factors based on demographics or other variables that can be modified by the user. The 2017 Westport Study scenario utilized a Level 3 {@Evac_TimeAnalysis} Evacuation Time Analysis. Those travel times were then combined with tsunami travel time, warning time and community reaction time parameters to provide an estimate of potential casualties. Based on data resulting from the Westport Study, the following Evacuation Travel Time Summaries were developed. Figure 12-11 represents a daytime event, while Figure 12-12 represents the nighttime population. The data is presented for populations under and over 65 years of age.

HAZUS MH EARTHQUAKE • WIND • FLOOD FEMA

Evacuation Travel Time Summary RiskMAP Increasing Resilience Together

March 15, 2017

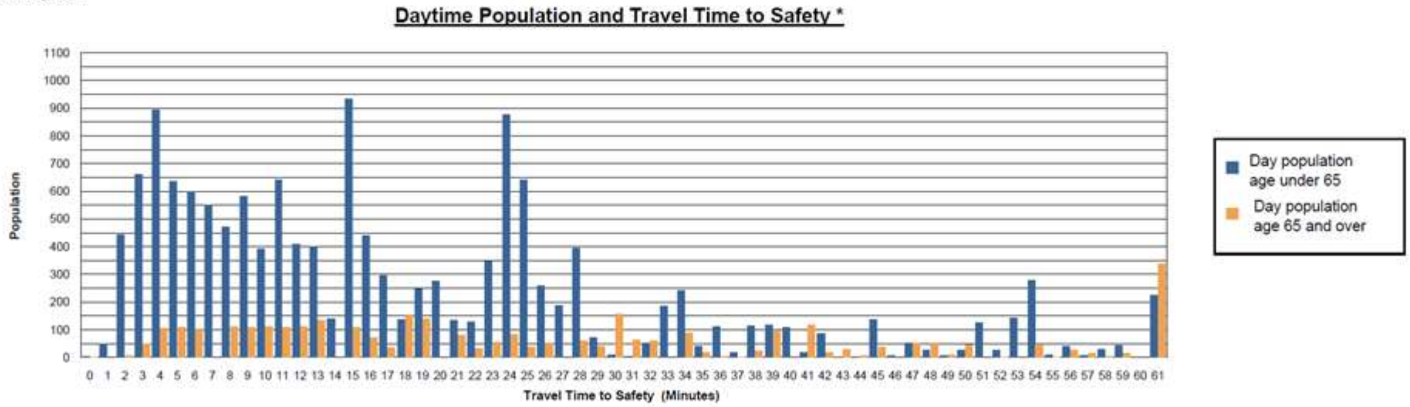


Figure 12-11 Evacuation Time - Daytime Population

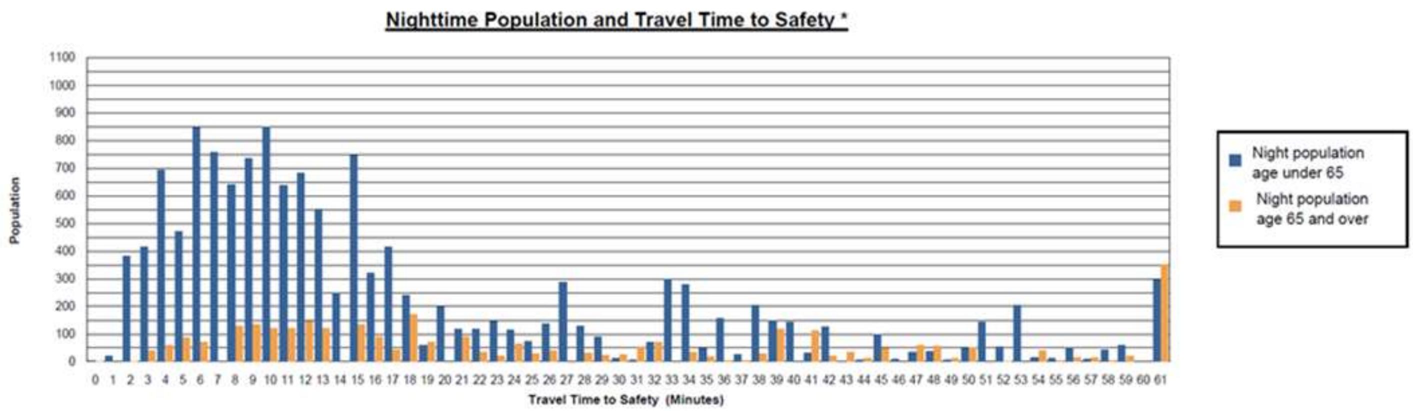


Figure 12-12 Evacuation Time - Nighttime Population

Deep-Ocean Assessment and Reporting of Tsunamis

NOAA's Deep-ocean Assessment and Reporting of Tsunamis system (see Figure 12-13) collects data that is relayed to the Pacific Tsunami Warning Center. These units generate computer models that predict tsunami arrival, usually within minutes of the arrival time. This information is relayed in real time. This system is not considered to be as effective for communities close to the tsunami because the first wave would arrive before the data were processed and analyzed. In this case, strong ground shaking would provide the first warning of a potential tsunami.

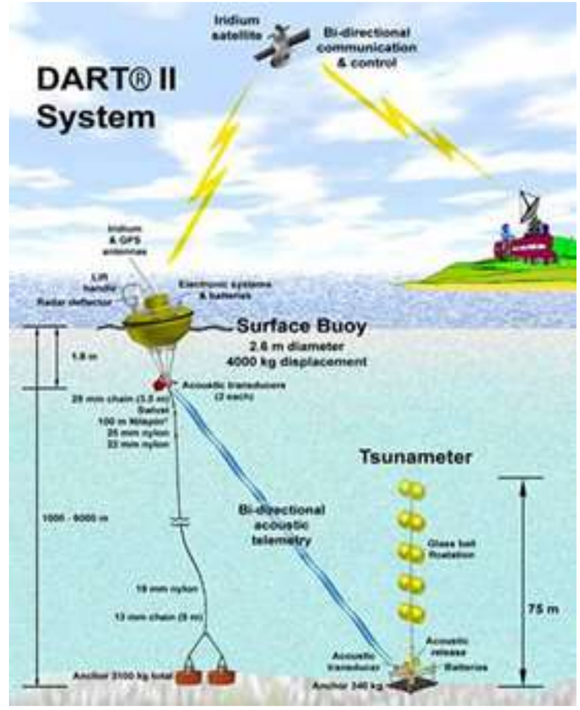


Figure 12-13 Deep-Ocean Assessment and Reporting of Tsunamis System (DART)

Pacific Tsunami Warning System

The Pacific Tsunami Warning System evolved from a program initiated in 1946. It is a cooperative effort involving 26 countries along with numerous seismic stations, water level stations and information distribution centers. The National Weather Service operates two regional information distribution centers. One is located in Ewa Beach, Hawaii, and the other is in Palmer, Alaska. The Ewa Beach center also serves as an administrative hub for the system. When a Pacific basin earthquake of magnitude 6.5 or greater occurs, the following sequence of actions begins:

- Data is interpolated to determine epicenter and magnitude of the event.
- If the event is magnitude 7.5 or greater and located at sea, a TSUNAMI WATCH is issued.
- Participating tide stations in the earthquake area are requested to monitor their gages. If unusual tide levels are noted, the tsunami watch is upgraded to a TSUNAMI WARNING.
- Tsunami travel times are calculated, and the warning is transmitted to the disseminating agencies and thus relayed to the public.
- The Ewa Beach center will cancel the watch or warning if reports from the stations indicate that no tsunami was generated or that the tsunami was inconsequential.

All-Hazard Alert Broadcasting Network

All-Hazard Alert Broadcast sirens have been installed along much of the Washington coast to provide warnings of tsunamis to outdoor populations (see Figure 12-14). The system provides rapid alert to citizens and visitors who are in the hazard zone, giving advanced warning for evacuation.

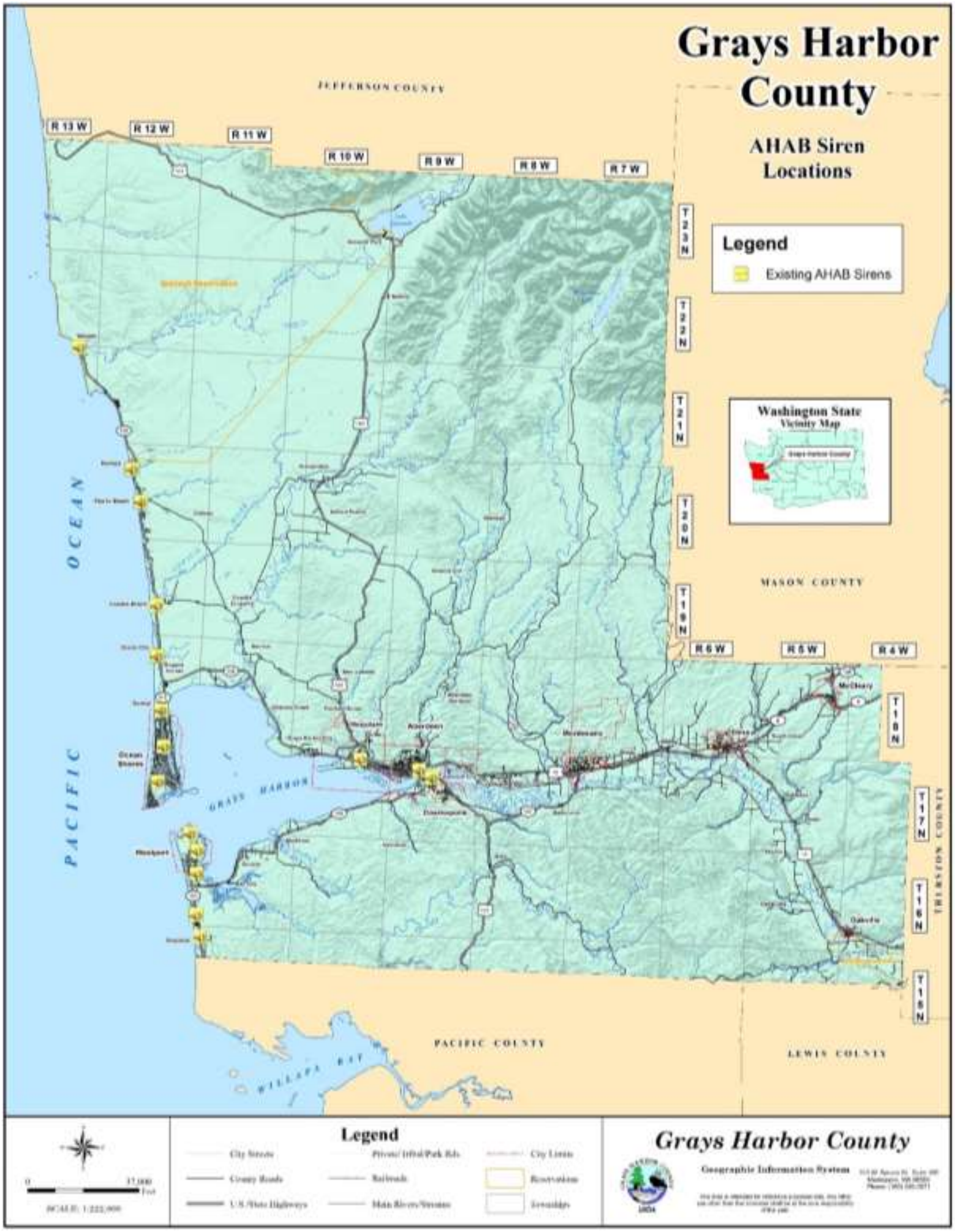


Figure 12-14 Grays Harbor County All-Hazard Alert Broadcasting Network

12.3.2 Impact on Life, Health, and Safety

The populations most vulnerable to the tsunami hazard are the elderly, disabled and very young who reside near beaches, low-lying coastal areas, tidal flats and river deltas that empty into ocean-going waters. In the event of a local tsunami generated in or near the planning area, there would be limited warning time, so more of the population would be vulnerable.

The degree of vulnerability of the population exposed to the tsunami hazard event is based on a number of factors:

- Is there a warning system?
- What is the lead time of the warning?
- What is the method of warning dissemination?
- Will the people evacuate when warned?

The exposed population for the Tsunami Inundation area was estimated by multiplying the average household size for the planning area (~2.5 persons per household) by the number of exposed residential buildings that intersect with the inundation zone. Using this approach, the estimated households and population are identified in Table 12-1. This population count does not include populations impacted by the preceding earthquake event which triggers the tsunami; it is based on population exposed to the tsunami inundation area only.

Grays Harbor County also has a very high population of tourists, which stay in local hotel and motels. Those population numbers are not factored into the population impacted due to the many variables such as occupancy rate, and the exact number of hotel/motel rooms available. Therefore, only the building count for temporary lodging was provided for each jurisdiction, which represent structures identified as RES 4 and RES 5 within the Assessor's data.

It should also be noted that FEMA's 2017 Westport Study indicates that 2,364 people will be displaced throughout the County, with 1,540 seeking temporary shelter as a result of the tsunami and earthquake; however, no specific numbers are provided for the tsunami event alone.

Table 12-1
Population and Exposure in Tsunami Inundation Area*

	Residential Building Count	Population Exposed (based on factor of 2.5 per person/ household	Percent of Total Population in Planning Area	**Temporary Lodging Building Count
Unincorporated Grays Harbor	938	2,445	8.7%	389
Aberdeen, City of	1,860	4,253	25.4%	8
Cosmopolis, City of	0	0	0.0%	0
Elma, City of	0	0	0.0%	0
Hoquiam	864	2,323	27.1%	7
McCleary	0	0	0.0%	0
Montesano	0	0	0.0%	0
Oakville	0	0	0.0%	0
Ocean Shores	4,193	6,055	100.0%	24
Westport	1,024	2,115	100.0%	40
Other	0	0	0	0
Total	8,879	17,191	23.6%	**468**

*Based on 2017 Westport Study

**Temporary lodging building count is included due to the large number of structures within the County; however, analysis for potential population impacted was not calculated as the variables are too great to determine (e.g., number of rooms rented, number of occupants per room, etc.). Therefore, only the building count was included, which represents the number of structures identified within the Assessor's data as RES 4 and RES 5.

12.3.3 Impact on Property

All structures along beaches, low-lying coastal areas, tidal flats and river deltas would be vulnerable to a tsunami, especially in an event with little or no warning time. The impact of the waves and the scouring associated with debris that may be carried in the water could be damaging to structures in the tsunami's path. Those that would be most vulnerable are those located in the front line of tsunami impact and those that are structurally unsound. The County has several ports, business, and structures which store or use chemicals. This could also render property unusable based on the type of chemical, while also increasing the level of damage.

Based on the 2017 Westport Study, inclusive of impact from both the earthquake and resulting tsunami, Hazus estimates that approximately 26,961 buildings will be at least moderately damaged, representing in excess of 80 percent of the buildings in the region (see Figure 12-15).

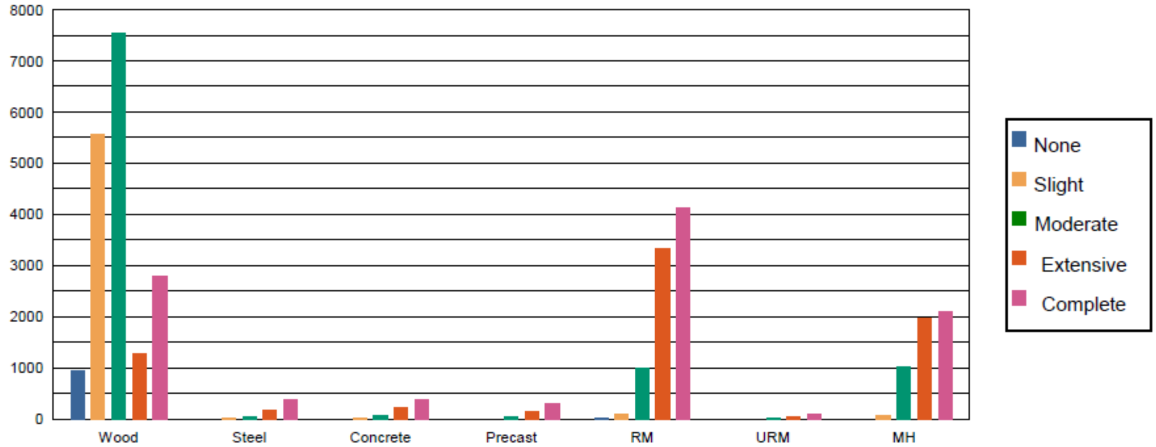


Table 3: Expected Building Damage by Building Type (All Design Levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	929	97.54	5563	97.23	7,551	77.73	1,258	17.74	2,787	27.44
Steel	0	0.05	3	0.05	40	0.41	162	2.29	375	3.70
Concrete	1	0.06	5	0.09	69	0.71	205	2.89	373	3.68
Precast	0	0.02	2	0.03	31	0.32	135	1.90	306	3.01
RM	20	2.07	77	1.35	1,001	10.30	3,329	46.95	4,119	40.56
URM	0	0.00	1	0.01	11	0.11	37	0.53	93	0.92
MH	3	0.26	70	1.23	1,012	10.42	1,965	27.71	2,103	20.70
Total	**952**		**5,721**		**9,714**		**7,091**		**10,156**	

*Note:
RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Figure 12-15 Hazus Outputs 2017 Westport Study

The value of exposed buildings in the tsunami hazard zone within the planning area was generated using Hazus-MH at the user-defined level and is summarized in Table 12-2. The estimates include the value of both the buildings and their contents. This methodology estimates that that there are 10,506 structures exposed to the tsunami hazard within the planning area, with an assessed value, including content, of $2.4 billion.

Table 12-2
Estimated Value of Exposed Structures in Tsunami Inundation Area – Westport Study

	Structures Impacted[a]	Assessed Value			% of AV
		Structure	Contents	Total	
Unincorporated Grays Harbor	1404	$123,602,350	$80,418,382	$204,020,733	6.53%
Aberdeen, City of	2367	$271,779,175	$234,441,176	$506,220,350	32.47%
Cosmopolis, City of	0	$0	$0	$0	0.00%
Elma, City of	0	$0	$0	$0	0.00%
Hoquiam	1016	$127,184,095	$119,711,487	$246,895,582	36.95%
McCleary	0	$0	$0	$0	0.00%
Montesano	0	$0	$0	$0	0.00%
Oakville	0	$0	$0	$0	0.00%
Ocean Shores	4475	$708,283,504	$415,636,347	$1,123,919,851	97.20%
Westport	1244	$177,202,830	$126,341,433	$303,544,263	97.91%
Other	0	0	0	0	0
Total	**10,506**	**$1,408,051,953**	**$976,548,825**	**$2,384,600,778**	**29.09%**

a. Impacted structures are those structures expected to receive measurable damage from the scenario tsunami event because they have lowest floor elevations below the projected tsunami inundation height.

Hazus-MH calculates losses to structures from tsunami by looking at depth of flooding and type of structure and estimates the percentage of damage to structures and their contents by applying established coastal flood damage functions to an inventory. For this analysis, Grays Harbor County building and assessor data was used in place of the default inventory data provided with Hazus-MH. The results are summarized in Table 12-3. Based on that, it is estimated that impact from a tsunami would be up to $1.4 billion of loss in the planning area representing 17.11 percent of the total value for the county.

Utilizing the Westport Study scenario, when combining loss data inclusive of both the earthquake and ensuing tsunami, losses exceed $2 billion dollars when calculating structure and content loss. Those figures are identified in Table 12-4.

Table 12-3
Building Impact for Tsunami Inundation Only - Westport Study

	Estimated Loss Associated with Tsunami			% of Total Assessed Value
	Structure	Contents	Total	
Unincorporated Grays Harbor	$81,180,456	$50,284,892	$131,465,348	4.21%
Aberdeen, City of	$3,819,385	$3,030,453	$6,849,839	0.44%
Cosmopolis, City of	$0	$0	$0	0.00%
Elma, City of	$0	$0	$0	0.00%
Hoquiam	$4,305,309	$5,453,419	$9,758,729	1.46%
McCleary	$0	$0	$0	0.00%
Montesano	$0	$0	$0	0.00%
Oakville	$0	$0	$0	0.00%
Ocean Shores	$661,001,998	$391,556,064	$1,052,558,062	91.03%
Westport	$115,542,459	$86,743,157	$202,285,616	65.25%
Other	$0	$0	$0	0.00%
Total	**$865,849,607**	**$537,067,986**	**$1,402,917,593**	**17.11%**

Table 12-4
Impact Estimates for Tsunami and Earthquake Combined – Westport Study

	Estimated Loss Associated with Tsunami			% of Total Assessed Value
	Structure	Contents	Total	
Unincorporated Grays Harbor	$101,801,022	$65,383,665	$167,184,686	5.35%
Aberdeen, City of	$176,987,741	$148,331,803	$325,319,544	20.87%
Cosmopolis, City of	$0	$0	$0	0.00%
Elma, City of	$0	$0	$0	0.00%
Hoquiam	$82,986,328	$76,070,658	$159,056,986	23.80%
McCleary	$0	$0	$0	0.00%
Montesano	$0	$0	$0	0.00%
Oakville	$0	$0	$0	0.00%
Ocean Shores	$694,054,797	$409,805,333	$1,103,860,131	95.46%
Westport	$151,525,191	$111,433,532	$262,958,724	84.82%
Other	$0	$0	$0	0.00%
Total	**$1,207,355,080**	**$811,024,991**	**$2,018,380,071**	**24.62%**

12.3.4 Impact on Critical Facilities and Infrastructure

Roads or railroads that are blocked or damaged can prevent access and can isolate residents and emergency service providers needing to get to vulnerable populations or to make repairs. Bridges washed out or blocked by tsunami inundation or debris from flood flows also can cause isolation. Water and sewer systems can be flooded or backed up, causing further health problems. Underground utilities can also be damaged during flood events. Figure 12-16 illustrates the location of the critical infrastructure. Table 12-5 provides an estimate of the number and types of critical facilities exposed to the tsunami hazard.

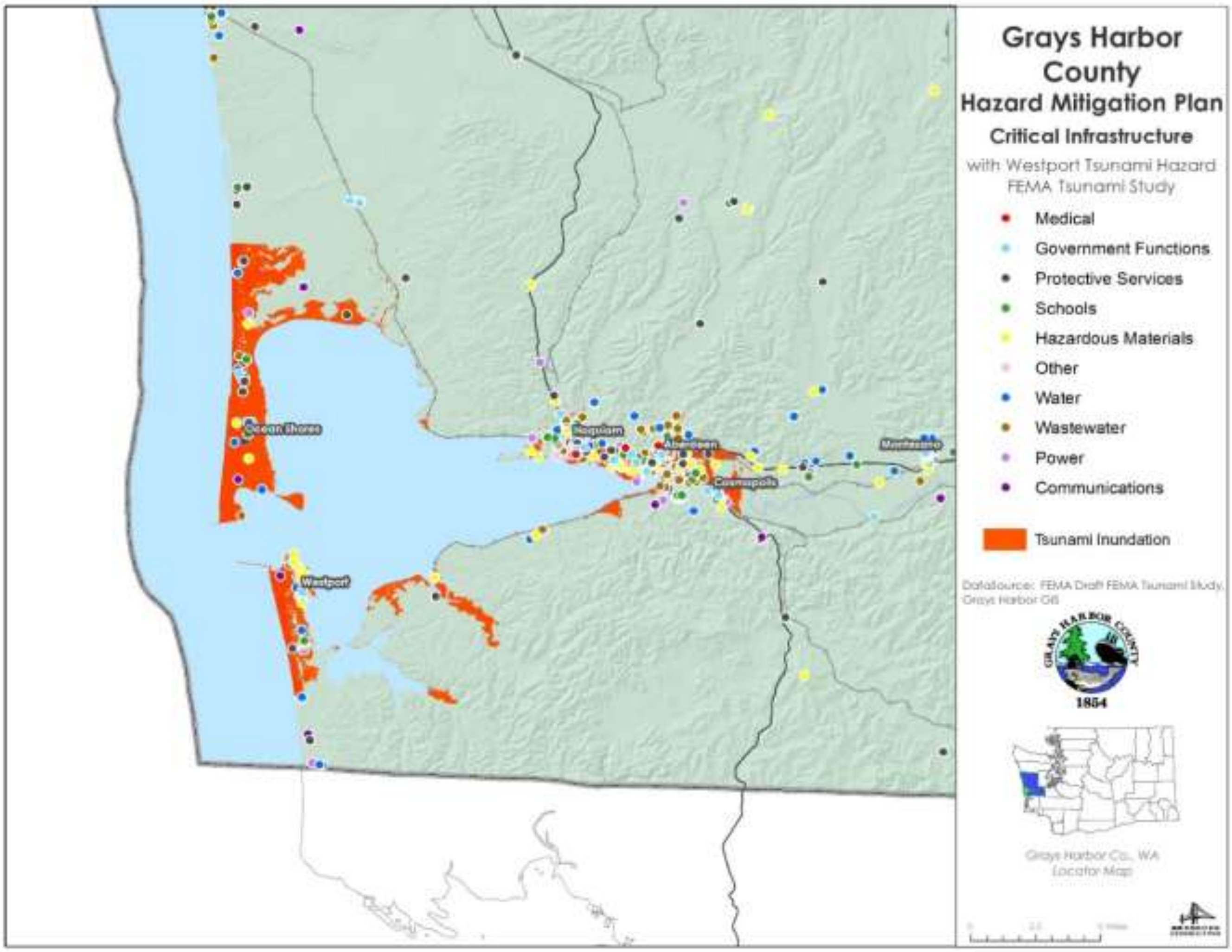


Figure 12-16 Critical Facilities and Infrastructure Impacted by Westport Tsunami Study Scenario

Table 12-5
Critical Facilities Exposed to Tsunami Hazard

Facility Type Identified	Number Identified
Medical and Health Services	1
Government Function	11
Protective Function	18
Schools	18
Hazmat	30
Transportation	34
Water	12
Waste Water	18
Communications	22
Power	13
Other Critical Function	6
Total	**183**

Roads

Roads are the primary resource for evacuation to higher ground before and during a tsunami event. For low depth, low velocity flood events, roads can act as levees or berms and divert or contain flood flows. Several major highways and roadways will be impacted by tsunami events, due to its proximity to the coastline along the entire length of the County. Likewise, bridges will also be impacted. The Westport Study, which includes both Earthquake and Tsunami impact, indicates that 101 bridges of various types along the highway system will be moderately damaged, with 44 completely damaged (Westport Study, 2017). These factors are of significant concern for evacuation purposes as these are the only thoroughfares out of the area and to higher ground.

Docks

Docks exposed to tsunami events can be extremely vulnerable due to forces transmitted by the wave run-up and by the impact of debris carried by the wave action. Many docks are old and unstable, with rotting pilings. During an earthquake, there is a high probability that such structures could collapse or be severely weakened. Any ensuing tsunami would collapse the dock through the force of the water. The debris from the collapsed dock would then be pushed ashore, potentially injuring individuals and damaging structures and facilities. The Port of Grays Harbor operates marine terminals, marinas, airports and business parks in various areas throughout the County, all of which would sustain some impact from a Tsunami event. Approximately 18 port facilities will be moderately impacted (Westport Study, 2017).

Water/Sewer/Utilities

Water and sewer systems can be affected by the flooding associated with tsunami events. 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 wastes to spill into homes, neighborhoods, rivers and streams. The forces of tsunami waves can impact above-ground utilities by knocking down power lines and radio/cellular communication towers. Power generation facilities can be severely impacted by both the impact of the wave action and the inundation of floodwaters. This would also impact facilities that are outside of the actual tsunami inundation area.

12.3.5 Impact on Economy

Port facilities, military facilities, fishing fleets and public utilities are often the backbone of the economy of the affected areas, and these are the resources that generally receive the most severe damage. Until debris can be cleared, wharves and piers rebuilt, utilities restored, and fishing fleets reconstituted, communities may find themselves without fuel, food and employment. Wherever water transport is a vital means of supply, disruption of coastal systems caused by tsunamis can have far-reaching economic effects.

Many of County's businesses are related to tourism, highly dependent on the millions of visitors to the area annually. Depending on the season, large numbers of visitors and tourists may be in the area, increasing response requirements. Those visitors and tourists will require some type of educational outreach with respect to what to do and where to go if an earthquake and tsunami occur.

At a more local perspective, 99% of Westport's developed land, 89% of its population, and all of its businesses are located within the tsunami hazard zone; a future tsunami event would devastate the Westport community and its economy. Similar impact would also be true for all planning partners.

A tsunami would also damage economically important natural resources, such as crab, clams, salmon and other fish, and outdoor recreation areas. Likewise, agri- and aqua-cultural, farmlands, and forestlands, which are a large part of the County's economy, would also be impacted with loss of revenue and destruction of businesses for future growth of the area.

The inundation zone for the planning region is quite significant, and would have a devastating impact on the planning region's economy. Loss of tax base, destruction of government facilities, destruction of private businesses, loss of land-base, loss of marine vessels for the fishing industry, among other items, all would be significant impacts to overcome to allow the economy to sustain itself. In addition to the County impact, all of Washington would be impacted as a result of the loss of connectivity with Canada to Washington, as well as the impact on major highways, the Port system, and the travel time associated with loss of the transportation infrastructure.

12.3.6 Impact on Environment

The vulnerability of agricultural and aquatic habit and associated ecosystems would be highest in low-lying areas close to the coastline. Areas near gas stations, industrial areas and Tier II facilities would be vulnerable due to potential contamination from hazardous materials. In addition, aquatic species attached to debris from the Japan tsunami were brought to the Washington Coastline. These invasive species represent a significant environmental impact.

Tsunami waves can carry destructive debris and pollutants that can have devastating impacts on all facets of the environment. Millions of dollars spent on habitat restoration and conservation in the planning area could be wiped out by one significant tsunami. There are currently no tools available to measure these impacts. However, it is conceivable that the potential financial impact of a tsunami event on the environment could equal or exceed the impact on property. Community planners and emergency managers should take this into account when preparing for the tsunami hazard.

12.3.7 Future Development Trends

With tsunami wave heights estimated to reach as high as ~11 meters in some portions of the County, standard floodplain development regulation would not provide adequate risk protection for new development. Once the data and science can be applied to official mapping with assigned probabilities of occurrence, the County may want to consider regulatory provisions for new development in high-risk tsunami inundation areas.

Of additional concern is the potential for erosion and bluff washout as a result of Tsunami waves. The planning area has a significant amount of dunes, bluffs, and steep hillsides. While the direct impact may not be from the wave flooding a structure, the direct influence of the wave on the shoreline could cause additional landslide and erosion, causing structures to slide which otherwise would not be impacted by Tsunami waves.

12.4 ISSUES

The worst-case scenario for the planning area is a local tsunami event triggered by a seismic event off the coast (a Cascadia scenario). Portions of Grays Harbor County residents can expect waves to reach their boundaries within approximately 25-30 minutes of a Cascadia Subduction Zone earthquake. This could result in loss of life due to residents' inability to evacuate quickly enough. This can also cause severe economic and environmental impacts.

The planning team has identified the following issues related to the tsunami hazard for the planning area:

- To measure and evaluate the probable impacts of tsunamis, new hazard mapping needs to be created based on probabilistic scenarios likely to occur for the County. The science and technology in this field are emerging. For tsunami hazard mitigation programs to be effective, probabilistic tsunami mapping will need to be a key component, with updated occurring as new data emerges. FEMA just recently completed such a study in March 2017; however, that data will continue to be enhanced using Hazus as time progresses. Regular updates should continue to occur.
- Some limitations associated with assessor's data relating to building codes, guidelines and building records provides limited information with respect to the impacts of tsunamis on structures.
- As tsunami warning technologies evolve, the tsunami warning capability within the planning area will need to be enhanced to provide the highest degree of warning to planning partners with tsunami risk exposure. The County has already taken proactive measures with the installation of the All Hazards Alert Broadcast (AHAB) system. Funding for weather radios, additional sirens, or notification systems which will be strategically located will allow for advanced warning in areas of concern.
- Additional elevated tsunami evacuation points throughout the area of inundation need to be constructed, which will require additional funding sources.
- With the possibility of climate change, the issue of sea level rise may become an important consideration as probable tsunami inundation areas are identified through future studies.
- Special attention will need to be focused on the vulnerable communities in the tsunami zone and on hazard mitigation through public education and outreach.

12.5 RESULTS

Based on review and analysis of the data, the Planning Team has determined that the probability for impact from Tsunami throughout the area is highly likely, with widespread impact with respect to geographic extent. While there area has experienced tsunami impact historically, those incidents have occurred infrequently. However, due to the fact that we are well over-due for a Cascadia type earthquake event, which undoubtedly will generate a significant tsunami within the entire region from Canada to California, the probability of occurrence is high. Implementation of mitigation strategies for vertical evacuation sites will help protect some lives, but not all. Based on the potential impact, the Planning Team determined the CPRI score to be 3.3, with overall vulnerability determined to be a high level.

CHAPTER 13.
VOLCANO

The Cascade Range of Washington, Oregon and California has volcanoes close to Grays Harbor County. The primary effect of the Cascade volcanic eruptions on the county would be ash fall, with some disruption of service due to impact on surrounding counties. The closest potential impact to the County are from Mt. Rainier (66 Euclidian miles) and Mount St. Helens (63 Euclidian miles).

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

DEFINITIONS

Ash—Ash is a harsh acidic with a sulfuric odor, consisting of small bits of pulverized rock and glass, less than 2 millimeters (0.1 in) in diameter. Ash may also carry a high static charge for up to two days after being ejected from a volcano. When an ash cloud combines with rain, sulfur dioxide in the cloud combines with the rainwater to form diluted sulfuric acid that may cause minor, but painful burns to the skin, eyes, nose, and throat.

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

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

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

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

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

13.1 GENERAL BACKGROUND

Hazards related to volcanic eruptions are distinguished by the different ways in which volcanic materials and other debris are emitted from the volcano (see Figure 13-1). The molten rock that erupts from a volcano (lava) forms a hill or mountain around the vent. The lava may flow out as a viscous liquid, or it may explode from the vent as solid or liquid particles. Ash and fragmented rock material can become airborne and travel far from the erupting volcano to affect distant areas.

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

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

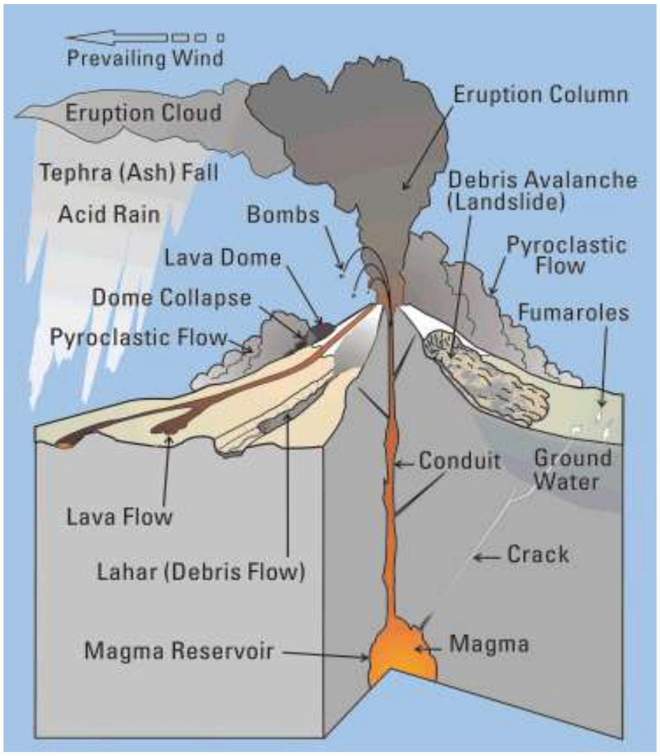


Figure 13-1 Volcano Hazard

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

13.2 HAZARD PROFILE

13.2.1 Extent and Location

The Cascade Range extends more than 1,000 miles from southern British Columbia into northern California and includes 13 potentially active volcanic peaks in the U.S. Figure 13-2 shows the location of the Cascade Range volcanoes, most of which have the potential to produce a significant eruption. The straight-line distance of the major volcanoes of potential impact on the planning region are as follows:

- Mount Baker—117 miles east/northeast of Grays Harbor County
- Glacier Peak— 118 miles east/northeast of Grays Harbor County
- Mount Rainier—66 miles southeast of Grays Harbor County

- Mount Adams – 90 miles southeast of Grays Harbor County
- Mount St. Helens – 63 miles southeast of Grays Harbor County

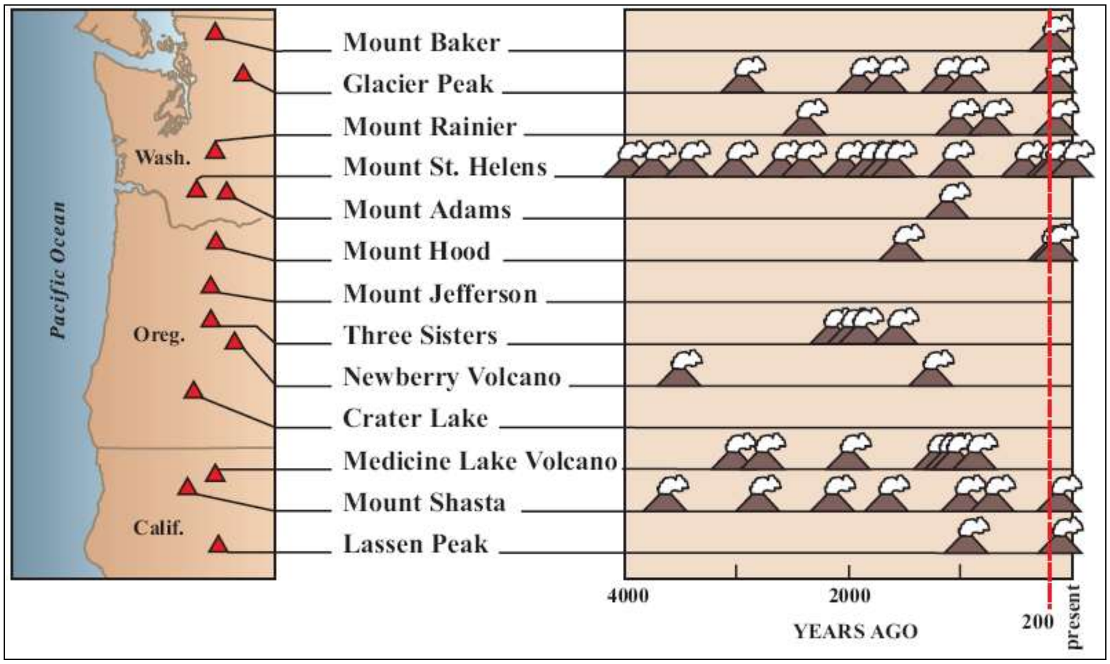


Figure 13-2 Past Eruptions of Cascade Volcanoes

Based on review, the volcanoes most likely to impact the planning area are Mount Rainier and Mount St. Helens. Mount Adams, at 12,280 feet could also cause Tephra to fall within the area.

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

13.2.2 Previous Occurrences

Table 13-1 summarize past eruptions in the Cascades. During the 1980 Mount St. Helens eruption, 23 square miles of volcanic material buried the North Fork of the Toutle River and there were 57 human fatalities. During the last 4,000 years, Mount St. Helens (see Figure 13-3) has erupted more frequently than any other volcano in the Cascade Range.

Figure 13-3 Shoestring Glacier on Mount St. Helens (viewed from southeast)
(Source: USGS files. Photo taken May 1965)

The May 18, 1980 eruption produced the largest terrestrial landslide in recorded history, reducing Mount St. Helens' summit by 1,300 feet. Within 15 minutes of the initial eruption, a vertical plume of volcanic ash rose over 80,000 feet, with a dense ash cloud turning daylight into darkness. The volcanic ash cloud traveled east across the United States in three days, and encircled the entire Earth in 15 days (see Figure 13-4).

Figure 13-4 May 18, 1980 Ash Cloud over Ephrata from Mount St. Helens Eruption
(Source: USGS https://volcanoes.usgs.gov/volcanoes/st_helens/st_helens_hazard_79.html)

Lahars (volcanic mudflows) filled rivers with rocks, sand, and mud, damaging 27 bridges and 200 homes and forcing 31 ships to remain in ports upstream. The May 18, 1980 eruption was the most economically destructive volcanic event in U.S. history. Since the 1980 eruption, Mount St. Helens again became more active during the 2004-2008 time period, when growing lava domes displaced and then divided Crater Glacier into east and west lobes, with lava oozing onto the crater floor, building domes taller than the Empire State Building and restoring 7 percent of the volume lost in 1980.[49]

[49] USGS Publication accessed 11/22/17 available at: https://pubs.usgs.gov/gip/103/

Table 13-1 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

13.2.3 Severity

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

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

Ash is harsh, acidic and gritty, and it has a sulfuric odor. Ash may also carry a high static charge for up to two days after being ejected from a volcano. When an ash cloud combines with rain, sulfur dioxide in the cloud combines with the rainwater to form diluted sulfuric acid that may cause minor, but painful burns to the skin, eyes, nose, and throat. Westerly winds dominate in the Pacific Northwest sending volcanic ash east and north–eastward about 80–percent of the time, though ash can blow in any direction.

Figure 13-5 shows probabilities of tephra accumulation from Cascade volcanoes in the Pacific Northwest (tephra is fragmented rock material ejected by a volcanic explosion). Wind in western Washington blows to the west, northwest and southwest only 10 percent of the time, so tephra from eruptions of Mount St. Helens or Mt. Rainier customarily would be far more likely on the east side of the volcano. Still, even a relatively small amount of ash in Grays Harbor County could have a significant impact with respect to individuals with health or breathing issues, mechanical or motorized devices, fish and other natural wildlife, and the forest and plant life. Figure 13-6 shows areas of the U.S. that have been covered by volcanic ash.

Figure 13-7, Figure 13-8, and Figure 13-9 identify the volcano hazard zones from Mount St. Helens, Mount Rainier, and Mount Adams, respectively, as identified by the USGS.

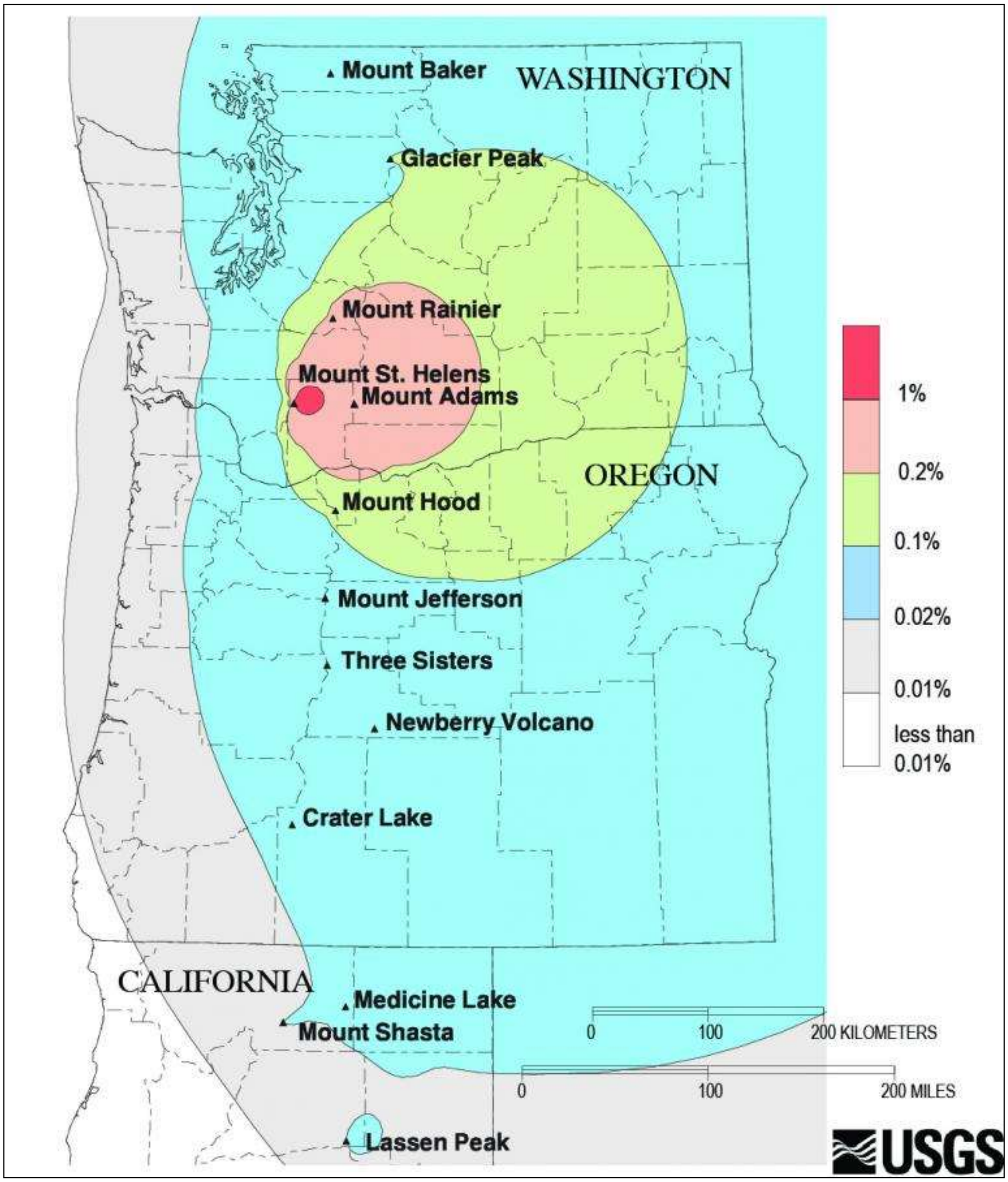


Figure 13-5 Probability of Tephra Accumulation in Pacific Northwest

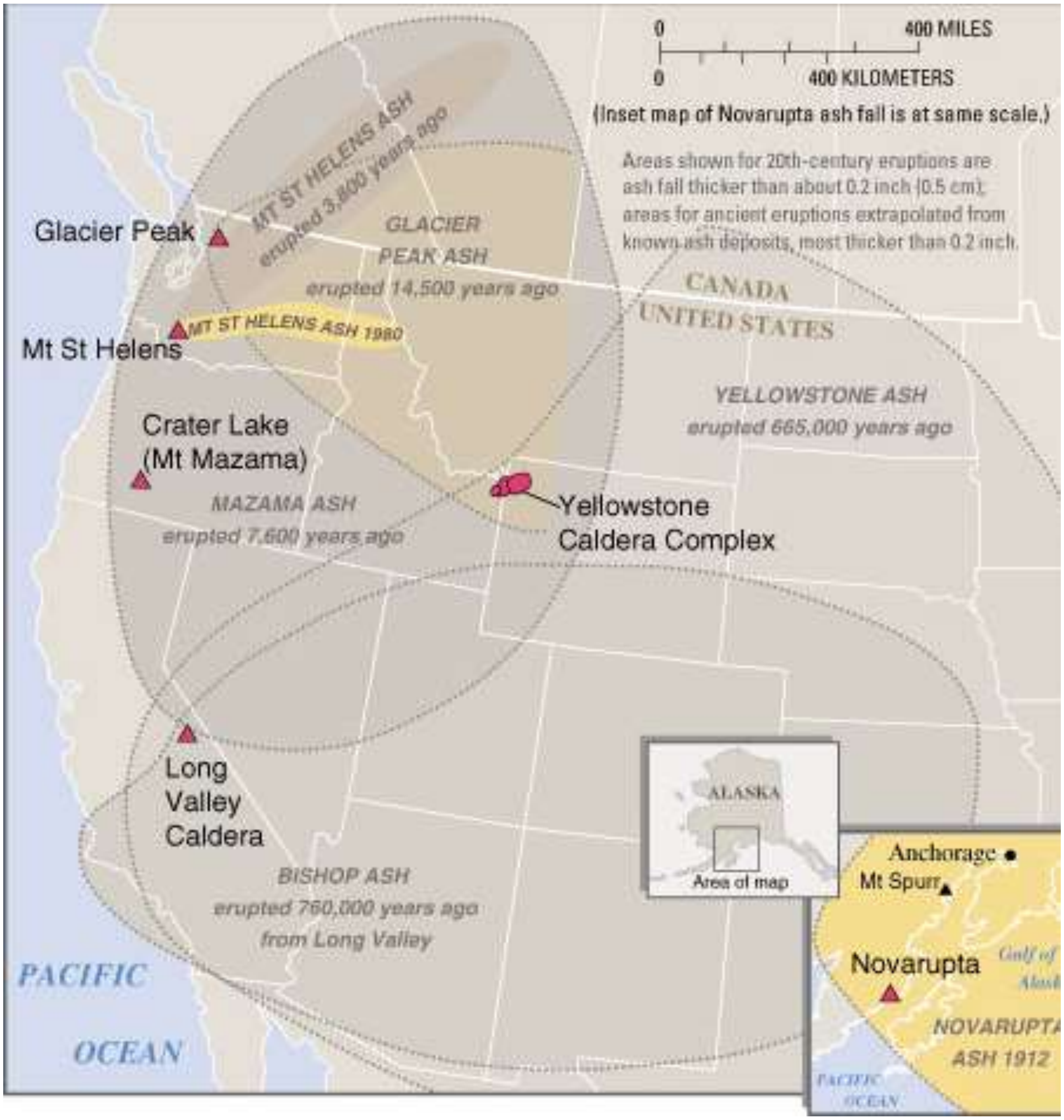


Figure 13-6 Defined Tephra Layers Associated with Historical Eruptions
Source: USGS. http://volcanoes.usgs.gov/vsc/multimedia/cvo_hazards_maps_gallery.html

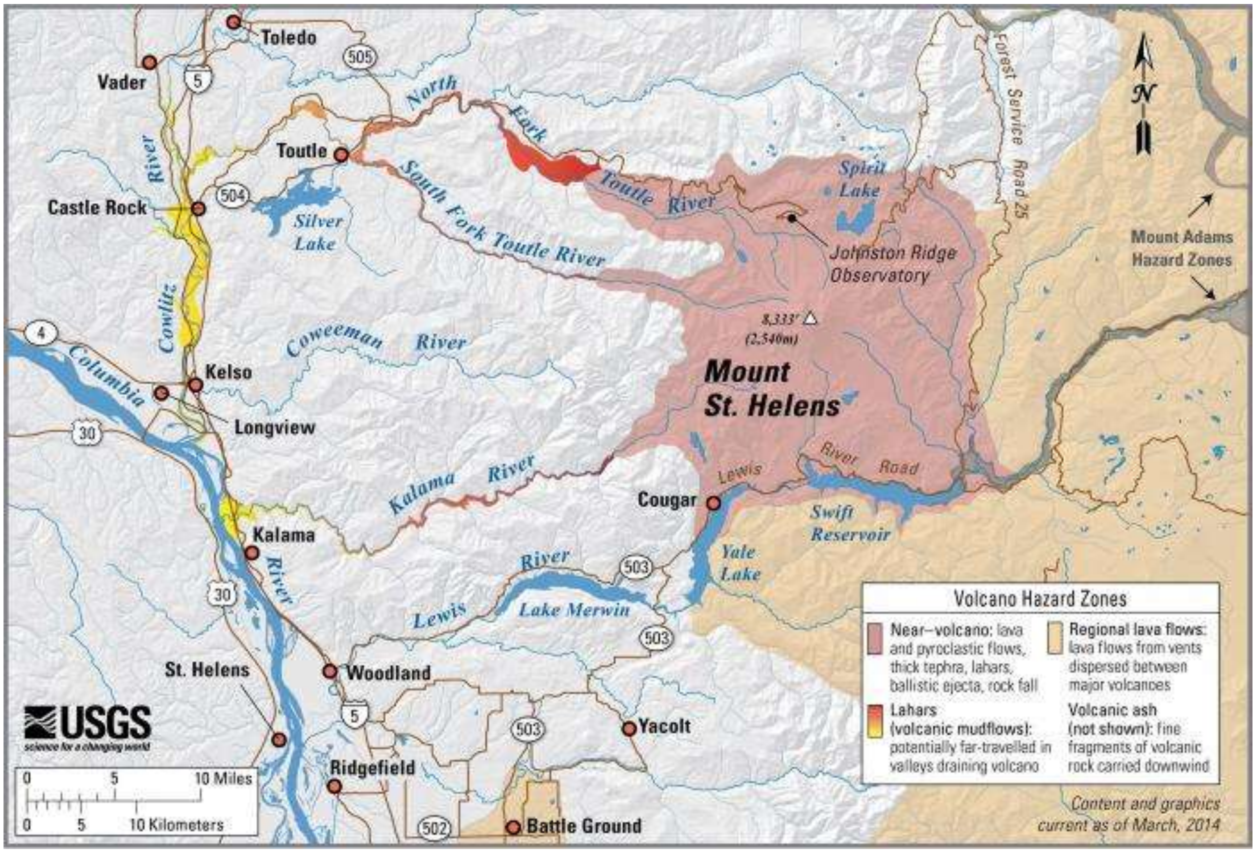


Figure 13-7 Volcano Hazard Zones From Mount St. Helens
Source: USGS. http://volcanoes.usgs.gov/vsc/multimedia/cvo_hazards_maps_gallery.html

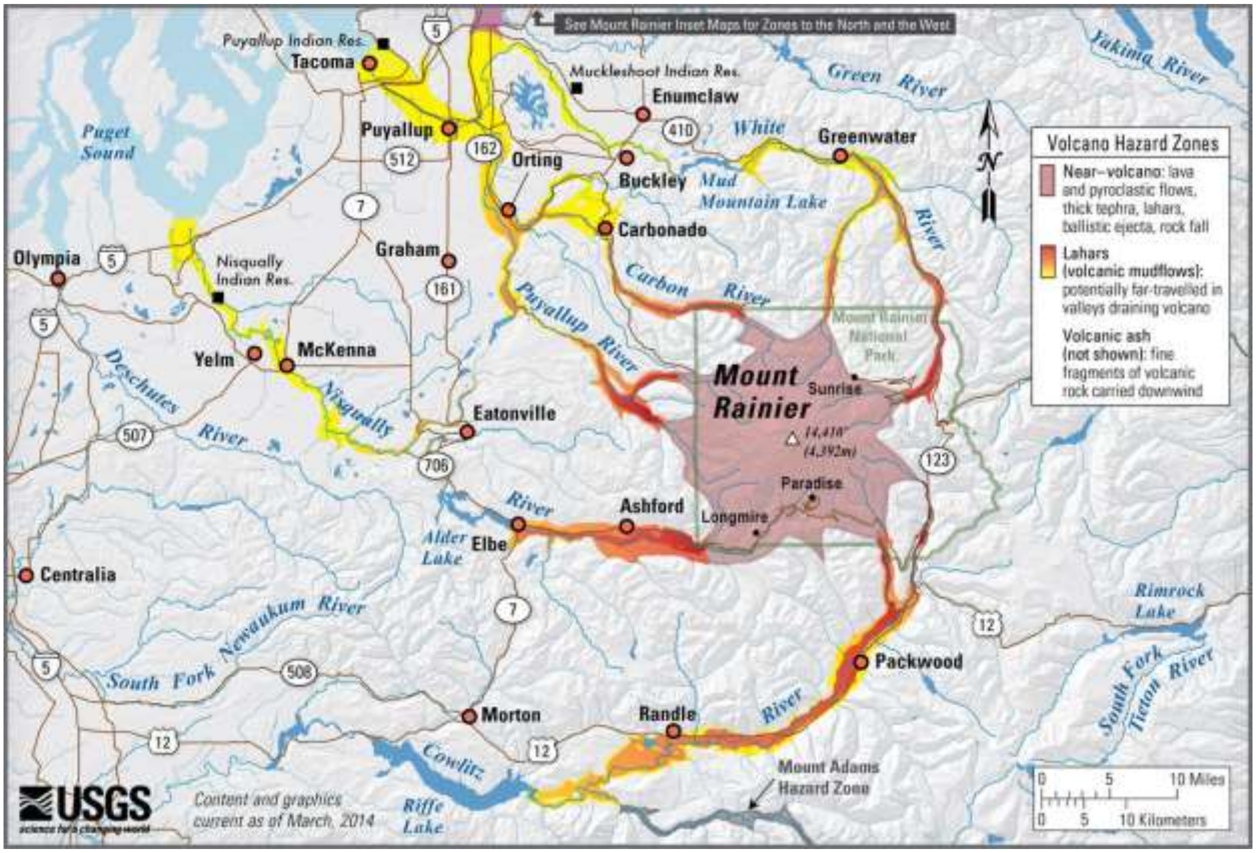


Figure 13-8 Volcano Hazard Zones from Mount Rainier

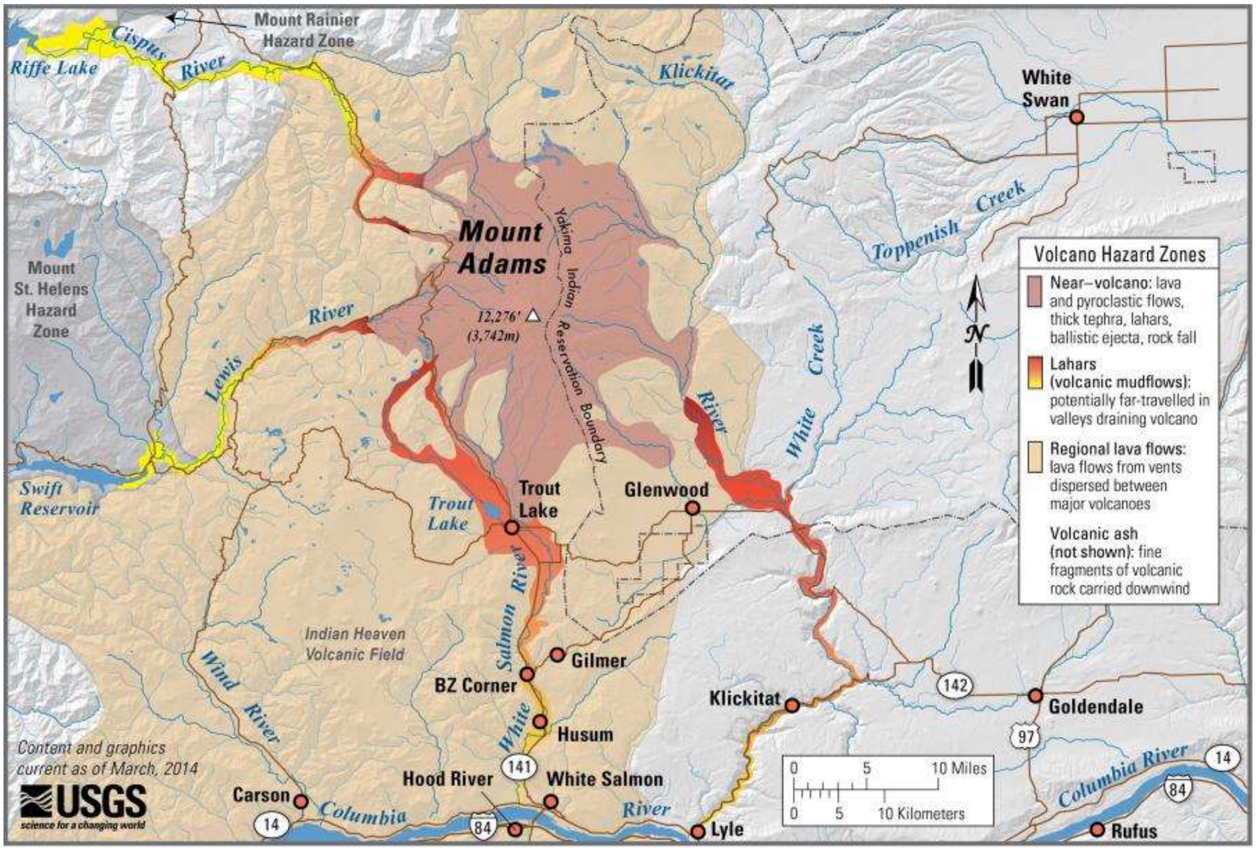


Figure 13-9 Volcano Hazard Zones from Mount Adams

13.2.4 Frequency

Many Cascade volcanoes have erupted in the recent past and will be active again in the foreseeable future. Given an average rate of one or two eruptions per century during the past 12,000 years, these disasters are not part of everyday experience; however, in the past hundred years, California's Lassen Peak and Washington's Mount St. Helens have erupted with terrifying results. The U.S. Geological Survey classifies Glacier Peak, Mt. Adams, Mt. Baker, Mt. Hood, Mt. St. Helens, and Mt. Rainier as potentially active volcanoes in Washington State. Mt. St. Helens is by far the most active volcano in the Cascades, with four major explosive eruptions in the last 515 years. There is a one (1) in 500 probability that portions of two counties in the state will receive four (4) inches or more of volcanic ash from any Cascade volcano in any given year. The probability increases to one (1) in 1,000 that parts, or all, of three or more counties will receive same quantity. There is a one (1) in 100 annual probability that small lahars or debris flows will impact river valleys below Mount Baker and Mount Rainier, with a less than 1:1,000 annual probability that the largest destructive lahars would flow down Glacier Peak, Mount Adams, Mount Baker or Mount Rainier. Based on USGS analysis, Grays Harbor County has a 0.01 to <0.01 percent probability of ash or tephra collection in any given year (see Figure 13-10).

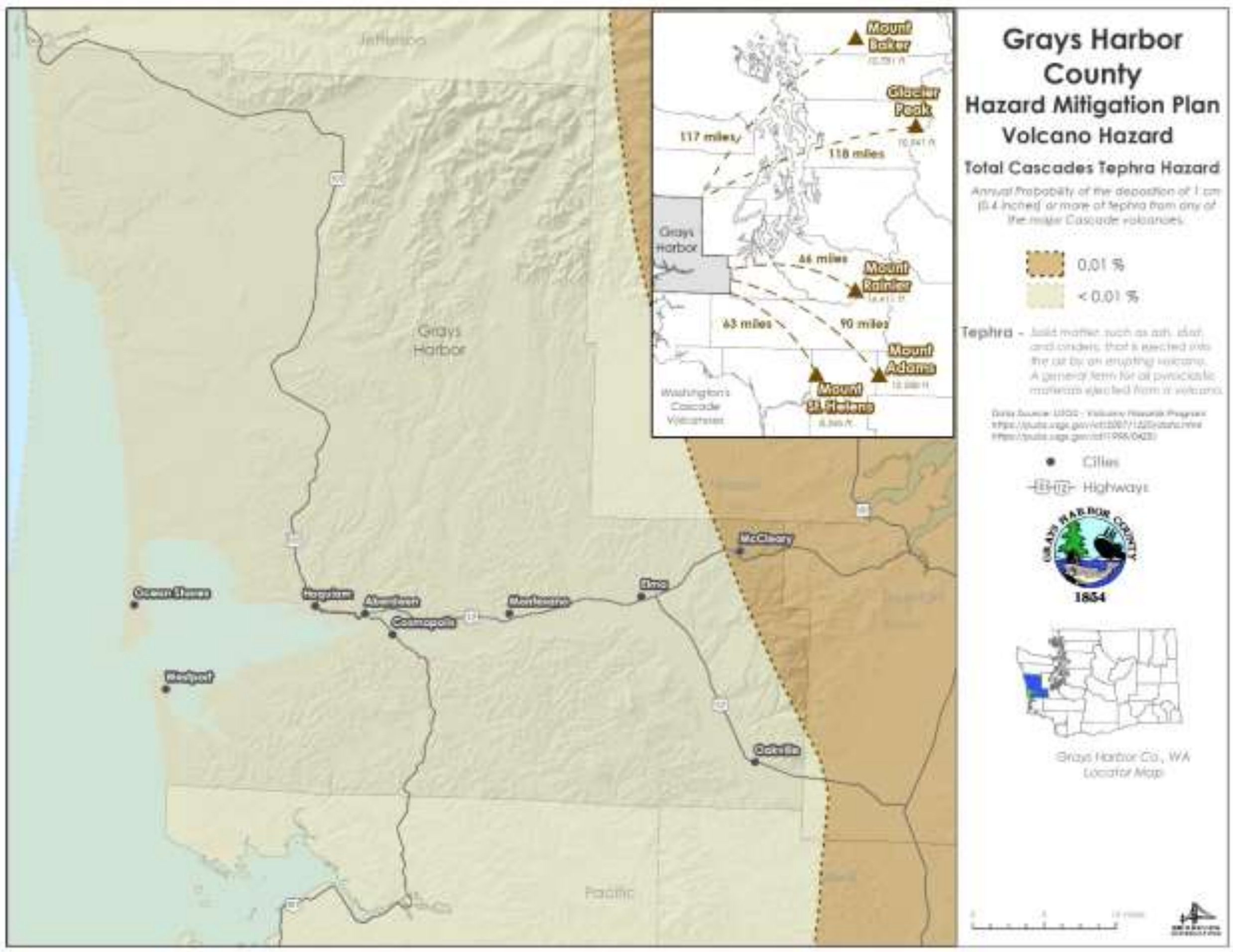


Figure 13-10 Grays Harbor County Volcano Hazard

13.3 VULNERABILITY ASSESSMENT

13.3.1 Overview

The planning area did report a significant amount of ashfall as a result of Mount St. Helens' eruption. Given the acidic nature of ash, the impact to the environment was of great concern.

The closest Cascade volcanoes to the planning area are Mt. Rainier, Mount St. Helens and Mt. Adams. A lahar is not of primary concern for those volcanoes within the region as identified in the above graphics, but secondary impacts from ash and commodity flow could cause low to moderate issues.

According to the USGS analysis, westerly winds dominate in the Pacific Northwest sending volcanic ash east and north–eastward about 80–90 percent of the time, though ash can blow in any direction. However, even 10 percent of ash reaching the Grays Harbor County or any of its coastlines could have a negative impact on the natural resources and the agricultural economy. The potential for fire danger also increases as a result of static charge contained within the ash.

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

Methodology

As the planning area would have no direct impact from a lahar generated by any of the volcanos of potential concern, no dollar losses can be associated with that aspect of the hazard. No historical data was available specifically for Grays Harbor County with respect to impact and losses associated with the eruption of Mount St. Helens on which an assessment could be based. In addition, there are currently no generally accepted damage functions for volcanic hazards in risk assessment platforms such as Hazus-MH or any GIS system for the ash fall associated with the hazard. There would also be too many variables to associate with any type of plume modeling for ash. Therefore, for planning purposes, it is assumed that the entire planning area is exposed to some extent to ash accumulations, and those structures could collapse under excessive weight of tephra and rainfall. Certain areas are more exposed due to geographic location and local weather patterns, as well as the response capabilities of local first responders.

Warning Time

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

The U.S. Geological Survey (USGS) volcanic alert-level system provides the framework for the preparedness activities of local jurisdictions, tribal governments and state and federal agencies. The USGS ranks the level of activity at a U.S. volcano using the terms "Normal", for typical volcanic activity in a non-eruptive phase; "Advisory", for elevated unrest; "Watch", for escalating unrest or a minor eruption underway that poses limited hazards; and, "Warning", if a highly hazardous eruption is underway or imminent. These levels reflect conditions at a volcano and the expected or ongoing hazardous volcanic phenomena. When an alert level is assigned by an observatory, accompanying text will give a fuller explanation of the observed phenomena and clarify hazard implications to affected groups. The USGS Cascade Volcano Observatory works in conjunction with PNSN to provide constant monitoring and notification when activities increase. Figure 13-11 depicts one of the sensors used by USGS and PNSN for monitoring purposes. Figure 13-12 identifies the various types of remote sensing devises available.

Since 1980 and 2004, 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.

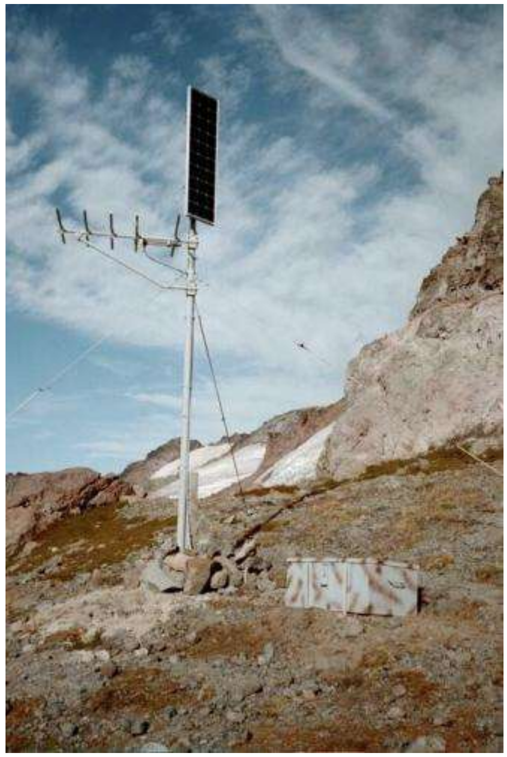


Figure 13-11 Monitoring Equipment

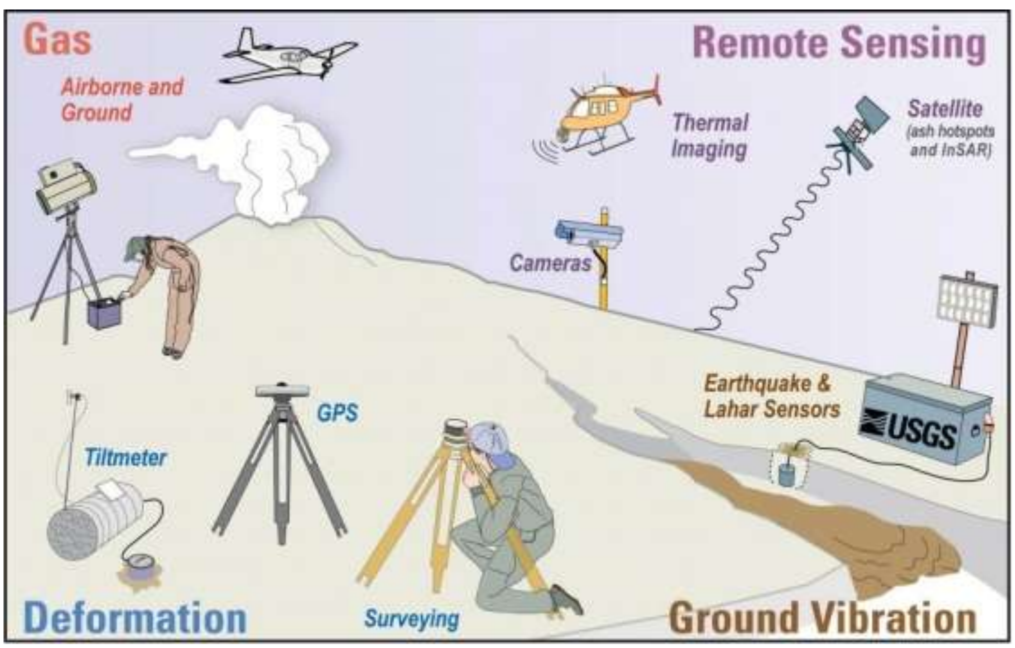


Figure 13-12 Remote Sensing Devices

13.3.2 Impact on Life, Health, and Safety

The entire population of the planning area, as well as any tourists traveling through to the various tourist attractions could be exposed to ash and its side effects. When an ash cloud combines with rain, sulfur dioxide in the cloud combines with the rainwater to form diluted sulfuric acid that may cause minor, but painful burns to the skin, eyes, nose, and throat. Given the high amount of annual rainfall and the constant mist from the ocean waves, this increases the potential impact on the population. The elderly, very young and those who experience ear, nose and throat problems are especially vulnerable to the tephra hazard, as well as the ash itself causing respiratory issues. In addition, the high number of tourists who annually visit the area would potentially increase the number of people to which the region would have to provide emergency services, housing, and associated support.

13.3.3 Impact on Property

All of the planning area to some degree would be exposed to ash fall and tephra accumulation in the event of a volcanic eruption. The age of the current building stock does not lend itself to be able to withstand large amounts of accumulation of ash on rooftops, as a one-inch deep layer of ash weighs an average of 10 pounds per square foot. This added weight to the aged buildings would increase the danger of structural collapse. Additionally, ash is harsh, acidic and gritty, and may carry a high static charge for up to two days after being ejected from a volcano. This static charge has the potential for igniting forest fires in the densely forested areas.

As indicated, loss estimations for the volcano hazard could not be based on modeling utilizing damage functions, as no such functions have been generated. Instead, loss estimates were developed representing 10 percent, 30 percent and 50 percent of the assessed value of all structures. This allows emergency managers to select a range of economic impact based on an estimate of the percent of damage to the 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 13-2 identifies the structural loss by count and assessed value (including content), at the identified percentages.

Table 13-2 Potential Structure Impact From Ash Accumulation

Jurisdiction	Estimated Building Count	Total Building Value (Structure and contents in $)	Exposed Building and Content Values 10-, 30-, and 50 Percent		
			10 Percent	30 Percent	50 Percent
City of Aberdeen	6,331	$1,558,813,283	$155,881,328	$467,643,985.02	$779,406,641.71
City of Cosmopolis	740	$219,110,855	$21,911,085	$65,733,256.35	$109,555,427.25
City of Elma	1,225	$345,049,384	$34,504,938	$103,514,815.19	$172,524,691.98
City of Hoquiam	3,457	$668,170,030	$66,817,003	$200,451,009.05	$334,085,015.08
City of McCleary	664	$138,539,384	$13,853,938	$41,561,815.05	$69,269,691.75
City of Montesano	1,554	$433,872,272	$43,387,227	$130,161,681.49	$216,936,135.82
City of Oakville	331	$66,998,060	$6,699,806	$20,099,418.00	$33,499,030.00
City of Ocean Shores	4,600	$1,156,337,793	$115,633,779	$346,901,337.97	$578,168,896.61
City of Westport	1,291	$310,030,743	$31,003,074	$93,009,222.99	$155,015,371.64
Unincorporated Grays Harbor County	12,816	$3,122,630,417	$312,263,042	$936,789,125.05	$1,561,315,208.42
Other(4)	718	$177,559,756	$17,755,976	$53,267,926.71	$88,779,877.85
Grays Harbor County	33,727	$8,197,111,976	$819,711,198	$2,459,133,592.86	$4,098,555,988.11

13.3.4 Impact on Critical Facilities and Infrastructure

None of the critical facilities within the planning region would be exposed to lahar inundation, but all would be exposed to the weight of ash, and, because of the age of the building stock, may fail to withstand the weight of the ash. All transportation routes in the area would be exposed to ash fall and tephra accumulation, which could create hazardous driving conditions on roads and highways and hinder evacuations and response. Utilities, including water treatment plants and wastewater treatment plants are vulnerable to contamination from ash fall, as well as impact from the ash itself that could damage motors.

13.3.5 Impact on Economy

Economic impact could result from potential aqua- and agri-cultural losses, the loss of tourism due to suspended travel and visitors to the area, structural losses, including businesses and governmental offices/buildings. Lost tax revenues from businesses disrupted by structural damage or as a result of fewer patrons would impact the area's economy. The tourism industry could also be impacted for a substantial amount of time if ash impacts the fishing industry.

13.3.6 Impact on Environment

The environment is highly exposed to the effects of a volcanic eruption. Even if the related ash fall from a volcanic eruption were to fall elsewhere, the watersheds, lakes, rivers and tributaries are vulnerable to damage due to ash fall since ash fall can be carried throughout the County by its rivers. A volcanic blast would expose the local environment to other effects, such as lower air quality, and many elements that could harm local vegetation and water quality, adversely impact wildlife and fish habitat. The sulfuric acid contained in volcanic ash could be very damaging to area vegetation, increasing the risk of wildfire danger, as well as wildlife.

13.4 FUTURE DEVELOPMENT TRENDS

Under the GMA, the County and its planning partners utilize the most recent building codes adopted by the State of Washington, which requires more stringent regulations with respect to support and payload structuring of facilities. Land use development has little influence as the area is not directly impacted by a Lehar zone. However, building codes with respect to load capacity does influence the ability to withstand impact. Grays Harbor County and its planning partners have adopted current IBC standards, which address the load capacity.

13.5 ISSUES

In the event of a volcanic eruption, there would probably not be any direct loss of life in the planning area as a direct result of the eruption. However, there could be significant health issues related to ash fall and health concern (especially for the young, elderly and those with breathing issues). In addition, there is also the potential for the increased potential for motor vehicle accidents; and potential structural damage if large amounts of ash accumulate as a result of the weight of the ash on structures. The potential exists for impact on the agricultural community, which would have an economic impact on the planning region. There would also be the possibility of severe environmental impacts due to ash within area lakes and streams, with the water supply potentially impacted by ash. A large area could be affected by this, and it is felt that the most severe impacts would be on the planning area's environment and the water supply.

13.6 RESULTS

Based on review and analysis of the data, the Planning Team has determined that the probability for impact from Volcanic eruption throughout the area is low, with impact limited. The area has experienced some level of ashfall with the last eruption of Mount St. Helens.

Implementation of mitigation strategies which help increase load capacities on roofs could potentially help reduce the number of structures at risk, but the environmental and economic impact cannot be so easily mitigated. Based on the potential impact, the Planning Team determined the CPRI score to be 1.55, with overall vulnerability determined to be a low level.

CHAPTER 14.
WILDFIRE

A wildfire is any uncontrolled fire occurring on undeveloped land that requires fire suppression. Wildfires can be ignited by lightning or by human activity such as smoking, campfires, equipment use, and arson. The wildfire season in Washington usually begins in April, picks up in early July, and generally ends in late September; however, wildfires have occurred every month of the year. Drought, snow pack, and local weather conditions can expand the length of the fire season.

People start most wildfires; major causes include arson, recreational fires that get out of control, smoker carelessness, debris burning, and children playing with fire. Wildfires started by lightning burn more state-protected acreage than any other cause, an average of 10,866 acres annually; human caused fires burn an average of 4,404 state-protected acres each year. 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.

14.1 GENERAL BACKGROUND

Wildland-Urban Interface Areas

The wildland urban-interface (WUI) is the area where development meets wildland areas. This can mean structures built in or near natural forests, or areas next to active timber and rangelands. The federal definition of a WUI community is an area where development densities are at least three residential, business, or public building structures per acre. For less developed areas, the wildland-intermix community has development densities of at least one structure per 40 acres. Review of the 2013 Washington State Enhanced Hazard Mitigation Plan does designate portions of Grays Harbor County as having WUI Communities.

In 2001, Congress mandated the establishment of a Federal Register which identifies all urban wildland interface communities within the vicinity of Federal lands, including Indian trust and restricted lands that are at high-risk from wildfire. The list assimilated information provided from States and Tribes, and is intended to identify those communities considered at risk. Review of the Federal Registry lists no communities within Grays Harbor County at high-risk within the vicinity of Federal lands.[50]

When identifying areas of fire concern, in addition to the Federal Register, the Washington Department of Natural Resources and its federal partners also determine communities at risk based on fire behavior potential, fire protection capability, and risk to social, cultural and community resources. These risk factors include areas with fire history, the type and density of vegetative fuels, extreme weather conditions, topography, number and density of structures and their distance from fuels, location of municipal watersheds, and likely loss of housing or business. The criteria for making these determinations are the same as those used in the National Fire Protection Association's *NFPA 299 Standard for Protection of Life*

[50] https://www.federalregister.gov/documents/2001/01/04/01-52/urban-wildland-interface-communities-within-the-vicinity-of-federal-lands-that-are-at-high-risk-from

and Property from Wildfire. Based on these criteria, Grays Harbor County has some areas considered to be at high risk (see Figure 14-1, Figure 14-2, and Figure 14-3).[51]

(WDNR 2012)

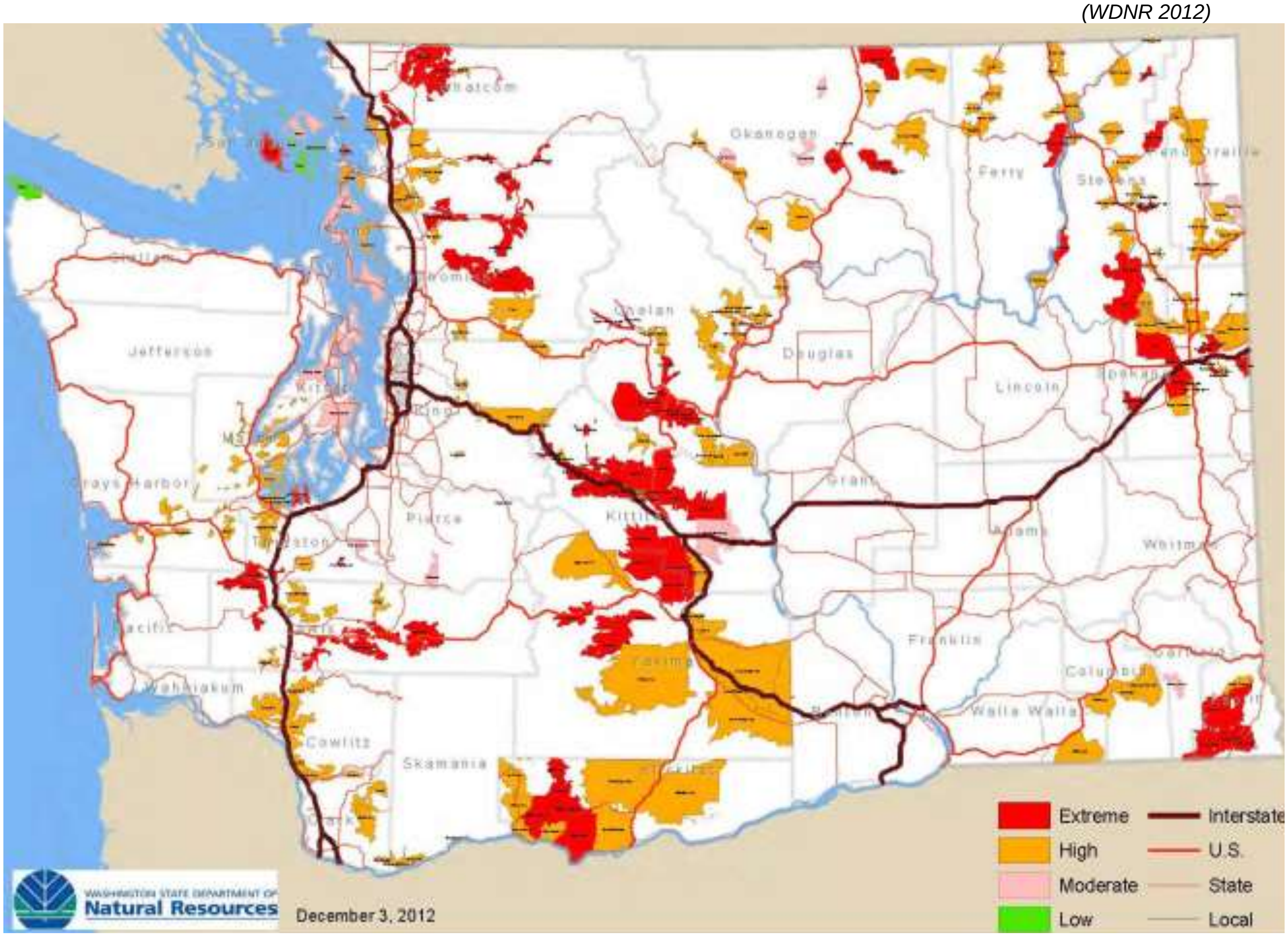


Figure 14-1 Level of Risk for Wildland Urban Interface Communities

[51] http://mil.wa.gov/uploads/pdf/HAZ%20MIT%20PLAN/Wildland_Fire_Hazard_Profile.pdf

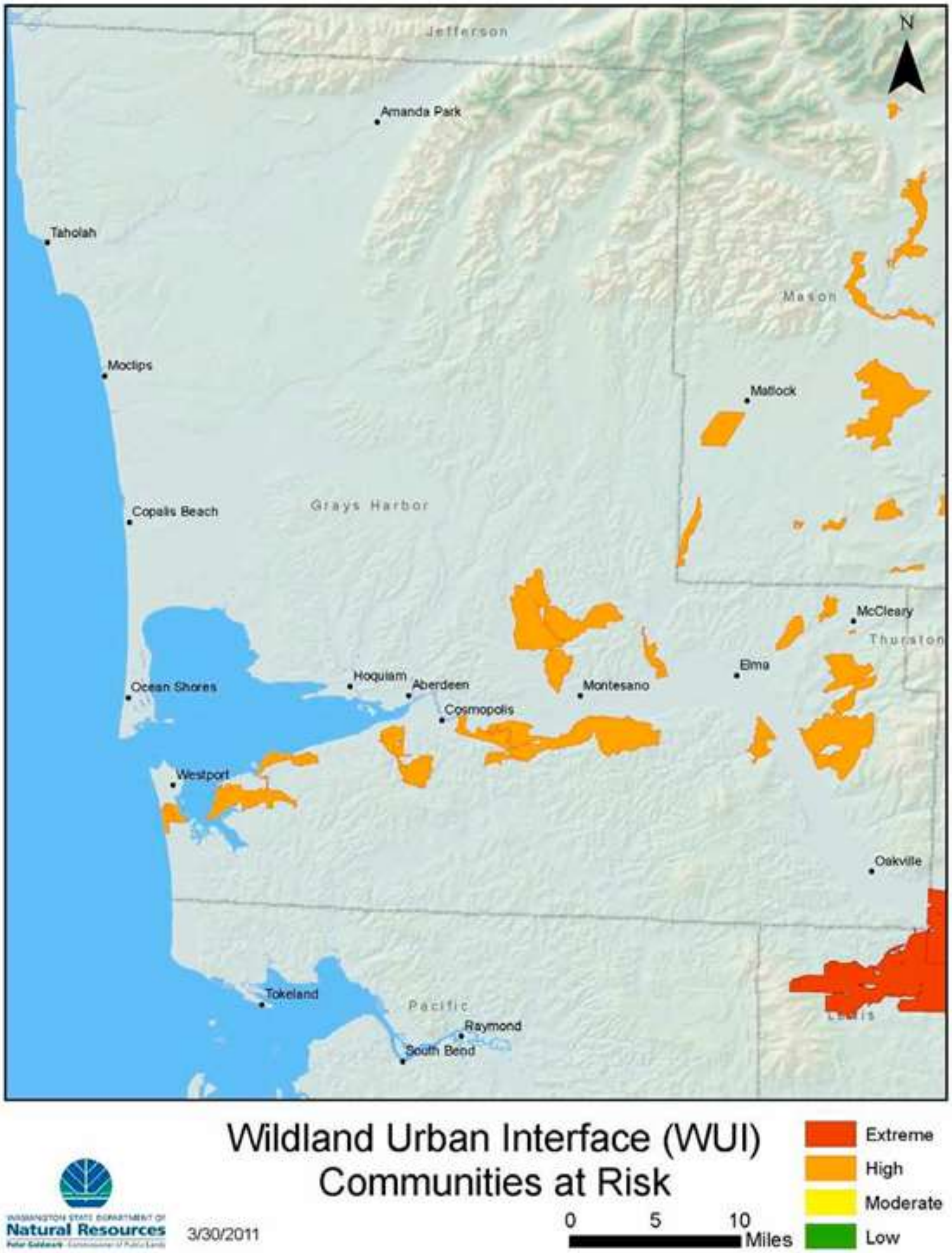


Figure 14-2 Wildland Urban Interface Communities at Risk - Grays Harbor County
Source: Washington State Department of Natural Resources, 2011

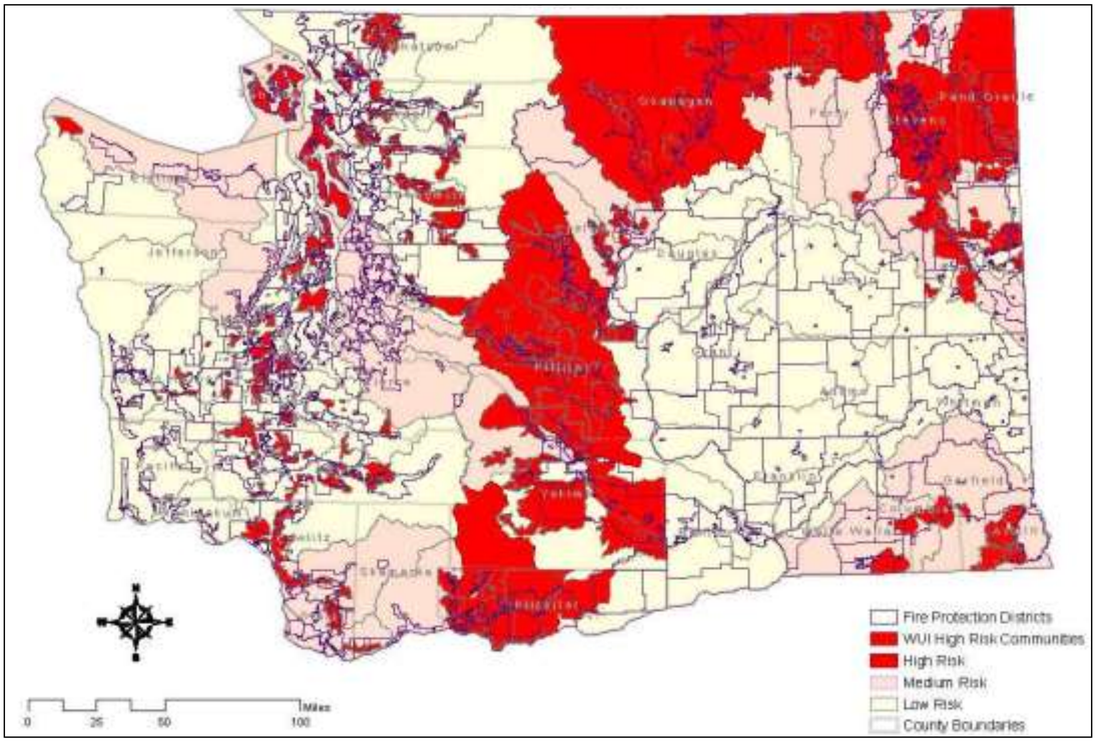


Figure 14-3 Washington WUI High Risk Communities, July 2011
Source: Washington State Department of Natural Resources 2011

14.1.1 Wildfire Behavior

The wildfire triangle (see Figure 14-4; DeSisto et al., 2009) is a simple graphic used in wildland firefighter training courses to illustrate how the environment affects fire behavior. Each point of the triangle represents one of three main factors that drive wildfire behavior: weather, vegetation type (which firefighters refer to as "fuels"), and topography. The sides represent the interplay between the factors. For example, drier and warmer weather combined with dense fuel loads (e.g., logging slash) and steeper slopes will cause more hazardous fire behavior than light fuels (e.g., short grass fields) on flat ground.

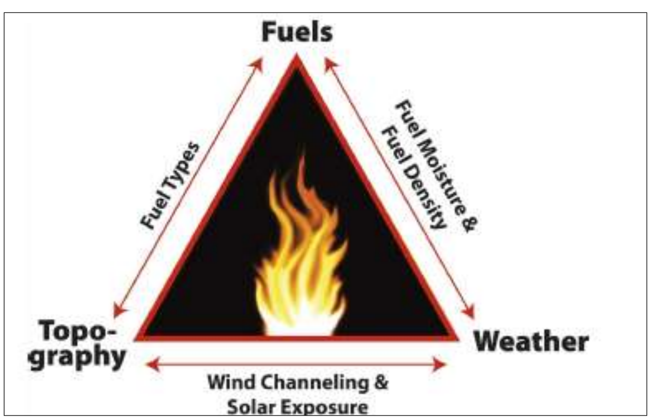


Figure 14-4 Wildfire Behavior Triangle

The following are key factors affecting wildfire behavior:

- **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 hazard trees—those that are diseased, dying, or dead—are larger but less prolific west of the Cascades than east of the Cascades. 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**— Relevant weather conditions include temperature, relative humidity, wind speed and direction, cloud cover, precipitation amount and duration, and the stability of the atmosphere. Of particular importance for wildfire activity are wind and thunderstorms:
    - Strong, dry winds produce extreme fire conditions. Such winds generally reach peak velocities during the night and early morning hours. East wind events can persist up to 48 hours, with wind speed reaching 60 miles per hour. Being a coastal community, the County experiences significant winds on a fairly regular basis during all times of the year.
    - 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.
- **Topography—**Topography includes slope, elevation and aspect. The topography of a region influences the amount and moisture of fuel; the impact of weather conditions such as temperature and wind; potential barriers to fire spread, such as highways and lakes; and elevation and slope of land forms (fire spreads more easily uphill than downhill).
- **Time of Day**—A fire's peak burning period generally is between 1 p.m. and 6 p.m.
- **Forest Practices—**In densely forested areas, stands of mixed conifer and hardwood stands that have experienced thinning or clear-cut provide an opportunity for rapidly spreading, high-intensity fires that are sustained until a break in fuel is encountered.

Fires can be categorized by their fuel types as follows:

- **Smoldering**—Involves the slow combustion of surface fuels without generating flame, spreading slowly and steadily. Smoldering fires can linger for days or weeks after flaring has ceased, resulting in potential large quantities of fuel consumed. They heat the duff and mineral layers, affecting the roots, seeds, and plant stems in the ground. These are most common in peat bogs, but are not exclusive to that vegetation.
- **Crawling**—Surface fires that consume low-lying grass, forest litter and debris.
- **Ladder**—Fires that consume material between low-level vegetation or forest floor debris and tree canopies, such as small trees, low branches, vines, and invasive plants.
- **Crown—**Fires that consume low-level surface fuels, transition to ladder fuels, and also consume suspended materials at the canopy level. These fires can spread rapidly through the top of a forest canopy, burning entire trees, and can be extremely dangerous (sometimes referred to as a "Firestorm").

Wildfires may spread by jumping or spotting, as burning materials are carried by wind or firestorm conditions. Burning materials can also jump over roadways, rivers, or even firebreaks and start distant fires. Updraft caused by large wildfire events draws air from surrounding area, and these self-generated winds can also lead to the phenomenon known as a firestorm.

14.1.2 Wildfire Impact

Short-term loss caused by a wildfire can include the destruction of timber, wildlife habitat, scenic vistas, and watersheds. Long-term effects include smaller timber harvests, reduced access to affected recreational areas, and destruction of cultural and economic resources and community infrastructure. Vulnerability to flooding increases due to the destruction of watersheds. The potential for significant damage to life and property exists in WUI areas, where development is adjacent to densely vegetated areas (DeSisto et al., 2009).

Forestlands in the planning area are susceptible to disturbances such as logging slash accumulation, forest debris due to weather damage, and periods of drought and high temperature. Forest debris from western red cedar, western hemlock, and Sitka spruce can be especially problematic and at risk to wildfires when slash is accumulated on the forest floor, because such debris resists deterioration. When ignited, these fuels can be explosive and serve as ladder fuels carrying fire from the surface to the canopy.

14.1.3 Identifying Wildfire Risk

Risk to communities is generally determined by the number, size and types of wildfires that have historically affected an area; topography; fuel and weather; suppression capability of local and regional resources; where and what types of structures are in the WUI; and what types of pre-fire mitigation activities have been completed. Identifying areas most at risk to fire or predicting the course a fire will take requires precise science. The following data sets are most useful in assessing risk in the area:

- **Topography (slope and aspect) and Vegetation (fire fuels)**—These are two of the most important factors driving wildfire behavior.
- **Weather**—Regional and microclimate variations can strongly influence wildfire behavior. Because of unique geographic features, weather can vary from one neighborhood to another, leading to very different wildfire behavior.
- **Critical Facilities/Asset Location**—A spatial inventory of assets—including homes, roads, fire stations, and natural resources that need protection—in relation to wildfire hazard helps prioritize protection and mitigation efforts.

14.1.4 Community Wildfire Protection Plan

In response to several significant fires occurring throughout the United States from 1995 to 2000, Congress implemented the National Fire Plan—now called the National Cohesive Wildland Fire Management Strategy (Cohesive Strategy)—to seek national solutions for wildfire management. To participate, a community must identify its WUIs and then develop strategies to reduce their impact. This often includes development of a Community Wildfire Protection Plan (CWPP). Many communities also elect to become a Firewise Community (discussed below).

A CWPP identifies communities at risk, prioritizes hazardous fuel treatments, and recommends ways to reduce structural ignitability. Grays Harbor County currently does not have a Community Wildfire Protection Plan, but have developed planning guides to assist communities who wish to develop a CWPP in the future.

For purposes of developing this Hazard Mitigation Plan Update, and in support of future CWPP development, some components of a CWPP are referenced in this plan. Over the course of the next five years, the County and its planning partners may elect to pursue grant funding to develop a CWPP.

Firewise Communities USA™

The NFPA's Firewise USA program encourages local solutions for safety by involving homeowners in taking individual responsibility for preparing their homes from the risk of wildfire. Firewise is a key component of Fire Adapted Communities – a collaborative approach that connects all those who play a role in wildfire education, planning and action with comprehensive resources to help reduce risk. Currently, while all of the Fire Departments throughout the County encourage the Firewise Program, there is only one recognized Firewise Community identified – Ocean Shores.[52]

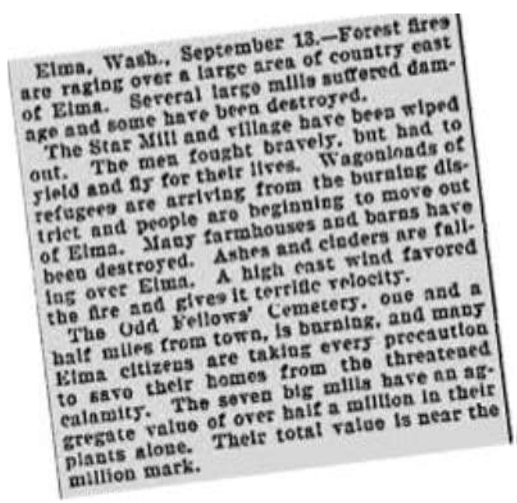
14.1.5 Secondary Hazards

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.

14.2 HAZARD PROFILE

14.2.1 Extent and Location

According to the Washington State Enhanced Hazard Mitigation Plan (2013) and FEMA disaster declaration records (2017), Grays Harbor County has never received a state or federal disaster declaration for a fire event. While the Washington State HMP does not identify Grays Harbor County has being high-risk to wildfire danger, this appears to be an error in the State's plan, as all other counties identified by DNR as high risk areas are identified within the State's plan as such, with the exception of Grays Harbor County. Given its rural land use complexity, densely wooded areas, and its proximity to the various large park systems (both federal and state), the entire region is susceptible to impact from wildfire, either as a direct result, or as a secondary result from health or economic impact.



Elma, Wash., September 13.—Forest fires are raging over a large area of country east of Elma. Several large mills suffered damage and some have been destroyed.

The Star Mill and village have been wiped out. The men fought bravely, but had to yield and fly for their lives. Wagonloads of refugees are arriving from the burning district and people are beginning to move out of Elma. Many farmhouses and barns have been destroyed. Ashes and cinders are falling over Elma. A high east wind favored the fire and gives it terrific velocity.

The Odd Fellows' Cemetery, one and a half miles from town, is burning, and many Elma citizens are taking every precaution to save their homes from the threatened calamity. The seven big mills have an aggregate value of over half a million in their plants alone. Their total value is near the million mark.

14.2.2 Previous Occurrences

Wildfires have been a common occurrence throughout Washington as a whole for thousands of years. Evidence from tree rings or fire-scarred trees indicates cycles of prehistoric fires burned in many locations in both Eastern and Western Washington. Natural fire occurrence is directly related, but not proportional, to lightning incidence levels. It is rare for a summer to pass without at least one period of lightning activity. Lightning incidence is greatest during July and August, though storms capable of igniting fires have occurred from early spring to mid-October. Lightning storms generally track across the park in a

[52] http://www.firewise.org/usa-recognition-program/state-listing-of-partcipants.aspx

southwest to northeast direction. At a national level, lightning starts over 4,000 house fires each year, which can ignite wildland fires through ember ignition and as a result of proximity to wildland areas. Lightning-caused fires cause over 10 times more acreage damage than human-caused fires, requiring great resource allocation.

Within Washington, lightning storms are typically followed by light to moderate amounts of precipitation. The rainfall may extinguish the fires, while high fuel moisture inhibits spread. However, prolonged periods of warm, dry weather, especially in combination with east winds, often reveal numerous latent "sleepers." While most lightning fires are less than a quarter acre in size, occasional large fires during dry periods account for most of the burned acreage.

Review of Washington State's Wildland Urban Fire Profile (2014), Grays Harbor County is not identified as one of those jurisdictions having a significant fire event since 1900. Nor are they identified has having a major wildland fire on any state protected land during the period of 1992-2012. Further reports from the Washington State Department of Natural Resources indicate no Type 1, 2, or 3 fires occurring in the County as of 2014 (most recent data available from DNR as of update).

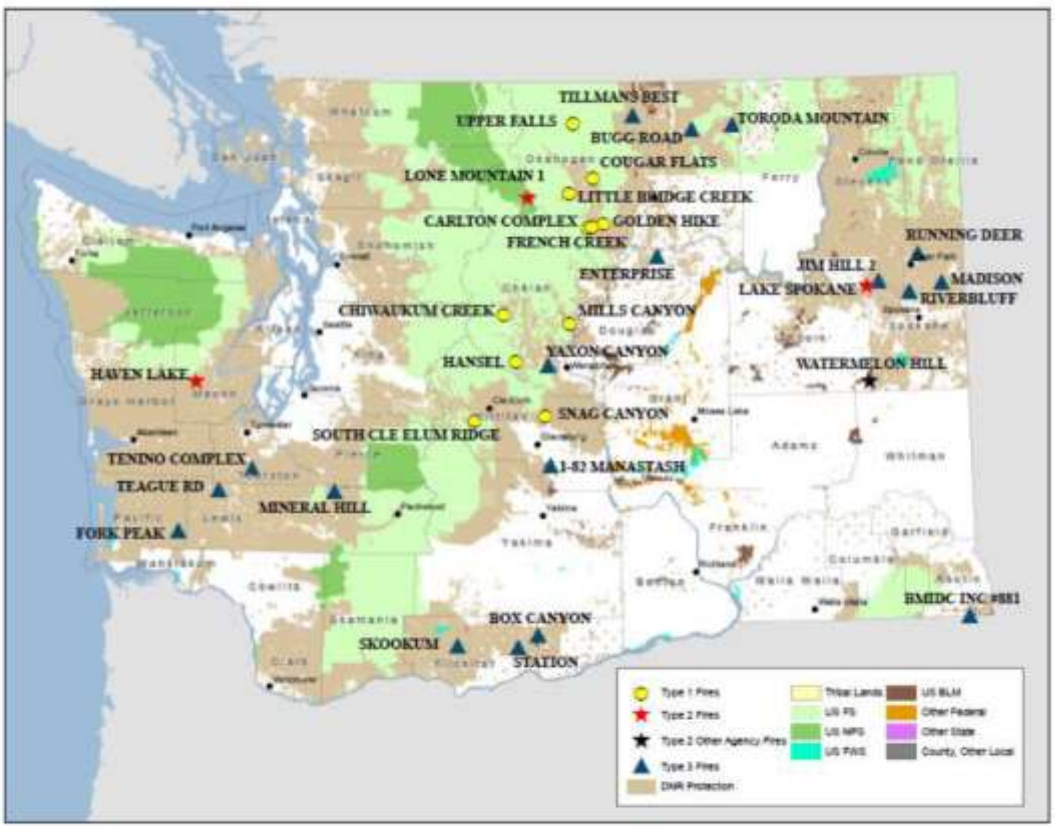


Figure 14-5 WDNR Typed Fires (2014)

During the time period 2004-2016, Grays Harbor County as a whole has experienced in excess of 242 wildfires, burning a total of 285 acres. Table 14-1 identifies the total number of fires and acres burned (updated data from 2014 forward was requested from WDNR, but due to an on-going and very active wildfire season, as of the time of this update, no information was received. As additional information comes in, this table will be enhanced).[53] Additional significant events are also identified in Table 14-2.

Table 14-1
Total Number Wildfire Events 2004-2016

Year	Total Number of Wildland Fires	Total Acres Burned
2004	32	20.5
2005	29	21.52
2006	49	81.07
2007	30	16.8
2008	15	14.2
2009	18	12.2
2010	15	7.46
2011	15	6.45
2012	23	44.95
2013	16	60.79
2014	Unknown	Unknown
2015	Unknown	Unknown
2016	Unknown	Unknown
Total	242	285.94

Table 14-2
Additional Historic Wildfire Incidents

1800	In the late 1800's, driftwood fires destroyed extensive woodpiles along beaches in southwest Washington State. The removal of this natural wood barrier eventually caused significant changes in the coastal shoreline. Sand dunes built up where none had been before, covering most of the coastal prairie. The destruction of the driftwood barricade also removed an effective obstacle against ocean winds and tide surges.
1867	Forest fires and smoke
1902	The famous fire of 1902 "crept to the outskirts of Elma and Montesano. Sweeping from Summit to Satsop, it cut a swath 13 miles long and from one to two miles wide, leaving a strip of charred and burning ruins. A dam on the west branch of the Hoquiam (River) burned and the New London

[53] Source: Washington State DNR, Washington State Enhanced Hazard Mitigation Plan Wildfire Profile (2014), and Grays Harbor County.

Table 14-2
Additional Historic Wildfire Incidents

	community was destroyed. Travel on the Wishkah road was impossible. The White Star mill and 1 million board feet of lumber turned into smoke. Telephone and telegraph lines to Puget Sound were cut by burning and falling timber. The smoke was so thick it blocked out the sun and sent the county into darkness.
July 1910	Forest fires, drought
August 1939	Forest fires, particularly near Copalis
June – August 1941	Forest fires
July 1945	Forest Fires
August 1951	Wildfire near Grayland

Unique to coastal communities are also the potential for dune fires, such as that figured right which occurred as a result of a campfire built in the dunes at Ocean Shores on April 20, 2015 (below). It is very common for campers or visitors along the beach to build fires with drift wood found along the beach; however, left unattended the results can be devasting if built too close to the dunes, or if high winds are occurring. The May 30, 2017 dune fire (below) which started as a 30' x 30' area, quickly spread to approximately three acres before being extinguished by local firefighting agencies, requiring a total of 14 firefighters to extinguish the blaze which was also pushed by wind.[54]

Figure 14-6 Ocean Shores Dune Fire (April 2015)

Figure 14-7 May 30, 2017 Ocean Shores Dune Fire

[54] https://www.northcoastnews.com/news/combined-effort-to-extinguish-seasons-first-dunes-fire/

14.3 SEVERITY

Potential losses from wildfire include human life, structures and other improvements, and natural resources. Smoke and air pollution from wildfires can be a health hazard, especially for sensitive populations such as children, the elderly and those with respiratory and cardiovascular diseases. Wildfire may also threaten the health and safety of those fighting the fires. Wildfire can lead to ancillary impacts such as landslides in steep ravine areas and flooding due to the impacts of silt in local watersheds. A large-scale wildfire would destroy timber and logging equipment, and the natural habitat for generations.

Extreme fires, when they occur, are characterized by more intense heat and preheating of surrounding fuels, stronger flame runs, potential tree crowning, increased likelihood of significant spot fires, and fire-induced weather (e.g., strong winds, lightning cells). Extreme fire behavior is significantly more difficult to combat and suppress, and can drastically increase the threat to homes and communities.

Due to many years of fire suppression, logging, and other human activities, the forests and rangelands of planning area have changed. Areas that historically experienced frequent, low-severity wildfires now burn with much greater intensity due to the build-up of understory brush and trees. At times, this equates to fires which are larger and more severe, killing the trees and vegetation at all levels. The combination of steep slopes, canyons, open rangeland, and fuel type have a history and potential for fast moving and fast spreading wildfires.

The Grays Harbor County planning area is vulnerable to wind-driven fires, whose embers could ignite grasses and weeds, and cause spot fires in more populated areas. Despite its relatively wet climate, large destructive fires have, and will continue, to occur. Typical summer conditions could prove to be problematic due to a fire moving uphill from a structure fire on a lower slope, or from a wildland fire pushing upslope through the trees on a windy day, endangering multiple homes simultaneously in a very short period of time. Residents would have very short notice of an approaching fire.

Based on Washington Department of Natural Resources reports, areas within the county classified as "wildland-urban interface communities" susceptible to high fire risk include: Montesano, Porter, the Capitol Forest, and west Grays Harbor County (GH HMP, 2014).

14.3.1 Frequency

As previously indicated, none of Washington State's most significant wildfires have occurred in Grays Harbor County, although smaller fires have occurred in the region annually. Fires historically burn on a regular cycle, recycling carbon and nutrients stored in the ecosystem, and strongly affecting species within the ecosystem. The burning cycle in western Washington is approximately every 100 to 150 years.

Historically, drought patterns are related to large-scale climate patterns in the Pacific and Atlantic oceans. The El Niño–Southern Oscillation 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.

Historic Fire Regime

Many ecosystems are adapted to historical patterns of fire. 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. A fire regime refers to the frequency and intensity of natural fires occurring in various ecosystem types. Alterations of historical fire regimes and vegetation dynamics have occurred in many landscapes in the

U.S., including Grays Harbor County through the combined influence of land management practices, fire exclusion, insect and disease outbreaks, climate change, and the invasion of non-native plant species. Anthropogenic influences to wildfire occurrence have been witnessed through arson, incidental ignition from industry (e.g., logging, railroad, sporting activities), and other factors. Likewise, wildfire abatement practices have reduced the spread of wildfires after ignition. This has reduced the risk to both the ecosystem and the urban populations living in or near forestlands, such as portions of Grays Harbor County.

The LANDFIRE Project produces maps of simulated historical fire regimes and vegetation conditions using the LANDSUM landscape succession and disturbance dynamics model. The LANDFIRE Project also produces maps of current vegetation and measurements of current vegetation departure from simulated historical reference conditions. These maps support fire and landscape management planning outlined in the goals of the National Fire Plan, Federal Wildland Fire Management Policy, and the Healthy Forests Restoration Act. The simulated historical mean fire return interval data layer quantifies the average number of years between fires under the presumed historical fire regime. This data is derived from simulations using LANDSUM. LANDSUM simulates fire dynamics as a function of vegetation dynamics, topography, and spatial context, in addition to variability introduced by dynamic wind direction and speed, frequency of extremely dry years, and landscape-level fire characteristics. The historical fire regime groups simulated in LANDFIRE categorize mean fire return interval and fire severities into five regimes defined in the Interagency Fire Regime Condition Class Guidebook:

- Regime 1: 0-35 year frequency, low to mixed severity
- Regime II: 0-35 year frequency, replacement severity
- Regime III: 35-200 year frequency, low to mixed severity
- Regime IV: 35 -200 year frequency, replacement severity
- Regime V: 200+ year frequency, any severity

Large wildfires have historically been infrequent in the coastal regions of the Pacific Northwest. While fires have occurred in the planning area, due to firefighting efforts, many have been contained with limited impact on acreage burned. Fire regimes in Grays Harbor County are illustrated in Figure 14-8. It should be noted that not all regime classes fall within the county boundary. The majority of the County falls within the 200-year frequency. This is also confirmed by DNR's latest identification of Fire Regime Groups, which illustrate the majority of Grays Harbor County's frequency to also be 200+ years (see Figure 14-9).

The Mean Fire Return Interval (MFRI) layer quantifies the average period between fires under the presumed historical fire regime. MFRI is intended to describe one component of historical fire regime characteristics. As illustrated, the average Mean Fire Return Interval for the majority of Grays Harbor County is every 200+ years (see Figure 14-10).

Figure 14-8 LANDFIRE Fire Regimes in Grays Harbor County

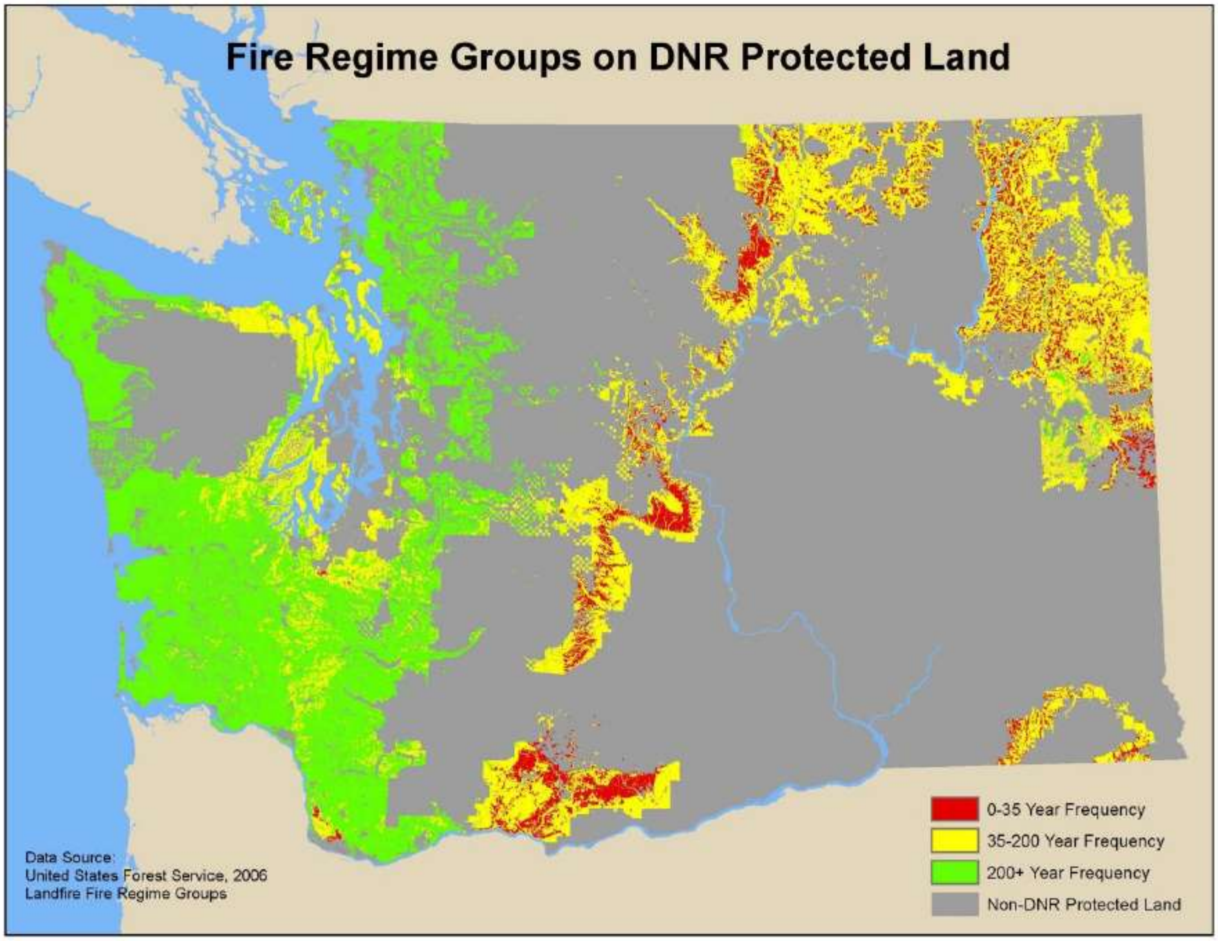


Figure 14-9 Washington State Department of Natural Resources Fire Regime Groups
Source: Washington State HMP, 2014

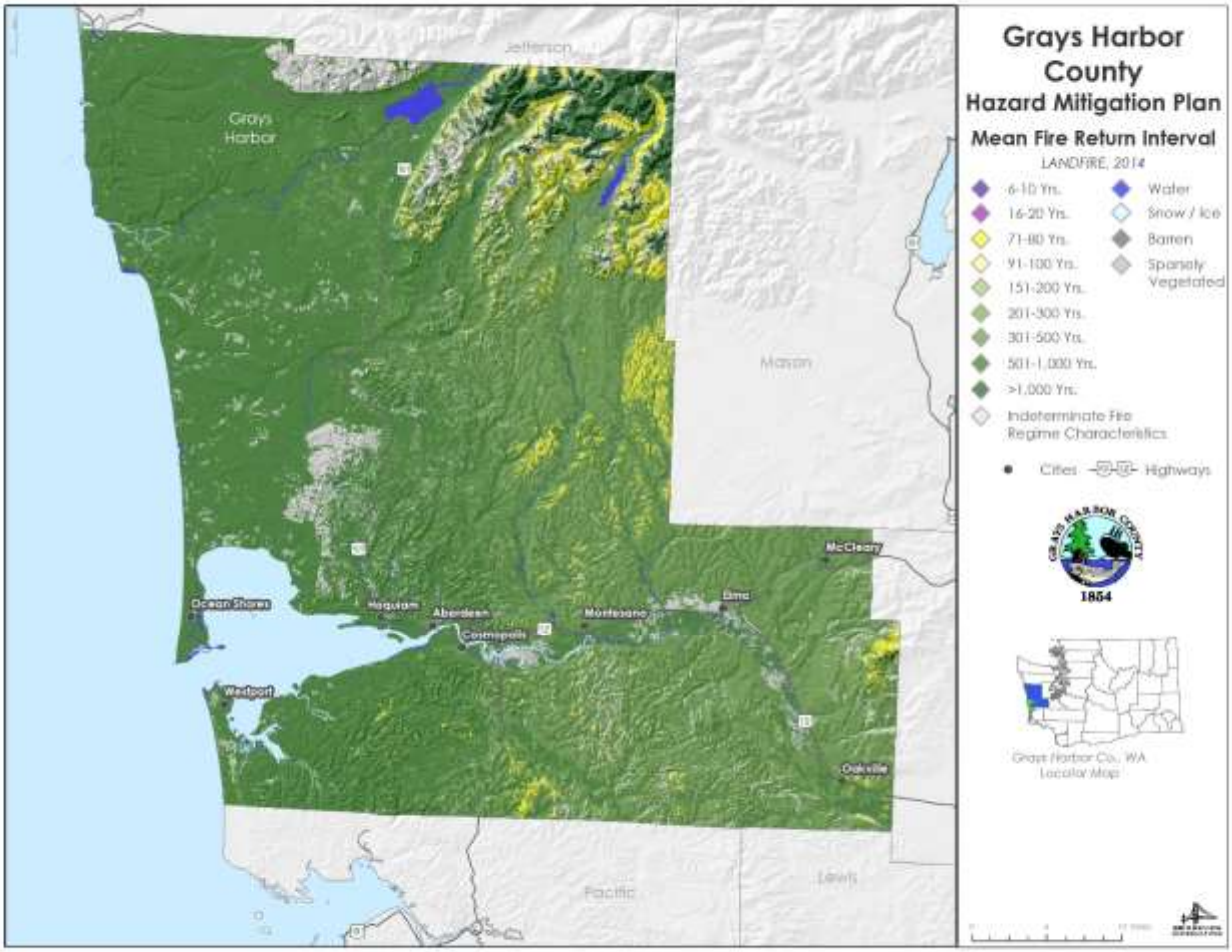


Figure 14-10 Mean Fire Return Interval

The existing Vegetation Condition Class (VCC) is identified in Figure 14-11. VCC represents a simple categorization of the associated Vegetation Departure (VDEP) layer and indicates the general level to which current vegetation is different from the simulated historical vegetation. The classes of variation range are low, medium and high. The variation of vegetation class directly influences fire.

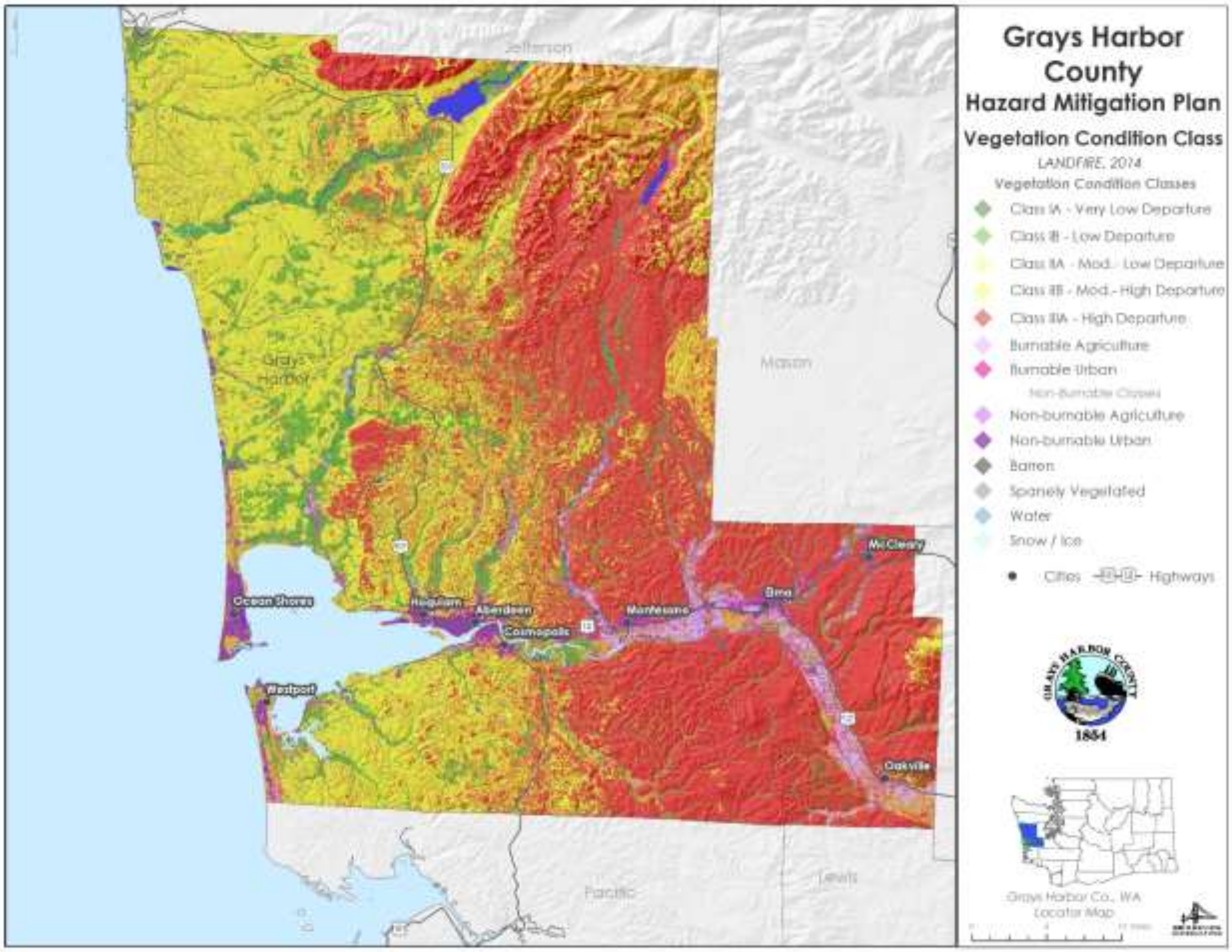


Figure 14-11 Vegetation Condition Class

14.4 VULNERABILITY ASSESSMENT

14.4.1 Overview

Structures, above-ground infrastructure, critical facilities and natural environments are all vulnerable to the wildfire hazard.

Methodology

There is currently no validated damage function available to support wildfire mitigation planning because no such damage functions have been generated. Instead, dollar loss estimates were developed by calculating the assessed value of exposed structures identified utilizing the various LANDFIRE Fire Regime (1-5) datasets. Population impact also utilized the various Fire Regimes, with population estimated using the exposed structure count of buildings in each Fire Regime area and applying the census value of two (2) persons per household for Grays Harbor County.

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.

Understanding the relationship between weather, potential fire activity, and geographical features enhances the ability to prepare for the potential of wildfire events. This knowledge, when paired with emergency planning and appropriate mitigation measures, creates a safer environment.

Wildfire studies can analyze weather data to assist firefighters in understanding the relationship between weather patterns and potential fire behavior. Fire forecasting examines similarities between historical fire weather and existing weather and climate values. These studies have determined that for areas such as Grays Harbor County, any combination of two of the following factors can create more intense and potentially destructive fire behavior, known as extreme fire behavior:

- Sustained winds from the east
- Relative humidity less than 40 percent
- Temperature greater than 72º Fahrenheit
- Periods without precipitation greater than 14 days in duration
- 1,000-hour fuel moisture less than 17 percent.

If a fire breaks out and spreads rapidly, residents may need to evacuate within a short timeframe. A fire's peak burning period generally is between 1 p.m. and 6 p.m. In normal situations, fire alerting would commence quickly, helping to reduce the risk. However, in more remote locations of the County, or in areas where cell phone services are sporadic at times, warning time and calls for assistance may be reduced.

14.4.2 Impact on Life, Health, and Safety

While there are no recorded fatalities from wildfire in the planning area, a statistical number of the population vulnerable to impact from fire is impossible to determine with any accuracy, due to the high number of variables that impact fire scenarios. The population at risk must also take into consideration tourists given the County's proximity to the campsites, parklands, and other Washington high-tourist destinations. With its high tourism rate, especially during summer months, there is an increase in the population vulnerability to fire. Given the increase in tourism during the summer months, when fire danger is at its greatest, increased consideration must be taken into account for fire response.

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. Grays Harbor County has a high population of retirees and individuals over 65, further increasing the potential impact on the fire hazard. 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 also threatens the health and safety of those fighting fires. First responders are exposed to the dangers from the initial incident and after-effects from smoke inhalation and heat stroke. The county does have a high number of elderly citizens.

Exposure to wildfire in Grays Harbor County is dependent upon many factors. The maps used in the analysis show areas of relative importance in determining fire risk, though they do not provide sufficient data for a statistical estimation of exposed population. For purposes of this assessment, the various Fire Regimes were used with population estimated using the structure count of buildings exposed within the various Fire Regime areas, and applying the census value of 2.5 persons per household for Grays Harbor County. These estimates are shown in Table 14-3 and Table 14-4. Not calculated within the potential impact is the number of tourists who may be visiting the area at any given time. Not all Fire Regimes are applicable to the planning area.

Table 14-3
Population Within Fire Regime Areas

	Fire Regime 1		Fire Regime 1		Fire Regime 3		Fire Regime 3	
	RES1, RES2, RES3(A,B,C) Population	% Of Total	# Of RES4 & RES5 Structures	% Of Total RES4 & RES5 Structures	RES1, RES2, RES3 (A,B,C) Population	% Of Total	# Of RES4 & RES 5 Structures	% Of Total RES4 & RES 5 Structures
Unincorporated Grays Harbor County	5.0	100%	0	0%	70	58.3%	0	0
City of Aberdeen	0	0%	0	0%	27.5	22.9%	0	0%
City of Cosmopolis	0	0%	0	0%	0	0%	0	0%
City of Elma	0	0%	0	0%	0	0%	0	0%
City of Hoquiam	0	0%	0	0%	0	0%	0	0%
City of McCleary	0	0%	0	0%	0	0%	0	0%
City of Montesano	0	0%	0	0%	0	0%	0	0%
City of Oakville	0	0%	0	0%	22.5	18.8%	0	0%
City of Ocean Shores	0	0%	0	0%	0	0%	0	0%
City of Westport	0	0%	0	0%	0	0%	0	0%
Other**								
Total	**5.0**	100%	0	0%	**120.0**	100.0%	0	0%

*Not all Fire Regimes exist in planning area. Therefore, only applicable Regimes are listed.
**Other includes Tribal, National Parks, and Military. Accurate population estimates for classifications are unavailable.
***RES1, RES2, and RES3(A, B or C) structures represent single and multi-family dwellings, RES4 and RES5 structures represent hotels/motels and institutional dormitories (i.e. jails, group housing for military or colleges)

Table 14-4
Population Within Fire Regime Areas

	Fire Regime 5		Fire Regime 5		Barren		Barren	
	RES1, RES2, RES3(A,B,C) Population	% of Total	# of RES4 & RES5 Structures	% of Total RES4 & RES5 Structures	RES1, RES2, RES3(A,B,C) Population	% of Total	# of RES4 & RES5 Structures	% of Total RES4 & RES5 Structures
Unincorporated Grays Harbor County	31,285.0	47.8%	606	86.4%	137.5	75.3%	1	20%
City of Aberdeen	1,562.5	2.4%	15	2.1%	10.0	5.5%	0	0%
City of Cosmopolis	1,772.5	2.7%	0	0%	10.0	5.5%	0	0%
City of Elma	2,855.0	4.4%	3	0.4%	0.0	0%	0	0%
City of Hoquiam	8,222.5	12.6%	12	1.7%	2.5	1.4%	0	0%
City of McCleary	1,572.5	2.4%	0	0%	0.0	0%	0	0%
City of Montesano	3,697.5	5.6%	4	0.6%	0.0	0%	0	0%
City of Oakville	680.0	1.0%	0	0%	0.0	0%	0	0%
City of Ocean Shores	11,000.0	16.8%	24	3.4%	22.5	12.3%	1	20%
City of Westport	2,847.5	4.3%	37	5.3%	0.0	0%	3	60%
Other**								
Total	**65,495.0**	100%	**701**	100%	**182.5**	100%	**5**	100%

*Not all Fire Regimes exist in planning area. Therefore, only applicable Regimes are listed.
**Other includes Tribal, National Parks, and Military. Accurate population estimates for classifications are unavailable.
***RES1, RES2, and RES3(A, B or C) structures represent single and multi-family dwellings, RES4 and RES5 structures represent hotels/motels and institutional dormitories (i.e. jails, group housing for military or colleges)

14.4.3 Impact on Property

Property damage from wildfires can be severe and can significantly alter entire communities. WDNR identifies relatively small portions of Grays Harbor County as being at high risk (Figures 14-1 through Figure 14-3). The potential exposure of the structures in the County should a fire occur is low, depending on the area, with the unincorporated county and its jurisdictions all having some degree of exposure to wildfire hazards. Details on the number of acres, and the number and value of structures exposed to LANDFIRE Wildfire Regimes 1, 3 and 5 are identified in Table 14-5 through Table 14-8. Not all regimes are applicable to the county as in the case of Regimes 2 and 4; therefore, no reference is identified within the tables for those Regimes.

Table 14-5 Grays Harbor County Acres in Wildfire Regime Groups								
Jurisdiction	**Barren**	**Fire Regime Group** *(Not all groups included in County)*			**Snow/ Ice**	**Sparsely Vegetated**	**Water**	**Total**
		I	**III**	**V**				
Unincorporated Grays Harbor	1,678.7	35.4	44,506.7	1,143,183.5	25.4	3.6	11,914.9	**1,201,348.2**
Aberdeen, City of	52.4	0.0	12.1	6,772.2	0.0	0.0	222.7	**7,059.2**
Cosmopolis, City of	4.2	0.0	0.0	867.6	0.0	0.0	34.5	**906.4**
Elma, City of	0.0	0.0	0.0	1,235.8	0.0	0.0	4.2	**1,240.1**
Hoquiam	28.0	0.0	0.0	6,008.2	0.0	0.0	187.7	**6,223.8**
McCleary	0.0	0.0	0.0	1,315.2	0.0	0.0	12.4	**1,327.6**
Montesano	0.7	0.0	123.9	6,526.4	0.0	0.0	32.5	**6,683.5**
Oakville	0.0	0.7	16.2	310.0	0.0	0.0	0.0	**326.8**
Ocean Shores	55.5	0.0	0.0	4,968.5	0.0	0.0	625.0	**5,649.0**
West Port	82.1	0.0	0.0	2,071.2	0.0	0.0	159.1	**2,312.4**
Total	**1,901.5**	**36.1**	**44,658.9**	**1,173,258.6**	**25.4**	**3.6**	**13,193.0**	**1,233,077.0**

Table 14-6 Planning Area Structures Exposed to LANDFIRE Fire Regime 1					
	Buildings Exposed	Estimated Value			% of Total Value
		Structure	Contents	Total	
Unincorporated Grays Harbor County	0	0	0	0	**0.00%**
City of Aberdeen	0	0	0	0	**0.00%**
City of Cosmopolis	0	0	0	0	**0.00%**
City of Elma	0	0	0	0	**0.00%**
City of Hoquiam	0	0	0	0	**0.00%**
City of McCleary	0	0	0	0	**0.00%**
City of Montesano	0	0	0	0	**0.00%**
City of Oakville	0	0	0	0	**0.00%**
City of Ocean Shores	0	0	0	0	**0.00%**
City of Westport	0	0	0	0	**0.00%**
Other	1	105,665	52,833	158,498	**0.09%**
Total	**1**	105,665	52,833	158,498	**0.00%**

Table 14-7
Planning Area Structures Exposed To LANDFIRE Fire Regime 3

	Buildings Exposed	Estimated Value			% of Total Value
		Structure	Contents	Total	
Unincorporated Grays Harbor County	24	$2,807,065	$1,403,533	$4,210,598	**0.1%**
City of Aberdeen	13	$1,075,520	$537,760	$1,613,280	**0.1%**
City of Cosmopolis	0	$0	$0	$0	**0.0%**
City of Elma	0	$0	$0	$0	**0.0%**
City of Hoquiam	0	$0	$0	$0	**0.0%**
City of McCleary	0	$0	$0	$0	**0.0%**
City of Montesano	0	$0	$0	$0	**0.0%**
City of Oakville	8	$859,325	$429,663	$1,288,988	**1.9%**
City of Ocean Shores	0	$0	$0	$0	**0.0%**
City of Westport	0	$0	$0	$0	**0.0%**
Other	7	$718,916	$359,458	$1,078,374	**0.6%**
Total	**52**	**$5,460,826**	**$2,730,413**	**$8,191,239**	**0.10%**

Table 14-8
Planning Area Structures Exposed To LANDFIRE Fire Regime 5

	Buildings Exposed	Estimated Value			% of Total Value
		Structure	Contents	Total	
Unincorporated Grays Harbor County	12,637	$1,724,033,095	$1,191,625,313	$2,915,658,407	**93.4%**
City of Aberdeen	6,304	$869,995,905	$685,050,349	$1,555,046,253	**99.8%**
City of Cosmopolis	735	$117,560,127	$98,215,723	$215,775,850	**98.5%**
City of Elma	1,224	$189,542,411	$155,381,973	$344,924,384	**100.0%**
City of Hoquiam	3,432	$360,302,086	$284,033,596	$644,335,682	**96.4%**
City of McCleary	664	$80,758,821	$57,780,563	$138,539,384	**100.0%**
City of Montesano	1,553	$261,416,493	$171,973,388	$433,389,882	**99.9%**
City of Oakville	323	$37,280,223	$28,428,850	$65,709,073	**98.1%**
City of Ocean Shores	4,519	$672,556,369	$376,870,582	$1,049,426,951	**90.8%**
City of Westport	1,261	$172,576,475	$122,183,006	$294,759,481	**95.1%**
Other	676	$98,434,402	$72,203,975	$170,638,377	**96.1%**
Total	**33,328**	**4,584,456,407**	**3,243,747,315**	**7,828,203,722**	**95.50%**

Density and the age of building stock in Grays Harbor County are contributing factors in assessing property vulnerability to wildfire. Many of the buildings in the planning area are of significant age, with many being constructed with wood frames and shingle roofs.

14.4.4 Impact on Critical Facilities and Infrastructure

Critical facilities of wood frame construction are especially vulnerable during wildfire events. In the event of wildfire, there would likely be little damage to most infrastructure. Most roads and railroads would be without damage except in the worst scenarios. Fueling stations could be significantly impacted. Power lines are also significantly 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 in Grays Harbor County could also impact wood-structured bridges, peers, and docks, which are utilized to moor watercraft, launch search and rescue vessels, dam safety inspections, shellfish harvesting, fishing vessels, or other private boats associated with tourism. Table 14-9 identifies critical facilities exposed to the wildfire hazard.

Hazardous Material Involved Fire Impact on Critical Facilities and Infrastructure

Currently there are in excess of 80 registered Tier II hazardous material containment sites throughout Grays Harbor County (based on 2017 reporting to Washington State Dept. of Ecology). During a wildfire event, hazardous material storage containers could rupture due to excessive heat and act as fuel for the fire, causing rapid spreading and escalating the fire to unmanageable levels. In addition the materials could leak into surrounding areas, saturating soils and seeping into surface waters, having a disastrous effect on the environment.

Table 14-9
Critical Facilities and Infrastructure Exposed to Fire Regime Areas

	Regime 1	Regime 3	Regime 5*	Barren	Water
Medical and Health Services	0	0	7	0	0
Government Function	0	0	37	0	0
Schools	0	0	82	1	0
Protective Function	0	0	71	1	0
Hazmat	0	0	70	2	0
Other Critical Function	0	1	10	0	0
Water	0	0	60	1	3
Wastewater	0	0	73	1	0
Power	0	0	40	3	0
Communications	0	0	60	0	0
Transportation	0	0	281	1	34
Other Critical Infrastructure	0	0	3	3	0
Total	0	1	794	13	37

*There are no Regimes 2 and 4 in the County.
** Facilities and Infrastructure located over water (i.e. bridges) on a structure or pier (i.e. ports or marinas)

14.4.5 Impact on Economy

The Grays Harbor economy is largely dependent on the forest industry. A large-scale wildfire would destroy timber and logging equipment. The economy could suffer from loss of supply for local industries dependent on raw logs to process. Tourism would also be impacted, as wildfire impact on the economy can be far reaching, ranging from damage to transportation routes to non-use of park facilities and campsites, to loss of structures influencing tax base from lost revenue.

Secondary impacts include erosion on burned slopes leading to runoff and contributing to flooding, landslides, and impacts to salmon-bearing streams. Wildfires in dune grass could destroy homes, hotels, restaurants and other tourist facilities while wildfires in farmlands could destroy crops, farms, and structures.

14.4.6 Impact on Environment

Fire is a natural and critical ecosystem process in most terrestrial ecosystems, dictating in part the types, structure, and spatial extent of native vegetation. However, wildfires can cause severe environmental impacts:

- Damaged Fisheries—Critical fisheries can suffer from increased water temperatures, sedimentation, and changes in water quality.
- Soil Erosion—The protective covering provided by foliage and dead organic matter is removed, leaving the soil fully exposed to wind and water erosion. Accelerated soil erosion occurs, causing landslides and threatening aquatic habitats.
- Spread of Invasive Plant Species—Non-native woody plant species frequently invade burned areas. When weeds become established, they can dominate the plant cover over broad landscapes, and become difficult and costly to control.
- Disease and Insect Infestations—Unless diseased or insect-infested trees are swiftly removed, infestations and disease can spread to healthy forests and private lands. Timely active management actions are needed to remove diseased or infested trees.
- Destroyed Endangered Species Habitat—Catastrophic fires can have devastating consequences for endangered species.
- Soil Sterilization—Topsoil exposed to extreme heat can become water repellant, and soil nutrients may be lost. It can take decades or even centuries for ecosystems to recover from a fire. Some fires burn so hot that they can sterilize the soil.

14.5 FUTURE DEVELOPMENT TRENDS

The County is optimistic that increased population growth will occur throughout the region. As areas of the County become more urbanized, the potential exists that the fire risk may increase as urbanization tends to alter the natural fire regime, and the growth will expand the urbanized areas into undeveloped wildland areas. However, the County feels that this expansion of the wildland-urban interface can be managed with strong land use and building codes. A growing body of research suggests that "the only effective home protection treatment is treatment in, on, and around the house (see Figure 14-12); homeowners must be responsible for protecting that property" (Nowicki 2001, p. 1:3). U.S. Forest Service research scientist, Jack Cohen has stated that "home ignitions are not likely unless flames and firebrand ignitions occur within 40 meters [131 feet] of the structure; the WUI fire loss problem primarily depends on the home and its immediate site."

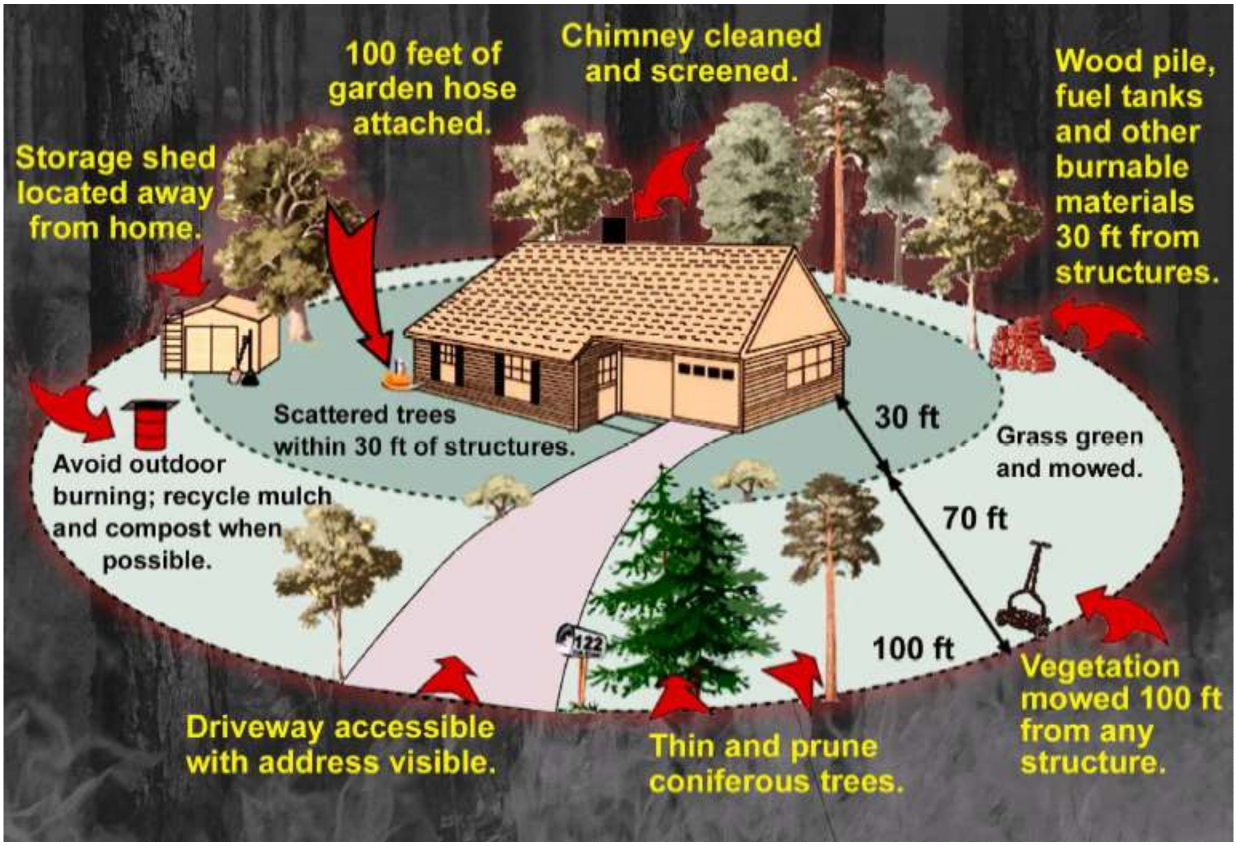


Figure 14-12 Measures to Protect Homes from Wildfire

14.6 ISSUES

The major issues for wildfire in Grays Harbor County 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 will affect the wildfire hazard.
- Future growth into interface areas should continue to be managed.
- Vegetation management activities should include enhancement through expansion of target areas as well as additional resources.
- Building code standards need to be enhanced, including items such as residential sprinkler requirements and prohibitive combustible roof standards.
- Increased fire department water supply is needed in high-risk wildfire areas.
- Obtain and maintain certifications and qualifications for fire department personnel. Ensure that firefighters are trained in basic wildfire behavior, basic fire weather, and that company officers and chief level officers are trained in the wildland command and strike team leader level.

A 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. Flood 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 the flood elevations would increase.

14.7 RESULTS

Based on review and analysis of the data, the Planning Team has determined that the probability for impact from Wildfire throughout the area is likely, but the impact is more limited with respect to geographic extent. The area experiences some level of wildfire almost annually, but the acreage burned has, thankfully, been more limited in nature due in large part to response activities.

Construction into the wildfire hazard areas undoubtedly will continue to expand, thereby increasing the risk of fires. Implementation of mitigation strategies which help reduce wildfire risk, such as landscaping regulations and mandatory sprinkler systems, could potentially help reduce the number of structures at risk. Based on the potential impact, the Planning Team determined the CPRI score to be 2.70, with overall vulnerability determined to be a medium level.

CHAPTER 15.
HAZARDOUS MATERIALS

15.1 GENERAL BACKGROUND

Chemicals labeled "hazardous materials" play a valuable role in most aspects of County life. They fuel vehicles, increase farm production, make drinking and wastewater safe, serve our health care needs, and form key ingredients in many manufactured products. Considerable quantities of hazardous materials are present throughout the county at any one time without any threat to people and environment. However, accidents do happen occasionally that become "hazardous materials incidents." Hazardous materials incidents are accidental, not deliberate, and their consequences are unintentional.

Hazardous material incidents occur during the manufacture, transportation, storage, and use of hazardous materials. Hazardous materials cover a broad category of substances that pose a potential risk to life, health, the environment, or property when not properly contained. These materials may be in solid, liquid, or gaseous forms that exhibit explosive, flammable, combustible, corrosive, reactive, poisonous, biological, or radioactive characteristics.

Incidents most often occur due to human error, natural hazards, or a breakdown in equipment or monitoring systems. The widest area of vulnerability to the public occurs during airborne releases of acutely toxic gases while liquid spills create immediate concerns to the environment.

Hazardous materials incidents fall into the category of a technological hazard. Technological hazards are associated with human activities during which an unintentional incident occurs with unintended consequences, or potentially resulting as a secondary impact from another hazard incident. Technological hazards are generally categorized as follows:

- Hazardous materials incidents
- Infrastructure and utility losses
- Air, rail and highway transportation accidents
- Dam/levee failure
- Commodity flow

For purposes of this assessment, dam failure is addressed within the dam and flood hazard profiles of the County's 2018 updated Hazard Mitigation Plan, and not further addressed within this profile. Commodity flow, where applicable, is referenced within the various hazards discussed, but no commodity flow study has been conducted within the planning area, so the nature of discussion is based on a qualitative assessment.

15.1.1 Hazardous Materials Incidents

Figure 15-1 McCleary Firefighters on scene of tanker fire on SR 8
Source: City of McCleary

Title 49 of the Code of Federal Regulations lists thousands of hazardous materials, including gasoline, insecticides, household cleaning products, and radioactive materials. Entities are required to report use, manufacture, and storage of hazardous materials based on the type and quantity of materials. The use of hazardous materials is associated with almost every industry to some degree, increasing the potential for a hazardous material incident. These hazardous materials incidents can be associated with the manufacture, transportation, storage and the daily use of hazardous materials. Within Grays Harbor County, review of current facilities include industries utilizing Methanol to sulfuric acid, with businesses ranging from chemical production and communications, to animal health facilities and fish hatcheries, all of which utilize hazardous materials. Figure 15-2 identifies the hazardous materials sites throughout the County.

As if 2017 filings, there are in excess of 80 Tier II facilities throughout Grays Harbor County, including facilities that produce, store, or utilize chemicals as in course of business. For example, water treatment plants use chlorine on-site to eliminate bacterial contaminants. Hazardous materials are transported along interstate highways and railways daily. Even the natural gas used in every home and business is a dangerous substance when a leak occurs. The following are the most common type of hazardous material incidents:

- **Fixed-Facility Hazardous Materials Incident**—This is the uncontrolled release of materials from a fixed site capable of posing a risk to health, safety and property as determined by the Resource and Conservation Act. It is possible to identify and prepare for a fixed-site incident because federal and state laws require those facilities to notify state and local authorities about what is being used or produced at the site.
- **Hazardous Materials Transportation Incident**—A hazardous materials transportation incident is any event resulting in uncontrolled release of materials during transport that can pose a risk to health, safety, and property as defined by Department of Transportation Materials Transport regulations. Transportation incidents are difficult to prepare for because there is little if any notice about what materials could be involved should an accident happen. Hazardous materials transportation incidents can occur at any place within the country, although most occur on the interstate highways or major federal or state highways, or on the major rail lines.

  In addition to materials such as chlorine that are shipped throughout the country by rail, thousands of shipments of radiological materials, mostly medical materials and low-level radioactive waste, take place via ground transportation across the United States. Many incidents occur in sparsely populated areas and affect very few people. Occasionally, however, accidents occur in areas with much higher population densities, such as the January 6, 2005 train accident in Graniteville, South Carolina that released chlorine gas killing nine, injuring 500, and causing the evacuation of 5,400 residents. Or the April 2013 West Fertilizer Company plant explosion in West, Texas which killed 15 people and injured hundreds more, flattening buildings and prompting widespread evacuations. Fortunately, such events are rare.

- **Interstate Pipeline Hazardous Materials Incident**—There are a significant number of interstate natural gas, heating oil, and petroleum pipelines providing natural gas to utilities and transporting these materials from production facilities to end-users.

The Washington State Hazardous Materials Program consists of several agencies, each responsible for specific elements of the program. A number of strategies have evolved to limit risk, response to, and recovery from hazardous materials releases, intentional discharges, illegal disposals, or system failures. A comprehensive system of laws, regulations, and resources are in place to provide for technical assistance, environmental compliance, and emergency management.

As of 2017, Grays Harbor County and other planning partners do have an active local emergency planning committee according to State records. This committee, in concert with the Department of Emergency Management, conducts hazard identification, vulnerability analysis, and risk analysis activities for its jurisdiction. Federal and state statutes require local emergency planning committees to develop and maintain emergency response plans based on the volumes and types of substances found in, or transported through, their districts.

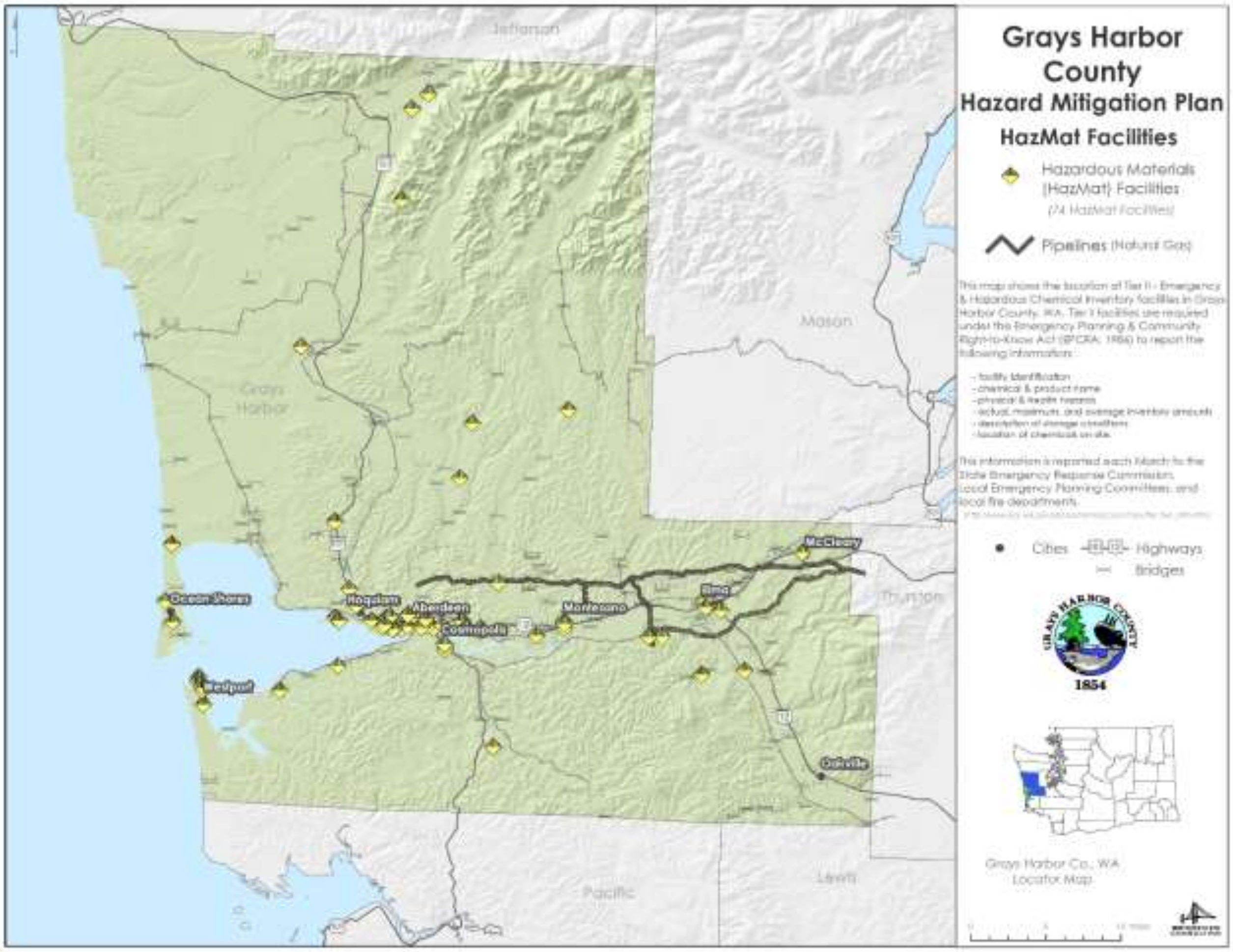


Figure 15-2 Hazardous Material Locations in Grays Harbor County

15.1.2 Infrastructure and Utility Failure

Technological hazards can impact all utilities within Grays Harbor County. According to a 2015 Draft Environmental Impact Statement prepared by the Washington State Department of Ecology for the Westway Expansion Project, Grays Harbor PUD obtains the majority of its electricity from hydroelectric power; however, additional sources include a mix of wind, gas, biomass, and nuclear generation resources (Grays Harbor Public Utility District 2014). In 2012, Grays Harbor PUD sold 975,944 megawatt hours to 41,413 customers (U.S. Energy Information Administration 2015). Industrial customers accounted for 18% (176,342 megawatt hours) of the electricity consumption in the Grays Harbor PUD electrical service area in 2012 (U.S. Energy Information Administration 2015).[55]

There are many other infrastructure sources which could be impacted by a utility failure. Impact can occur as a result of system failure – such as a Supervisory Control and Data Acquisition (SCADA) computer

[55] http://www.ecy.wa.gov/geographic/graysharbor/docs/wwCh03_06_Energy_PublicDEIS_web.pdf

system which is used to monitor and control plant or equipment industries, or as a result of an accidental incident severing lines.

- **Electrical Power—**A power failure is any interruption or loss of electrical service due to disruption of power generation or transmission caused by an accident, natural hazards, equipment failure, or fuel shortage. These interruptions can last anywhere from a few seconds to several days. Power failures are considered significant only if the local emergency management organization is required to coordinate basic services such as the provision of food, water, and heating as a result. Power failures are common with severe weather and winter storm activity.
- **Natural Gas and Pipelines–** The loss of natural gas or interruption of service caused by an accident natural hazards, equipment failure – including lines or SCADA systems, or commodity shortage. These interruptions can last a short period of time to several days. The loss of natural gas, when a primary heat source, can impact those individuals reliant on the fuel, particularly if the event occurs during periods of a cold-weather. Two major providers in Grays Harbor County include Williams Gas and Cascade Natural Gas Corporation.
- **Cyber Failure, Data and Telecommunications—**The loss of data (non-terrorist related event) and/or telecommunications is often a secondary hazard to natural and or technological hazards. Data and telecommunications provide a primary method for service to the community by the government and the private sector. A loss of data and telecommunications could result in loss of emergency dispatch capabilities, emergency planning services, infrastructure monitoring capabilities, access to statistical data, and loss of financial and personnel records. Sustained loss of data could impact continuity of governmental operations. Random hackers are one source common to cyber-attacks, as are organized crime syndicates who also engage in cyber-attacks for monetary gain, primarily through the use of stealing personal information such as credit card numbers (identity theft).
- **Water Disruption—**A breach in water pipelines in the County would have significant temporary impacts until alternative water sources are obtained. Long-term disruption of the water supply would have significant impacts on residences and businesses should demand exceed secondary supplies and water conservation measures not provide enough relief to reduce demand to equal the secondary supplies.
- **Wastewater Disruption—**Disruption of wastewater collection and treatment would have significant regional impacts. Wastewater treatment plants may also have emergencies internal to the plant such as chlorine gas leaks or oxygen deficiencies that render them incapable of treating waste. The disruption of service may also have significant environmental impacts on the waterways adjacent to the treatment plants.

Loss of these services due to accidents would mean a potential life-threatening situation in the case of electricity for medically dependent residents, and a public health threat if the services are disrupted for some time. Loss of services could also impact the continuity of government operations.

15.1.3 Transportation

Transportation accidents are incidents involving air, roadway, or marine vessel passengers resulting in death or serious injury. Grays Harbor County has several airports, water-vessel systems, and several primary roadways which serve as the only ingress and egress to portions of the County. Incidents can occur in the air, on waterways, highway/roadways, bridges and overpasses, all of which have the potential to shut down transportation for extended periods of time.

Figure 15-3 Overturned Tanker Incident (McCleary)

Washington State Freight Economic Corridors are roadways, railways and waterways which are significant for the movement of commerce in Washington State. The corridor designation recognizes the importance of these systems' resiliency (alternate routes to primary cross-state freight routes during severe weather or other disruptions) and supply chains. Those routes for the Southwest region of Washington are illustrated in Figure 15-4.[56] (Graphic is scaled due to size. An on-line version is available here: http://www.wsdot.wa.gov/NR/rdonlyres/AD99ADF9-00F0-426D-A4FE-22CEA9944A6F/0/SouthwestWashingtonRTPO.pdf)

Airports

The region has several airports, heliports, and landing strips, which enhances the potential for an air disaster. Ownership varies and includes publicly owned, medical resources, and private ownership, as follows:

- Westport Municipal Airport (Public)
- Bowerman Airport (Public)
- Elma Municipal Airport (Public)
- Ocean Shores Municipal Airport (Public)
- GH Community Hospital Heliport (Medical)
- Mark Reed Hospital Heliport (Medical)
- Copalis State Airport (Washington State Aviation Division)
- Banas Field Airport (Private)
- Grayland Intergalactic Airport (Private)
- D and B Airpark Airport (Private)
- MY Airport (Private)
- Hogans Corner Airport (Private)
- Bear Valley Skyranch Airport (Private)
- Wishkah River Ranch Airport (Private)
- Wynoochee Valley Landing Strip

[56] http://www.wsdot.wa.gov/Freight/EconCorridors.htm

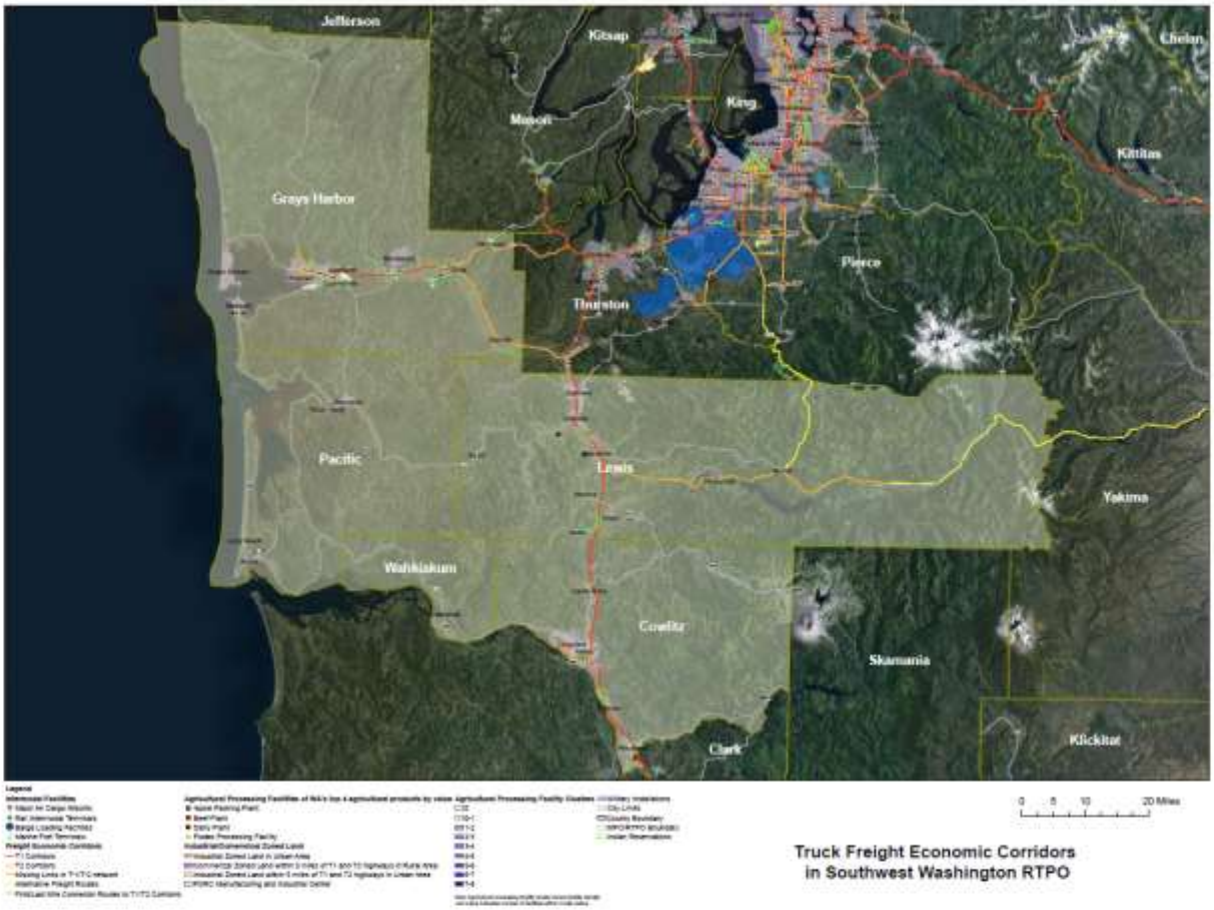


Figure 15-4 Washington State Southwest Region Truck Freight Economic Corridors
Source: WSDOT (2017)

Highways

Major transportation in the area consist of State Routes 8, 105, 107 and 109, as well as U.S. Routes 12 and 101. US Highways 12 and 101, and State Routes 8 and 105, are the main thoroughfares connecting Grays Harbor County to the east, south, and north. SR 8 crosses the Grays Harbor/ Thurston County line approximately 4 miles east of McCleary, and terminates in Elma at its intersection with US 12. US Highway 12 enters the county southeast of Oakville and terminates at the US Highway 101 intersection in Aberdeen. US Highway 101 is miles in length and runs from Pacific County to Jefferson County. Other lesser State Routes include 105 (23.1 mi), 107 (8 mi), 109 (40.5 mi), and 115 (2.3 mi).

The potential for transportation accidents that block ingress, egress, and commodity-flow movement through the county is significant, as well as the likelihood of hazardous materials incidents resulting from a traffic accident.

Bridges

According to the 2016 annual report filed by the U.S. Dept. of Transportation, Federal Highway Administration, Grays Harbor County has in excess of 321 bridges. Of the total identified, 19 are considered structurally deficient.[57] [58] Of the 19 deficient bridges, three are federally owned.

Rail

The County has rail facilities traveling through its boundaries, including Puget Sound & Pacific (PS&P) rail line which is headquartered in Elma, Washington. Rail lines for PS&P come in close proximity to the shoreline and water boundaries (Figure 15-5). In addition, PS&P interchanges with the BNSF and Union Pacific Class I railroads. The PS&P runs through the forest lands of Washington State and serves major lumber customers with transportation services. Freight moves over 108 miles of track in Northwest Washington. Major commodities shipped include lumber, logs, and chemicals for the pulp and paper mills. The PS&P provides an integral service to national account lumber companies moving their products to the Class I roads for further movement throughout North America. Spills associated with any PS&P shipments would have a significant environmental impact on the County.

[57] US Dept. of Transportation, Federal Highway Administration. Available at: https://www.fhwa.dot.gov/bridge/nbi/no10/county16e.cfm#wa Accessed November 29, 2017.

[58] Structurally Deficient was previously defined as having a condition rating of 4 or less for Item 58 (Deck), Item 59 (Superstructure), Item 60 (Substructure), or Item 62 (Culvert), OR having an appraisal rating of 2 or less for Item 67 (Structural Condition) or Item 71 (Waterway Adequacy). Beginning with the 2018 data archive, this term will be defined in accordance with the Pavement and Bridge Condition Performance Measures final rule, published in January of 2017, as a classification given to a bridge which has any component [Item 58, 59, 60, or 62] in Poor or worse condition [code of 4 or less]. See FTHWA for more information: https://www.fhwa.dot.gov/bridge/britab.cfm

Figure 15-5 Washington State Rail System
(Source: WSDOT – most recently available as of this 2018 update)

Marine/Vessel Transport

The Port of Grays Harbor operates four deep-water cargo terminals in Aberdeen and Hoquiam as well as the Westport Marina. The Port is currently working on several projects to address the impacts of growing rail traffic, which include: PGH Marine Terminal Rail, Hoquiam River Rail Bridge, and Wishkah River Rail Bridge. Sierra Pacific Industries is also a major marine shipping point within Grays Harbor Estuary. The County also has several marinas within the planning area.

15.2 HAZARD PROFILE

15.2.1 Overview

Hazardous Materials

All communities located near Grays Harbor County's transportation corridors are subject to the probability of a significant hazardous materials release. Hazardous materials are transported over or near numerous wetlands, environmentally sensitive areas, and through densely populated centers. Proximity of critical infrastructure to hazardous materials facilities does increase the risk of exposure to such chemicals.

Natural disasters like floods, landslides, and earthquakes can also trigger hazardous material incidents. Illegal drug labs used for methamphetamine manufacturing, and illegal dumping of drug paraphernalia and items used to cook drugs present yet another hazardous materials concern. Recent history shows an increase in the national threat from terrorist use of hazardous materials. The combination of possible sources of exposure to our sizable population and workforce presents complex problems to responders.

Infrastructure and Utility Failure

Societal norms indicate that we are fully dependent upon information technology and information infrastructure. At the core of the information infrastructure upon which we rely is the Internet, which connects one computer to another, networking the nation's infrastructure and essential services. Services such as electrical transforms, water distribution centers, security systems (radar), and economic sectors (stock markets) all exist with the infrastructure at its nexus.

While a technological incident of cyber-failure can occur internal to organizations or be a widespread incidents due to an accident or resulting from a natural hazard, loss of information networks can have serious consequences, such as disruption of critical operations, loss of revenue or intellectual property, or loss of life. Of primary concern is the lack of redundant systems (or security measures) which could impact infrastructure to the extent capable of causing debilitating disruption, including compromising computer functions, and prolonged disruption of service. Those impacted by such cyber failures, including potential data loss, can include government and private sector owned control systems for transportation and communications, industrial processes, power and other utility generation and distribution.

Transportation

The range of magnitude of impact from transportation incidents varies depending on the mode of transportation involved. Incidents involving commercial vehicles carrying hazardous materials; impact from incidents involving structural integrity of bridges; incidents involving water vessels, or air traffic traveling over jurisdictions can have a devastating impact on the County. Given the reliance on water travel, freight, and other cargo moved over public access routes, the potential for a major transportation issue is relatively high.

15.2.2 Extent and Location

Hazardous Materials

With respect to locations of impact or concern from hazardous materials incidents, the most vulnerable areas are those associated with the storage of hazardous materials, and those areas adjacent to the major transportation corridors. However, the transformation of chemicals into a gas or vapor, or entering a waterbody has a major impact on the extent and location which can be impacted. Grays Harbor County is also a fairly high agricultural community, and as such maintains quantities of potentially dangerous fertilizers.

Major transportation corridors are often adjacent to highly populated commercial and residential centers. The greatest threat appears to be the transportation corridor through the cities of Hoquiam, Aberdeen and Cosmopolis based solely on the number of chemicals and facilities within those areas, not based on analysis for the type of chemicals stored. Such analysis exceeds the level of analysis contained within this document and is considered protected from public disclosure.

Also of concern are illegal operations such as laboratories for methamphetamine pose a significant threat. Laboratory residues are often dumped along roadways, left in rented hotel rooms, transported in the back of vehicles, or cooked within residential structures. All of these scenarios create a serious health threat to unsuspecting individuals, first responders, hazmat clean-up entities, and to the environment.

Illegal dumping sites for hazardous wastes such as used motor oil, solvents, and paint often dumped in remote areas or along roadways, creating a potential health threat to unsuspecting individuals and to the environment. Chemicals leaking from containers seep into groundwater, or are carried distances by vehicles traveling through the sites. These chemicals also increase fire danger as many are highly flammable and can cause fires to spread more quickly by acting as a fuel source.

Accidental releases of pesticides, fertilizers, and other agricultural chemicals may be harmful to both humans and the environment. Agricultural pesticides are regularly transported in and around Grays Harbor County. As a community with a fairly high agricultural industry, Grays Harbor County does maintain pesticides, fertilizers and other agricultural chemicals year round, with increased quantities during the growing seasons.

Infrastructure and Utility Failure

All areas of the County are susceptible to infrastructure failure or disruption of service as a result of technological hazards. The impact on computer systems can include government and private sector owned control systems for transportation and communications, financial disruptions, industrial processes, power and other utility generation and distribution.

Transportation Routes

All transportation facilities have the potential for impact related to technological hazards, which have the potential to impact commodity flow. Grays Harbor County Transportation routes include:

- Rail
- Highway
- Marine
- Air
- Bridges

All areas and modes of transportation can be impacted from the various technological hazards. Air and rail transportation can be disrupted through cyber-failures; highway and marine traffic can be impacted from hazardous materials incidents, as well as technological hazards. Bridges can be shut down as a result of a vehicle striking the bridge structure itself, or for the draw bridges, failure of operating systems.

Commodity Flow

Pipelines

Pipeline statistics are difficult to assimilate, so limited data is available which demonstrates capacity and transport of the various substances transported through a region. The Washington State Utilities and Trade Commission has identified some pipeline activities which impact Grays Harbor County as identified in Figure 15-6 and Figure 15-7. Pipelines distribute several different types of materials that are widely used throughout Grays Harbor County. Other types of fuels and energy sources are illustrated in Table 15-1.

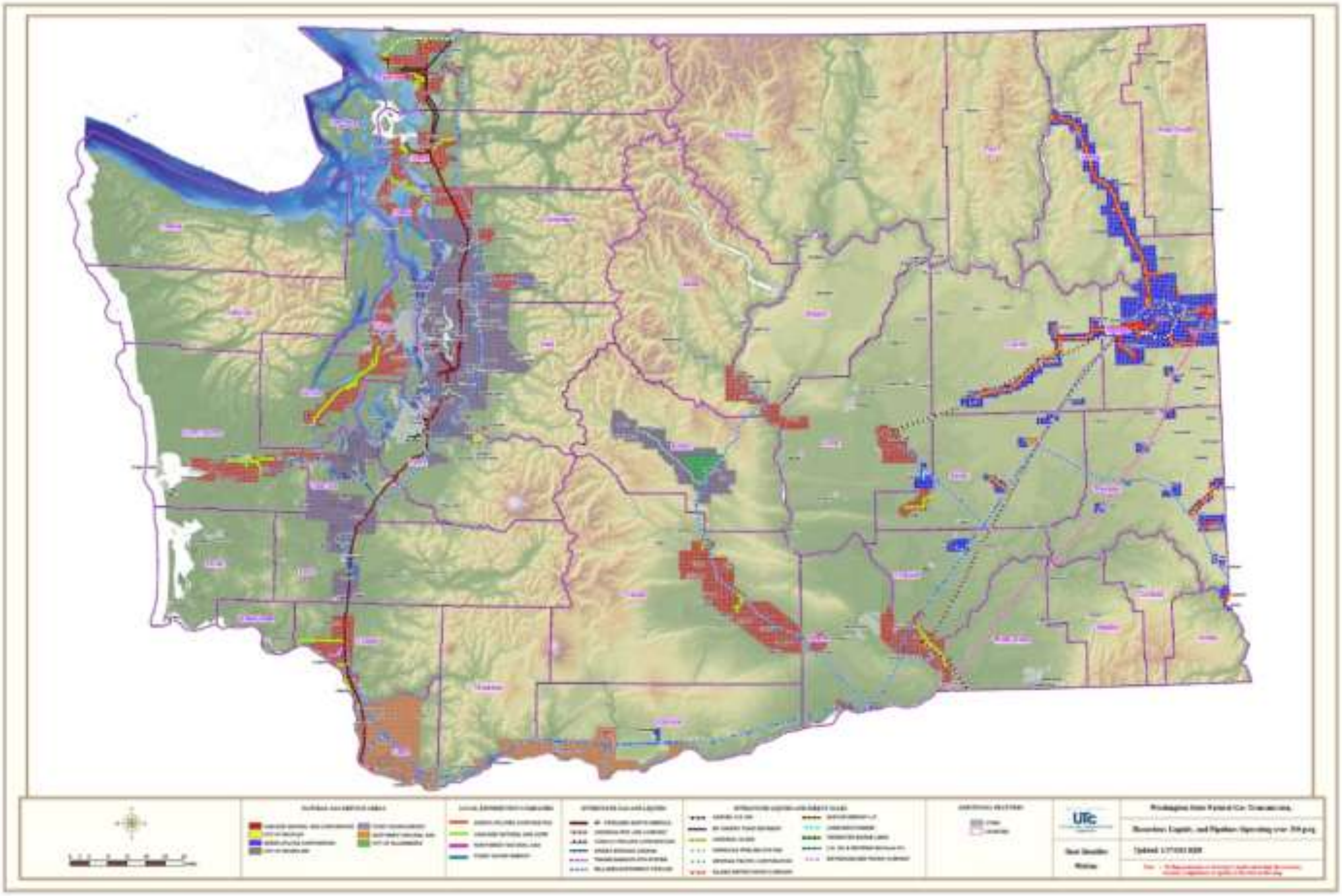


Figure 15-6 Washington State Utility Trade Commission Pipeline Data

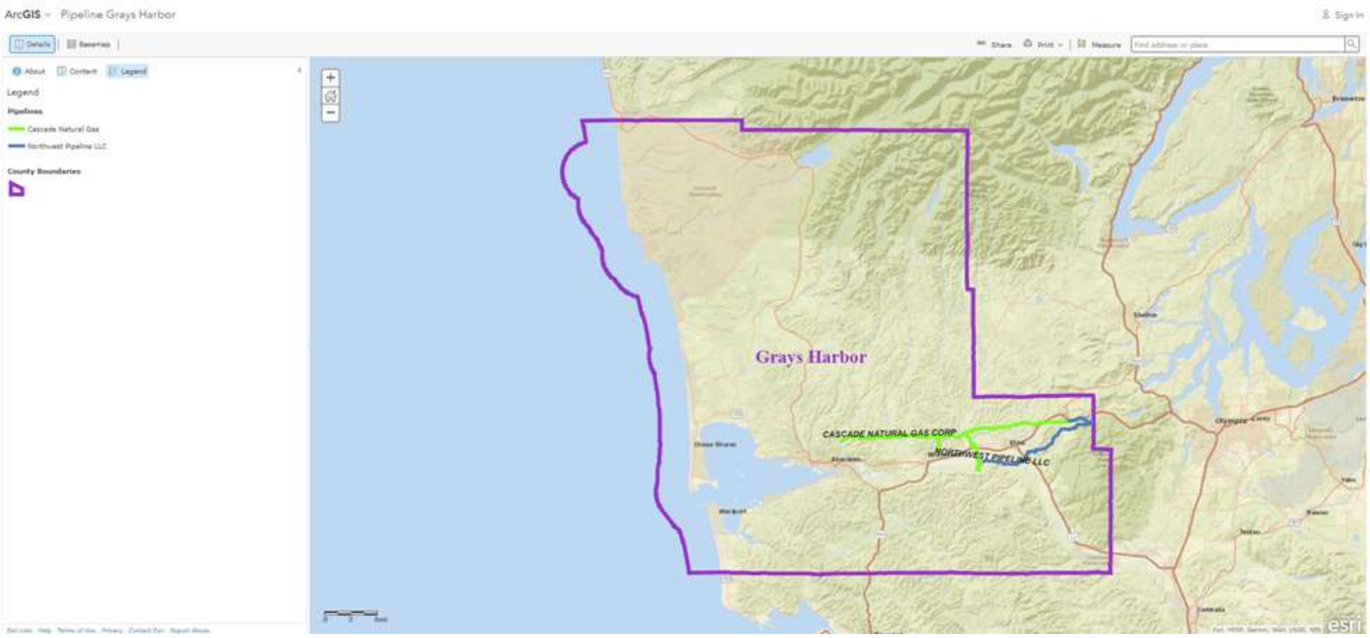


Figure 15-7 Washington State Utility Trade Commission Pipeline Data Grays Harbor County

Table 15-1
Heating Fuel Usage by Type, 2010-2014

Fuel Used by Housing Unit	No. of Units	Percent of Units	Usage Ranking	Percent Usage Statewide Totals	Percent Usage US Totals
Total Housing Units	27318	100%		2,645,396	116,211,092
Utility Gas	3,066	11.22	23	35.08%	48.85%
Bottled, Tank, or LP Gas	1,030	3.77%	21	3.08%	4.86%
Electricity	19,324	70.74%	10	53.93%	36.68%
Fuel Oil, Kerosene, etc.	356	1.30%	26	2.50%	5.86%
Coal or Coke	0	0.00%	0	0.01%	0.12%
Wood	3,143	11.51%	15	4.39%	2.12%
Solar Energy	0	0.00%	0	0.03%	0.05%
Other Fuel	280	1.02%	12	0.63%	0.47%
No Fuel Used	119	0.44%	5	0.36%	1.00%

“0” Represents no reported usage to Census data
Based on 2010-2014 Data
Source: http://www.usa.com/grays-harbor-county-wa-housing--historical-house-heating-fuel-data.htm

Commodities in general can be impacted from incidents occurring outside of the immediate vicinity. Such incidents have occurred previously within Washington on a number of occasions, including the 2006/2007 flooding along the I-5 corridor which required detours of in excess of 500 miles to Eastern Washington.

Fuel and Food

Given areas of potential isolation restricting the delivery of commodities during a significant incident, this is of moderate concern to the planning partners due to the limited resources available within the planning area. The planning team has identified two different mitigation strategies to address this potential issue:

- Gather information with respect to the number fueling stations and grocery stores which have generators to allow the continued pumping of fuel, as well as the ability to keep food products at the appropriate temperatures to avoid spoilage;
- Gather information on the number of days of surplus supply various distributors in the area maintain.

15.2.3 Previous Occurrences

Hazardous Materials[59]

Hazardous material incidents may occur at any time in Grays Harbor County, and occur much more frequently than the average citizen is aware (see Table 15-2). The vast majority of incidents occurring are minor in nature, and not what would be defined as a "serious incident" which is defined as:

- A fatality or major injury caused by the release of hazardous material;
- The evacuation of 25 or more people as a result of a release of hazardous material or exposure to fire;
- A release or exposure to fire which results in the closure of a major transportation artery;
- The alteration of an aircraft flight plan or operation;
- The release of radioactive materials from Type B packaging;
- The release of over 11.9 gallons or 88.2 pounds of a severe marine pollutant; or
- The release of a bulk quantity (over 119 gallons or 882 pounds) of a hazardous material

Table 15-2
Previous Hazardous Material Spill Incidents

Date	Site	Incident Description	Impact/ Death/ Injuries	Dollar Losses
3/11/1964	Transportation Related - United Transportation Barge	A 200-foot fuel barge towed by the Seattle tug Neptune, carrying 2,352,000 gallons of gasoline, diesel, and stove oil, drifted ashore between Moclips and Pacific Beach. Spill of 1.2 million gallons destroyed all beach life for a 10-mile area and severely affected sea life along the beaches to	Aquatic life significantly impacted.	Unknown

[59] Department of Ecology - Spill Response Clandestine Drug Lab and Dump Site Cleanup Activity 1990-2012 http://www.ecy.wa.gov/programs/spills/response/drug_labs/County_Table_1990_to_2012.pdf Accessed 28 Nov 2017.

Table 15-2
Previous Hazardous Material Spill Incidents

		the north on the Quinault Reservation.		
12/23/1988	Transportation Related - Nestucca Barge (Sause Towing	The Nestucca barge and its tender Ocean Service collided at the mouth of Grays Harbor. 231,000 gallons of fuel oil spilled from the ruptured barge, killing 3,500 sea birds and other sea life from Grays Harbor to Vancouver Island.	3,500 sea birds and other sea life killed.	Clean-up costs estimated to be ~$28 million (1997 dollars)
7/11/2002	Fixed Facility-Weyerhaeuser Pulp Mill Cosmopolis	Release of 50-55 pounds of chlorine dioxide into the atmosphere. The cloud eventually dissipated as it traveled southeast of the mill. Portions of the mill as well as the Highlands Golf Course and 10 residents were evacuated for three hours. US 101 was closed between the Cosmopolis-Aberdeen city line and the junction with SR 107. Weyco staff contained the leak.	None	~$10,000 / Weyco fined $10,000
11/27/2003	Transportation Related - Reinhard Petroleum Truck Explosion	A tanker truck carrying 11,000 gallons of gasoline overturned and exploded on Highway 8 mp 1 eastbound. The cause of the accident was driver error due to icy road conditions. The truck and fuel burned for hours, forcing closure of Highway 8 and requiring a detour on county roads.	None	Unknown
5/27/2004	Fixed Facility-Weyerhaeuser Pulp Mill Cosmopolis	353 lbs. of sulfur dioxide released into the atmosphere.	Unknown	Unknown
7/17/2004	Fixed Facility-Weyerhaeuser Pulp Mill Cosmopolis	Approximately 29,000 gallons of sulfur dioxide leaked into the plant's sewer system. The leak was contained.	None	Unknown

Of all the serious hazardous material incidents that have occurred in Grays Harbor County, the United Transportation and Nestucca incidents rank as having the most significant impact to the environment and the highest monetary cost. Both incidents fall within the top five oil spills of all time within Washington waters. The Nestucca case in particular spurred the Washington State legislature soon afterwards to establish an innovative spill prevention and response program.

In addition to the hazardous material releases, Washington State Department of Ecology has recorded 262 incidents of meth lab occurrences in Grays Harbor County during the time period 1990-2012 (see Figure 15-8) (most recent statistics available as of 2018 update).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	TOTAL
Adams								1		1		3	4	4			1			2	2			18
Asotin										1	1	5	3	4						1				15
Benton				1		1	3	4	7	38	52	85	87	82	57	16	13	9	4				11	470
Chelan				1		1	1			2	14	34	15	13	9	3		6	1	1			1	102
Clallam					1	1	1	3	3		1	3	10	2	2		2	3	3		1		1	37
Clark	5	2	4	1	3	3	12	20	12	16	34	57	57	35	28	18	9	6	4	4	1	3	3	337
Columbia										1	3	2	1	4	1		1							13
Cowlitz			3	1		1	3	9	2	8	7	9	28	18	11	6	5	3	4	1				119
Douglas									1	1	6	5	7	4	8	6								38
Ferry											7	4												11
Franklin									1	8	10	15	11	13	14	3	1			1			2	79
Garfield										2			4	1		1								8
Grant			2			1				2	19	27	46	34	14	11	15			7	6		7	191
Grays Harbor	3	1		2	2	1	3	5	5	16	24	41	32	50	27	28	2	14		2	1	1	2	262
Island						1		1	2	5	1	5	5	14	18	5	6	4	4	22	2		1	96
Jefferson								1	1	2	7	6	4	12	2	1	5		1	1			1	44
King	6	10	2	7	7	10	23	17	48	107	231	271	241	202	199	123	63	42	37	16	11	5	7	1685
Kitsap	1	1	2	1			3		1	21	45	54	60	50	44	18	2	1	1		1	1	15	322
Kittitas				1		1			1	3		5	3	5	3	6		3			1		1	33
Klickitat			1			1	1	1	3		6	4	2	1		1	2	1	2		1			27
Lewis	3	1	1	2	3	4	7	9	31	33	43	61	83	67	30	22	14	3	5	6	3	1	2	434
Lincoln			1									5	3	2	1	1	1	1						15
Mason	3			2			4	4	10	21	32	30	22	15	32	32	6	4	7	3	3	1	1	232
Okanogan			1					2	3	2	2	3	3	1	4		3	1						25
Pacific						1		4	1	6	2	3	4	3	2	2							1	29
Pend Oreille				1				2	6	10	12	5	12	6	7	5	2				2			70
Pierce	10	18	18	12	17	17	53	42	129	318	545	589	438	466	542	349	148	76	71	56	35	16	14	3979
San Juan												1	1											2
Skagit				1		1			4	2	5	11	34	12	31	12	9	4	3		3	6		138
Skamania	1									2	1	2	3	3	1	1	2	2			1		1	20
Snohomish	2	2		2			7	6	5	13	37	69	83	98	102	43	14	15	12	19	11	8	1	549
Spokane					1	2	1	7	11	36	137	248	189	91	42	21	28	14	3	16	6	3	7	863
Stevens		1					1	1		5	4	15	10	3	5	5	3	2		3	1	1		60
Thurston	1	4	5	4	2	6	25	63	58	86	139	151	115	96	62	37	18	6	15	7	1		4	905
Wahkiakum										1		2	2	2		1	1							9
Walla Walla									2	8	12	16	15	16	9	4	1	8	2	3				96
Whatcom				1								5	9	24	25	14	6	2	3	4			1	94
Whitman											1	3	4		2	5				1	1			17
Yakima	3	3		2		1	5	1	2	12	14	36	43	27	7	9	7	7	2	10	1			192
TOTAL	**38**	**43**	**40**	**42**	**36**	**54**	**153**	**203**	**349**	**789**	**1454**	**1890**	**1693**	**1480**	**1341**	**809**	**390**	**237**	**184**	**186**	**95**	**46**	**84**	**11636**

Figure 15-8 Department of Ecology Report on Meth Lab Incidents 1990-2012

Review of data received from Washington State Department of Ecology identify in excess of 392 incidents during the time period 2012-2017 identified in Table 15-3. Those incidents range from reports of oil slicks which have turned out to be jellyfish floating on the surface, to vandalism at Brookside Cranberry Vintners, where vandals punctured vats and approximately 2,000 gallons of wine soaked into the ground. The Grays Harbor Paper, LLC., suffered an equipment failure, which resulted in the heal of a pumped tank releasing chemicals into its swale.

Table 15-3 Annual Number Of Incidents Reported	
Year	**Number Of Report Incidents**
2012	81
2013	79
2014	63
2015	53
2016	61
2017 (through 11/6/17)	49

Infrastructure and Utility Failure

Infrastructure and utility failure can result from a multitude of incidents covering large areas. Incidents can range from computer input or operator error to a lone vehicle striking a major power distribution line as a result of an accident. While downed trees and wind storms were the leading cause of power outages in Grays Harbor County accounting for 77% of the utility outages in 2016, a significant event would have far-reaching impact ranging from hospitals not being able to operate a full capacity, to individuals who are on oxygen not receiving the care needed.

Transportation Issues

Transportation issues occur regularly throughout the County. Daily accidents disrupt commutes. The public airports throughout the County have experienced flight cancelations and delays due to various types of events. It is unclear if impacts related to computer or other infrastructure issues have occurred.

Figure 15-9 Derailed Train Cars - Montesano May 15, 2014

Rail incidents also occur on a regular basis, three occurring within days of each other:

- April 29, 2014 - five cars derailed at 5 mph at South Washington Street in Aberdeen. The track was back in service on April 30.
- May 9, 2014 - seven cars derailed at 6 mph at Heron Street in Aberdeen. The track was back in service on May 14.
- May 15, 2014 - 11 cars derailed at 10 mph at Devonshire Road in Montesano.
- December 28, 2015 – Six cars derailed after teenagers played "chicken" on the tracks.

Marine vessels have been impacted by weather events, disrupting cargo lines. Spills of chemicals have also occurred within the planning region, which have negatively impacted the environment throughout the planning area. Hazardous material incidents along the marine waters are unique from those shared by fixed facilities and other transportation systems. The marine coastline is particularly vulnerable to hazardous materials spilled by cargo ships and barges. This is especially true of fuel and oil spills. Spills off the Grays Harbor coastline can contaminate beaches and marine environments as far north as Vancouver Island, British Columbia. Valuable and sensitive marine environments critical to fish and wildlife, commercial fish and shellfish businesses, property values, and tourism are all vulnerable to the impacts of spills. Because only 20% of spill material is typically recoverable in marine waters, it can take many years for these environments to recover.

15.2.4 Severity

The severity of technological hazards is challenging to measure because of the multitude of variables that are involved, and in many instances, the lack of data supporting such incidents. Effects may include serious injuries or loss of life (mass casualty incident), associated property damage, impacts to commodity flow, and lack of continuity of government.

Due to a potentially large number of patients that may be involved in a technological incident, significant mass casualties may tax local emergency, medical and hospital resources, and therefore require a regional response. The first responders, including fire, police, emergency room personnel at local hospitals, and coroner's offices develop and plan for response of such incidents; however, as in most cases, resources are limited. Grays Harbor County has mutual aid agreements in place should local officials be unable to respond appropriately with available personnel and equipment.

Hazardous Materials

Hazardous material incidents are a significant issue within Grays Harbor County due, in part, to the unknown quantities and types being shipped through the County en route for bordering counties, as well as the amount of hazardous materials known to exist for the various purposes mentioned. While hazardous material incidents can be both intentional and/or unintentional releases of a material, because of their chemical, physical, or biological nature, they pose a potential greater risk to life, health, environment, or property. Each incident's impact and resulting response depend on a multitude of interrelated variables that range from the quantity and specific characteristic of the material to the conditions of the release and area/population centers involved. Releases may be small and easily handled with local response resources or rise to catastrophic levels with long-term consequences, such as the one which was experienced in West, Texas with the destruction of the West Fertilizer Company. Fifteen people were killed as a result of the explosion, with hundreds injured. Approximately 37 square blocks of the surrounding community was destroyed, including businesses, schools, residences and a nursing home. The USGS recorded the explosion as a Magnitude-2.1 tremor. Damage from the explosion was estimated by the Insurance Council of Texas to exceed $100 million of insured losses; the town received a Presidential Disaster Declaration and sought recovery in excess of $57 million.

Figure 15-10 Anacortes Refinery Fire

The Tesoro Refinery Explosion and Fire[60] on April 2, 2010 in Anacortes (see photo right) cost the lives of seven refinery workers (two women and five men). The fire impacted fuel supplies within Washington, causing gas prices to increase as the incident occurred during the exchange from winter to summer fuels. To date, this is the largest fatal incident at a US petroleum refinery since the BP Texas City accident of March 2005.

[60] http://www.csb.gov/assets/1/7/Tesoro_Anacortes_2014-May-01.pdf

Washington also experienced another tragic event on June 10, 1999 in Bellingham as a result of an explosion of a 16-inch fuel line owned by Olympic Pipe Line, spilling 277,200 gallons of gasoline into two local creek beds, and killed three young men.

While significant hazardous materials incidents have occurred within Grays Harbor County, no such events have taken any lives. However, the potential for a significant event does exist due to the nature and amount of chemicals stored and transported throughout the region.

Infrastructure and Utility Failure

The length associated with the power disruption can vary from a few hours, to in excess of weeks as was the case with the 1996 power outage resulting from an ice storm. The issues surrounding the primary cause of the power failure has the potential to increase severity, such as extreme heat or cold weather, which has the potential to increase impact on health and safety.

Cyber Failure

Cyber-failure on information networks can have serious consequences, such as disruption of critical operations, loss of revenue or intellectual property, or loss of life. Of primary concern is the threat that malicious actors attack our critical information infrastructure to the extent capable of causing debilitating disruption, including compromising computer functions, and promoting fear. Cyber failures occur with some regularity to at least some degree. The severity of impact from such a failure is associated with damage to equipment and loss of data, as well as the system itself as would be the case for a system regulating power, water flow, etc. The time involved can range from minutes to days depending on the issue. The longer the system remains down, the greater the severity of impact.

Transportation

Several primary critical infrastructure routes and other forms of transportation have the potential for a mass-casualty incident (MCI) because of the heavy volume of traffic. Adverse weather may play a role in transportation accidents, enhancing the potential for an MCI incident, which can occur throughout the County at any time or day.

15.2.5 Frequency

Hazardous Materials

The locations of businesses and industry, hospitals, medical facilities and laboratories that use hazardous materials, as well as the presence of scattered illegitimate clandestine drug laboratories and the improper disposal of hazardous waste demonstrate unknown risk factors which make the determination of frequency of an occurrence in a quantitative manner impossible due to the unknown variables.

Infrastructure and Utility Failure

The utility infrastructure may also be impacted as a result of various hazard-related events, or through accidental events. Routinely, the County and its jurisdictions can expect at least one incident of power failure annually based on review of historical records. The length associated with the power disruption can vary from a few hours, to in excess of weeks as was the case with the 1996 power outage resulting from an ice storm. As part of the Western Electricity Coordinating Council, major power distributors in the County work with regulatory agencies to ensure protection of our power distribution centers. Historically, the average of power outages and customers impacted continues to decline.

Cyber-infrastructure failure resulting from non-terrorist related attacks against computers, networks and/or information stored thereon, can occur at any time with no advanced warning. Cyber failure occurs with regular frequency as a result of server failure, power outages, lines being severed, etc. The time involved can be from minutes to days depending on the issue.

Transportation

Over the course of time, the number of transportation conveyances has grown significantly throughout the County, with increased populations traversing the roadways. Of concern throughout Grays Harbor County is the potential for isolation as a result of a transportation failure or incident which will block ingress and egress from portions of the region.

15.3 VULNERABILITY ASSESSMENT

15.3.1 Overview

No analysis was conducted with respect to specific values associated with vulnerability or impact from technological hazards. Rather, a qualitative assessment was completed, which follows.

Exposure and impact from a technological hazard is based on a system that measures the potential consequence of the hazard based on varying factors, which may include:

- Casualty Impact – What is the potential for loss of life or serious injury to the population within the geographic area impacted?
- Economic Impact – To what extent does the loss of the facility impact the economy of region, state, or nation? This would also include the replacement cost of the facility, and the downtime or functionality of the structure or system.
- Hazardous Materials—Are flammable, explosive, biological, chemical and/or radiological materials present on site?
- Collateral Damage Potential—What are the potential consequences for the surrounding area if the asset is damaged?
- Public or Emergency Response Functions—Does the facility perform a function during an emergency? Is this facility or function capable of being replicated elsewhere?

Warning Time

Technological hazard accidents occur without predictability under circumstances that give responders little time to prepare.

15.3.2 Impact on Life, Health, and Safety

Each technological hazard identified has the potential to impact the population in varying ways. Large-scale technological incidents have the potential to kill or injure many citizens in the immediate vicinity, but may also affect people a relative distance from the initial event. For instance, utility failures during extreme weather events have the potential to impact a significant amount of the population due to lack of heat or cooling systems. Transportation failure can significantly disrupt commodity flow, while also causing isolation of vulnerable populations. Hazardous materials and contaminants from roadways (including nonpoint source pollution and normal traffic along impermeable roadway) have the potential to impact water quality, especially where surface ground-water serves as the drinking water source for a community. A hazardous materials spill has the potential to contaminate river quality, thereby impacting the life, health and safety of the population at large if the river serves as the source of drinking water.

In terms of assessing the potential impact on population for general planning purposes, variables affecting exposure for a hazardous material accident include the type of product, the physical and chemical properties of the substance, the physical state of the product (solid, liquid, or gas), the ambient temperature, wind speed, wind direction, barometric pressure, and humidity. Computer models can be used to provide data to first responders to advise for evacuation planning purposes, or sheltering in place during an incident. Real time information of the variables would be used to make the assessment. Certain fixed facilities are also required to develop operational response plans to determine impact based on the chemicals on site. In addition, residences and business in close proximity to major transportation corridors are at enhanced risk for exposure as a result of a transportation incident.

In a response capacity, hazardous materials pose a significant risk to emergency response personnel. All potential first responders and follow-on emergency personnel must be properly trained to the level of emergency response actions required of their individual position at the response scene. Hazardous materials also pose a serious long-term threat to public health and safety, property and the environment.

15.3.3 Impact on Property

All property throughout the planning region has the potential for being impacted as a result of a technological hazard occurring. Disruption of service of utilities can increase fire danger due to diminished water-flow capacity. Reduced cyber capacity can impact infrastructure, while also leaving security features inoperable. A transportation accident involving hazardous materials can contaminate property or waterways for an extended period of time. In the case of agricultural lands and crops, or harvestable aquatic life, hazardous materials can potentially render entire areas useless for significant periods of time.

15.3.4 Impact on Critical Facilities and Infrastructure

Grays Harbor County has a fairly significant number of critical facilities identified throughout the planning region which are vulnerable to technological hazards. Based on established vulnerability criteria, the majority of all critical facilities carry some level of exposure risk because of their potential impact from the various hazards of concern. A potential cyber failure could impact the majority of all transportation facilities, including air, water vessels, and highways (especially draw bridges), potentially limiting accessibility, thereby impacting commodity flow. Such accessibility could also impact emergency response. Impact to a critical facility such as a hospital would impact medical providers. Utility infrastructure could disrupt water, wastewater and fuel and heating supplies.

15.3.5 Impact on Economy

Economic impacts from technological hazards could be significant. The cost of a hazardous materials incident would be felt in terms of loss of life and property, clean-up costs (discussed further below), disruption of business activity, and long-term emotional impacts. Recovery would take significant resources and expense at the local level.

Utility losses could cause a reduction in employment, wholesale and retail sales, utility repairs, and increased medical risks. Local jurisdictions may lose sales tax and property taxes, and the finances of private utility companies and the businesses that rely on them would be disrupted.

The economic impacts should a transportation facility be rendered impassable would be significant. The loss of a roadway or railway would have serious effects on the County's economy and ability to provide services. Loss of travel routes would result in loss of commerce, and may impact the County's ability to provide emergency services by delaying response times or limiting routes for equipment such as fire apparatus, police vehicles, and ambulances. The ability to receive fuel deliveries and other necessary commodities could also be impacted.

Cost Factors

The cost of cleaning up an oil spill depends on several factors, including location and size of the spill, the type of oil and the amount of manpower and equipment needed to restore the spill area. Near-shore spills are typically four to five times as costly as offshore spills.

Using dispersants, or chemicals sprayed over a spill that break down the oil into smaller droplets, can significantly reduce the cost of cleanup, as they require fewer personnel to administer them and allow the cleanup to finish up in a shorter period of time.

The cost for cleanup increases over time due not only to the actual clean-up expenses, but also to increasing litigation as well as changing social and political pressures around environmental responsibility.

15.3.6 Issues

Major issues related to technological hazards would be its effect on the economy and environment, both of which could be catastrophic for the region.

Environmental impacts related to a chemical spill could effect a very large portion of the coastline from Canada to California in a relatively short period of time. Aquatic and wildlife could be altered for years, with habitats, tidelands, wetlands, and aquifers destroyed. A scenario occurring during a significant weather event could disperse chemicals much more quickly, and to a much greater area. Significant storm events could slow response operations for cleanup, further influencing its potential for destruction.

Economic impacts from technological hazards would also be far-reaching in its effect on not only the planning region, but the state as a whole, including factors such as:

- Continuity of government, which could be impacted as a result of the loss of revenue to maintain specific services.
- Utility losses, which could cause a reduction in employment, wholesale and retail sales, utility repairs, and increased medical risks. Local jurisdictions may lose sales tax and property taxes and the finances of private utility companies and the businesses that rely on them would be disrupted.
- The economic impact of computer issues associated with data and telecommunications losses or breaches can be staggering.
- The economic impacts should a transportation facility be rendered impassable would be significant. The loss of a roadway or railway would have serious effects on the local economy and ability to provide services. Loss of travel routes in particular would result in loss of commerce, and could impact emergency services by delaying response times or limiting routes for equipment such as fire apparatus, police vehicles, ambulances, and chemical release or spill response equipment. The ability to receive fuel deliveries could also be impacted.
- The effects of re-routed traffic could have a serious impact on local roadways. Heavy traffic on routes through urban areas already occurs at peak commute times. Traffic control may burden local public works departments. Mass transit services would also be impacted as routes may be delayed or forced to be detoured causing economic impacts.

15.4 RESULTS

Based on review and analysis of the data, the Planning Team has determined that the probability for impact from a technological incident throughout the area is likely. The area experiences some level of hazardous material release on a regular basis, although the level or quantity of release may be limited in nature.

Based on the review of the existing data, in a qualitative assessment, the likelihood of occurrence of some level of hazardous material incident is high to moderate. With the increased transportation of various chemicals through the county, the potential exists for increased frequency of hazardous materials incidents.

Continued economic expansion, transport of chemicals through the county on roadways or along the coastline will only increase over time, thereby increasing risk. Implementation of mitigation strategies which help reduce risk. Based on the potential impact, the Planning Team determined the CPRI score to be 2.65, with overall vulnerability determined to be a medium level.

CHAPTER 16.
HAZARD RANKING

16.1 CALCULATED PRIORITY RISK INDEX

In ranking the hazards, the Planning Team completed a Calculated Priority Risk Index worksheet for each hazard identified below. The index examines five criteria for each hazard as discussed in Chapter 4 (probability, magnitude/severity, extent/location, warning time, and duration), defines a risk index for each according to four levels, then applies a weighting factor. The result is a score that has been used to rank the hazards at the County level. All planning partners also completed their own hazard rankings, using the same process. Table 16-1 presents the results of the Calculated Priority Risk Index scoring for all hazards impacting the County. Table 16-2 is a summary of the hazard ranking results for the planning partners.

Utilizing a process such as this is beneficial when discussing risk with the public, as it provides a means to identify risk throughout the entire planning area, and then more narrowly focus the risk to the specific municipality. When comparing the risk assessment data to that contained within the public outreach surveys, this then provides another mechanism of determining how citizens view risk at their geographic area of impact to help validate the risk assessment as identified by the citizens.

Table 16-1
County Calculated Priority Risk Index Ranking Scores

Hazard	Probability	Magnitude and/or Severity	Extent and Location	Warning Time	Duration	Calculated Priority Risk Index Score
Climate Change	3	2	2	1	4	2.35
Drought	3	2	2	1	4	2.35
Earthquake	4	4	4	4	1	3.85
Erosion	4	2	1	3	4	2.85
Flood	4	3	3	1	3	3.10
Landslide	3	3	2	4	3	2.95
Other Hazards of Concern	3	2	2	4	1	2.65
Severe Weather	4	2	4	1	2	3.05
Tsunami	3	4	3	4	2	3.30
Volcano	1	1	3	1	4	1.55
Wildfire	3	2	2	4	2	2.70

The Calculated Priority Risk Index scoring method has a range from 0 to 4. "0" being the least hazardous and "4" being the most hazardous situation.

Table 16-2
Countywide Combined Risk Ranking Summary

City or Town	Climate Change *	Drought	Earth-quake	Erosion	Flood **	Land-slide	HazMat /Other Hazard ***	Severe Weather	Tsunami	Volcano	Wild-fire
County	9	9	1	6	3	5	8	2	4	10	7
Aberdeen	5	7	1	10	3	3	6	4	2	9	8
Cosmopolis	7	7	1	3	6	4	9	5	2	10	8
Elma	6	6	1	8	3	5	NR	2	9	7	4
Hoquiam	7	8	1	5	2	3	NR	4	3	9	6
McCleary	6	6	1	8	5	7	4	3	9	10	2
Montesano	6	6	1	2	4	3	NR	4	5	6	3
Oakville	4	4	1	9	1	3	6	2	7	8	5
Ocean Shores****	4	9	3	1	7	11	NR	2	3	10	5
Westport	6	7	1	3	4	9	10	5	2	7	8
Port of Grays Harbor	9	4	3	8	5	10	6	2	1	7	11
Grays Harbor Transit	9	9	1	7	4	8	5	2	3	10	6
Grays Harbor Hospital District	8	10	1	9	5	2	7	4	3	11	6
Summit Pacific Medical Center	3	6	1	6	6	7	NR	2	4	3	5
Grays Harbor College	8	9	1	5	10	2	6	4	3	11	7
Fire District 2	6	7	1	9	3	5	NR	8	2	10	4
Fire District 5	8	8	1	5	3	4	7	2	3	9	6
Fire District 7	8	9	2	5	6	3	NR	4	1	10	7
Fire District 8	5	5	2	5	6	8	4	3	1	7	2
Fire District 16	4	4	2	6	7	7	1	3	5	6	2
South Beach Regional FD	5	6	3	8	7	10	NR	1	4	9	2

*Includes sea level rise; **Includes coastal flooding, local flooding, and dam failure; ***Hazardous materials incident; **** Ocean Shores included Windstorm Ranked as #6 and High Vulnerability, and Invasive Species, Ranked as #8 and a Medium Vulnerability.

16.1.1 Calculated Priority Rate Index

CPRI Category	Degree of Risk			Assigned Weighting Factor
	Impact/ Level ID	**Description**	**Impact Factor**	
Probability	Unlikely	• Rare with no documented history of occurrences or events. • Annual probability of less than 1% (~100 years or more).	1	40%
	Possible	• Infrequent occurrences; at least one documented or anecdotal historic event. • Annual probability that is between 1% and 10% (~10 years or more).	2	
	Likely	• Frequent occurrences with at least two or more documented historic events. • Annual probability that is between 10% and 90% (~10 years or less).	3	
	Highly Likely	• Common events with a well-documented history of occurrence. • Annual probability of occurring. (1% chance or 100% Annually).	4	
Magnitude/ Severity	Negligible	• People – Injuries and illnesses are treatable with first aid; minimal hospital impact; no deaths. Negligible impact to quality of life. • Property – Less than 5% of critical facilities and infrastructure impacted and only for a short duration (less than 24-36 hours such as for a snow event); no loss of facilities, with only very minor damage/clean-up. • Economy – Negligible economic impact. • Continuity of government operating at 90% of normal operations with only slight modifications due to diversion of normal work for short-term response activity. Disruption lasts no more than 24-36 hours. • Special Purpose Districts: No Functional Downtime.	1	25%
	Limited	• People – Injuries or illness predominantly minor in nature and do not result in permanent disability; some increased calls for service at hospitals; no deaths; 14% or less of the population impacted. Moderate impact to quality of life. • Property – Slight property damage -greater than 5% and less than 25% of critical and non-critical facilities and infrastructure. • Economy – Impact associated with loss property tax base limited; impact results primarily from lost revenue/tax base from businesses shut down during duration of event and short-term cleanup; increased calls for emergency services result in increased wages. • Continuity of government impacted slightly; 80% of normal operations; most essential services being provided. Disruption lasts >36 hours, but <1 week. • Special Purpose Districts: Functional downtime 179 days or less.	2	
	Critical	• People – Injuries or illness results in some permanent disability or significant injury; hospital calls for service increased significantly; no deaths. 25% to 49% of the population impacted. • Property – Moderate property damages (greater than 25% and less than 50% of critical and non-critical facilities and infrastructure). • Economy - Moderate impact as a result of critical and non-critical facilities and infrastructure impact, loss of revenue associated with tax base, lost income. • Continuity of government ~50% operational capacity; limited delivery of essential services. Services interrupted for more than 1 week, but <1 month. • Special Purpose Districts: Functional downtime 180-364 days.	3	
	Catastrophic	• People - Injuries or illnesses result in permanent disability and death to a significant amount of the population exposed to a hazard. >50% of the population impacted. • Property – Severe property damage >50% of critical facilities and non-critical facilities and infrastructure impacted. • Economy – Significant impact - loss of buildings /content, inventory, lost revenue, lost income. • Continuity of government significantly impacted; limited services provided (life safety and mandated measures only). Services disrupted for > than 1 month. • Special Purpose Districts: Functional Downtime 365 days or more.	4	
Geographic Extent and Location	Limited	Less than 10% of area impacted.	1	20%
	Moderate	10%-24% of area impacted.	2	
	Significant	25%-49% of area impacted.	3	
	Extensive	50% or more of area impacted.	4	
Warning Time / Speed of Onset	<6 hours	Self-explanatory.	4	10%
	6 to 12 hours	Self-explanatory.	3	
	12 to 24 hours	Self-explanatory.	2	
	> 24 hours	Self-explanatory.	1	
Duration	< 6 hours	Self-explanatory.	1	5%
	< 24 hours	Self-explanatory.	2	
	<1 week	Self-explanatory.	3	
	>1 week	Self-explanatory.	4	

16.2 SOCIAL VULNERABILITY

Once the hazard ranking was completed, the Planning Team then conducted a Social Vulnerability Assessment for those priority hazards identified in Table 16-1 and Table 16-2. Several different assessments were completed with respect to social vulnerability, including both a quantitative assessment contained within each profile and summarized below, and a qualitative assignment based on the CPRI analysis.

When determining risk, it is significant to remember that risk is measured by not only the hazard, but also on how resilient a population is, or will be during the hazard. Resilience is influenced by many factors, including: age or income; available social networks, and neighborhood characteristics, all of can be used to measure the social vulnerability of the area and its citizens. Based on a study completed by the University of North Carolina, factors that contribute to the level of vulnerability of a population are associated with four areas of impact, which, in part, are utilized within this assessment with a few modifications to the original study, as indicated:

- Socioeconomic status:
  - Below Poverty Level
  - Employment Status
  - Income level
  - No High School Diploma
- Household composition:
  - Age 65 or older
  - Age 5 or younger (the North Carolina study references age 17 or younger)
  - Disability (the North Carolina study referenced “Older than Age 5 with a Disability”)
  - Single Parent Households
- Minority Status and Language:
  - Minority – race or ethnicity
  - Language barrier (Speak English “Less than Well”
- Housing/transportation:
  - Multi-Unit Structures, including Group Quarters
  - Mobile Homes
  - Crowding
  - No Vehicle

The purpose of the classifications is to better understand whose needs are not being addressed through traditional service providers or who cannot safely access and use the standard resources offered for disaster preparedness, relief and recovery. Special focus on these groups during emergency situations is crucial because not only are they more likely to be effected by an event, but they are many times also less likely to recover.

16.2.1 Classifications

Socioeconomic status considers things such as income, poverty, employment status, and education level. Those who are economically disadvantaged will be affected by an event more significantly. The monetary value of their possessions may be less, but they represent a larger proportion of total household assets. These groups are less likely to have renters or homeowner’s insurance, so their possession will be more costly to replace, and individuals are less likely to evacuate in order to ensure the protection of their belongings. In the event of injury or death, those who are unemployed will not have the benefits or the income to assist with costs for recovery. In addition, in most cases, the poor lack the assets and the resources to prepare for a disaster in advance, and once impacted, to recover.

Household composition and disability grouping is comprised of age (those under the age of 5 and above the age of 65), single parent homes, and any disability. These groups are more likely to need financial support, transportation, medical care, or assistance with day to day activities during disasters. The elderly and the children, especially the younger ones often lack the resources, knowledge, or life experiences to effectively address the situation and cannot protect themselves. Elderly living alone, and people who have a physical, sensory, or cognitive challenges are more likely to be vulnerable during an incident. These groups often need a higher level of assistance than others, and may have caretakers who are less able to assist during a crisis if those caretakers have families of their own. This places a heavier burden on medical and first responders.

Minority status and language includes race, ethnicity, and proficiency of the English language. The social and economic marginalization of certain racial and ethnic groups have made these populations more likely to be vulnerable at all stages, and are automatically associated with a higher vulnerability rate. Many citizens are not fluent in English, which makes providing them with real time information difficult. Because Spanish is the most prominent second language, there are often translators available, and many times emergency notifications are provided in Spanish; however, those who speak other languages are at greater risk if notifications are not provided in the appropriate languages. These groups often rely on family, friends, neighbors and social media for information.

Housing and transportation considers the structure of the home (e.g., building codes, age of structure, etc.), crowding, and access to vehicles or public transportation. The quality of the housing in crucial when calculating vulnerability and is often tied to the person's wealth. Those who are economically disadvantaged often live in poorly constructed houses or mobile home, neither of which are designed to withstand strong winter storms (ice and snow loads), wind events, earthquakes, or flooding. In addition, mobile homes are often located in places without easy access to highways or public transportation, are in cluster communities, and many times not tied down to a foundation, all of which add another layer of vulnerability. Multi-unit housing in densely populated areas are difficult to evacuate because of the limited amount of space and crowding. Urban areas often have a lower automobile ownership rate (e.g., walkable communities), especially in the lower income populations, which can make evacuations more challenging. Despite the lower proportion of people with vehicles, urban areas often have to deal with congestion on highways and major roads because of crowding. Group quarters are another housing situation that cause concern during evacuations, especially nursing homes and long term care facilities because many institutions are unprepared to quickly remove staff and residents, and as with private group/independent living homes, the data that such facilities exist is not publicly known and/or identified.

16.2.2 Results and Discussion

Once the summary of the vulnerable populations were identified through the social vulnerability analysis, a generalized impact assessment of vulnerable populations and the potential spatial distribution of impact were discussed in Table 16-3 through Table 16-6.

Table 16-3
Vulnerable Populations

Population Group	Percent of Total Population
Households Children 5 and Under	5.5
Populations 65 and Older	19.8
Population Below Poverty Level	12.7
Language Other Than English	9
Total Population with Reported Disability	17.1
At Least One Disability Under 65	14.6
At Least One Disability 18 years and under	4.6
At Least One Disability 18-64	25.1
At Least One Disability 65 and over	82.6

Sources: US Census

Table 16-4
Potential Spatial Distribution of Exposure by Jurisdiction

Jurisdiction	Estimated Building Count	Total Exposed Value (Structure and Content)	Exposed Building and Content Values — 10-, 30-, and 50 Percent: 10 Percent	30 Percent	50 Percent
Aberdeen	6,331	$1,558,813,283	$155,881,328	$467,643,985.02	$779,406,641.71
Cosmopolis	740	$219,110,855	$21,911,085	$65,733,256.35	$109,555,427.25
Elma	1,225	$345,049,384	$34,504,938	$103,514,815.19	$172,524,691.98
Hoquiam	3,457	$668,170,030	$66,817,003	$200,451,009.05	$334,085,015.08
McCleary	664	$138,539,384	$13,853,938	$41,561,815.05	$69,269,691.75
Montesano	1,554	$433,872,272	$43,387,227	$130,161,681.49	$216,936,135.82
Oakville	331	$66,998,060	$6,699,806	$20,099,418.00	$33,499,030.00
Ocean Shores	4,600	$1,156,337,793	$115,633,779	$346,901,337.97	$578,168,896.61
Westport	1,291	$310,030,743	$31,003,074	$93,009,222.99	$155,015,371.64
Unincorporated Grays Harbor County	12,816	$3,122,630,417	$312,263,042	$936,789,125.05	$1,561,315,208.42
Other (4)	718	$177,559,756	$17,755,976	$53,267,926.71	$88,779,877.85
Total	**33,727**	**$8,197,111,976**	**$819,711,198**	**$2,459,133,592.86**	**$4,098,555,988.11**

Once the Social Vulnerability was determined, the Planning Team conducted a qualitative assessment combining the value of the CPRI, and summarizing the potential impact based on past occurrences, spatial extent, and subjective damage and casualty potential. Those items were categorized into the following levels and illustrated in the following tables:

- Extremely Low—The occurrence and potential cost of damage to life and property is very minimal to nonexistent.

- Low—Minimal potential impact. The occurrence and potential cost of damage to life and property is minimal.
- Medium—Moderate potential impact. This ranking carries a moderate threat level to the general population and/or built environment. Here the potential damage is more isolated and less costly than a more widespread disaster.
- High—Widespread potential impact. This ranking carries a high threat to the general population and/or built environment. The potential for damage is widespread. Hazards in this category may have occurred in the past.

Extremely High—Very widespread with catastrophic impact.

Table 16-5
Planning Team Countywide Vulnerability Rating

Jurisdiction	Climate Change*	Drought	Earth-quake	Erosion	Flood**	Land-slide	Haz-Mat	Severe Weather	Tsunami	Volcano	Wildfire
County	Low	Low	High	Medium	High	High	Medium	High	High	Low	Medium
Aberdeen	High	Medium	High	Medium	High	High	Medium	High	High	Low	Medium
Cosmopolis	Medium	Medium	High	High	Medium	High	Medium	High	High	Medium	Medium
Elma	Medium	Medium	High	Low	High	Medium	NR	High	Low	Low	Medium
Hoquiam	Medium	Low	High	Medium	High	High	NR	High	High	Low	Medium
McCleary	Medium	Medium	High	Low	Medium	Medium	Medium	High	Low	Low	High
Montesano	Low	Low	High	High	Medium	Medium	NR	Medium	Medium	Low	Medium
Oakville	Medium	Medium	High	Low	High	Medium	Medium	High	Low	Low	Medium
Ocean Shores***	High	Low	High	Medium/ High	Medium	Low	NR	High	Ex. High	Low	High
Westport	Low	Low	High	High	High	Low	Low	Medium	High	Low	Low
Grays Harbor Transit	Low	Low	High	Low	High	Low	Medium	High	High	Low	Low
Grays Harbor Hospital Dst.	Low	Low	High	Low	Medium	High	Medium	Medium	High	Low	Medium
Summit Pacific Medical Ctr.	Low	Low	High	Low	Low	Low	NR	High	Low	Low	Low
Port of Grays Harbor	Low	Medium	High	Medium	High	Low	Medium	High	High	Low	Low
Grays Harbor College	Low	Low	High	Medium	Low	High	High	High	Low	Medium	Medium
South Beach Regional Fire	Medium	Medium	High	Medium	Medium	Medium	NR	High	High	Medium	High
Fire District 2	Medium	Medium	High	Low	High	Medium	NR	Medium	High	Low	High
Fire District 5	Medium	Medium	High	Medium	High	High	Medium	High	High	Low	Medium
Fire District 7	Medium	Low	High	High	High	High	NR	High	High	Low	Medium
Fire District 8	Medium	Medium	High	Medium	Low	Low	Medium	High	High	Low	High
Fire District 16	Medium	Medium	High	Low	Low	Low	Ex. High	High	Low	Low	High

*Includes Sea Level Rise; **Flood Includes Dam Failure; **** Ocean Shores included Windstorm Ranked as #6 and High Vulnerability, and Invasive Species, Ranked as #8 and a Medium Vulnerability.

Table 16-6
Vulnerability Overview

Hazard	Synopsis of Potential Impact	Population Groups Impacted (By Group Type): Business	Children	Disabled	Elders	Families	Low Income	Language	Level of Impact High, Medium, Low	Summarized Extent and Location
Climate Change	Climate change is often measured in terms of impact on other hazards of concern. Impact varies, but can include physical drought conditions, water shortage, increased flood incidents, increased wildfire danger, environmental changes which impact habitats and species.	X	X	X	X	X	X	X	Low	Climate change itself customarily does not impact structures; however, the entire population and natural resources of the area will be impacted by climate change in some form. Wildfire danger will increase. Flood depths and sea level rise will also undoubtedly increase, causing additional damage and impact throughout the area, both in areas previously flooded (more severe flooding), and in areas which previously have not flooded.
Drought	Drought is typically measured in terms of water availability in a defined geographical area, and is not a sudden-onset hazard, allowing some preparation. Socioeconomic droughts occur when physical water shortage begins to affect people, individually and collectively. Social impacts mainly involve public safety, health, reduced quality of life, and inequities in the distribution of impacts and disaster relief. Many impacts identified as economic and/or environmental also have a social component. During warm seasons, water suppliers are often faced with more demand for water than they are able to distribute. This may lead to rationing and curtailment, with business that rely heavily on water usage (landscapers, golf courses, car washes, etc.) suffering financially. Most socioeconomic definitions of drought associate it with supply, demand, and economic good.	X	X	X	X	X	X		Low	Drought customarily does not impact structures, but would adversely impact people, resources, and aqua- and agri-cultural businesses (among others) within the area. Therefore, all populations would be susceptible, although the degree would be determined by the severity of the drought in place, and the availability of water. Most of the planning partners do have some type of water-shortage plan in place, and have identified additional water sources should a shortage occur.

Table 16-6
Vulnerability Overview

Hazard	Synopsis of Potential Impact	Population Groups Impacted (By Group Type): Business	Children	Disabled	Elders	Families	Low Income	Language	Level of Impact High, Medium, Low	Summarized Extent and Location
Earthquake	Older structures (pre ~1970) have high probability of collapse due to building code standards; Non-English speakers may have issues gaining hazard information for preparedness. Low-income individuals may not be able to stockpile supplies or medications. Elderly populations are vulnerable due to health issues, the lack of physical strength to extricate themselves, etc. Businesses many times do not carry insurance which will help them recover from losses. A Cascadia-type event could cause a large tsunami wave to impact the area, increasing the risk and vulnerability to citizens in the area.	X	X	X	X	X	X	X	High	Many structures in the area were built pre-1970, when lower codes were in place, making the structures more vulnerable to collapse, increasing the potential for injury. Of primary concern, especially in a Cascadia-type event, is the potential and impact from Tsunami. Low-lying areas would require immediate evacuation to higher ground, with some areas experiencing the first tsunami wave in 25 minutes. Areas which are not in the tsunami inundation zone could still be impacted through waves traveling up river/stream beds, and the drainage of those areas blocked by increased water levels, causing back-flow. Roadways and evacuation routes would also be impacted. The majority of the entire area susceptible to the impacts from an earthquake to some degree. Also of concern with earthquake are landslides and slope stability. Stability in the area could be significantly undermined.

Table 16-6
Vulnerability Overview

Hazard	Synopsis of Potential Impact	Population Groups Impacted (By Group Type): Business	Children	Disabled	Elders	Families	Low Income	Language	Level of Impact High, Medium, Low	Summarized Extent and Location
Flood	Year of construction will influence the building code and the height to which the structures were built when compared to the Base Flood Elevation. In most instances, weather patterns which cause flooding are identified in advance, allowing pre-planning for evacuation, thereby potentially reducing the individuals at risk. Individuals without homeowner's insurance which covers flooding may suffer extreme financial risk. Businesses impacted many times do not carry insurance which will help them recover from losses. In many instances, those businesses do not return to the area because they cannot overcome the financial loss.	X	X	X	X	X	X	X	High	Flooding in the area has been significant, with 12 declared events since 1954. Flooding in the area has also impacted transportation, causing roadways to be blocked, and causing landslides which also block major arterials. This has caused issues with evacuation in certain areas. All areas within the floodplain would be vulnerable, however, given the higher-than-average population of elderly and young, the level of vulnerability is higher than when compared to other areas. The County also has increased populations from tourists who frequent the area, and travel through to other counties along the coastline. For planning purposes, tourism increases the population by 4 million on average throughout the year.

Table 16-6
Vulnerability Overview

Hazard	Synopsis of Potential Impact	Population Groups Impacted (By Group Type): Business	Children	Disabled	Elders	Families	Low Income	Language	Level of Impact High, Medium, Low	Summarized Extent and Location
Severe Weather – inclusive of heat, cold, wind, snow, ice, hail, Thunder-storm, lightening	Severe weather occurs regularly throughout the planning area. In most instances, weather patterns are forecasted in advance, allowing for preparation. Individuals with lower income may not have the ability to stock supplies, nor afford the cost of increased energy costs for both heating or cooling, depending on the weather event. In snow or ice conditions, while rare, secondary impacts from driving or shoveling snow increases the risk of impact. Elderly and young children are especially susceptible to cold, ice, and heat conditions. Lighting strikes also occur throughout the planning area, although in a limited capacity. In densely wooded areas, such as the Olympic National Forest or any of the timer land, fires could go un-noticed for a period of time, allowing the fire to gain strength and severity, especially during drought situations. Lightning risks also increase due to the large waterbodies in the area, and the time it takes for boaters to get to safety. The area also has a number of golf courses, which are open and provide little cover from lightning strikes.	X	X	X	X	X	X	X	High	The entire region is susceptible to severe weather incidents, including impact to people, property, economy, and the environment. Incidents of some nature and degree occur annually. Depending on the type of event, roadways may be impassible. Significant power outages do not occur often, and do not customarily last for a long period of time. However, when coupled with cold conditions, the impact to vulnerable populations increases. With extreme heat events, physical manifestation on the young and elder rise. In addition, the increased fire danger impacts the entire area.

Table 16-6
Vulnerability Overview

Hazard	Synopsis of Potential Impact	Population Groups Impacted (By Group Type): Business	Children	Disabled	Elders	Families	Low Income	Language	Level of Impact High, Medium, Low	Summarized Extent and Location
Tsunami	While Tsunamis have occurred in the planning area, their impact to date has been limited in nature, with the exception of the 1964 tsunami resulting from the Alaskan Earthquake.	X	X	X	X	X	X	X	High	Impact from a tsunami resulting from a Cascadia-type incident would be devastating with respect to life-safety, the economy, and the environment, especially along the coastal areas of Westport and Ocean Shores. Areas not directly impacted by tsunami waves would still be significantly impacted as a result of evacuation and assistance to citizens fleeing the flooded areas; depletion of resources needed to assist in the region, including first responders; and environmental devastation, including saltwater intrusion to agricultural areas, wells, and hazardous materials, among others.
Volcano	Volcanic eruption would impact the area primarily through ash accumulations. The area is outside of the lahar zone. Ash accumulations could impact structures due to not only machinery, but also from the weight of the ash itself, and load capacity. Individuals with health concerns, especially breathing or lung issues, would be more susceptible and at risk.	X	X	X	X	X	X	X	Low	One incident of volcanic eruption has occurred in the area which rose to the level of a disaster declaration. No dollar loss figures were captured on which to base economic impact; however, due to the areas reliance on agriculture and aquaculture, economic impact could be significant. Environmental impact would also be a major concern throughout the entire area, as ash spread would be carried both through wind and also vehicles traveling through the area, carrying ash. Small amounts of ash can negatively impact water sources and vegetation due to the acidic nature of the ash itself.

Table 16-6
Vulnerability Overview

Hazard	Synopsis of Potential Impact	Population Groups Impacted (By Group Type): Business	Children	Disabled	Elders	Families	Low Income	Language	Level of Impact High, Medium, Low	Summarized Extent and Location
Wildfire	Impact from wildfires has increased over time due to effective suppression tactics. This has now caused fires to burn with greater intensity, with the traditional fire regimes being modified. Embers from wildfires can be carried significant distances (miles). With climate change impacting drought conditions, the potential for wildfire increases as moisture content is depleted. People are one of the major causes to wildfires, which can spread very quickly, leaving little to no time to evacuate. Individuals with access and functional needs, the young and elderly are at greater risk due to their potential dependence on others to assist with evacuation. Individuals with health concerns are impacted significantly by smoke. Increased rates of death due to smoke can occur.	X	X	X	X	X	X	X	Medium	Wildfire danger can impact the entire planning area; however, there has been limited impact to date. The various Fire Regimes do identify areas of higher levels of risk, although wildfires can occur in any area with vegetation, including dune fires, which are frequent occurrences in the area. It should be noted that not all Fire Regimes exist in the area. Due to the wind patterns in the area, including the shift of winds during afternoon hours, embers have the potential to travel great distances (miles) and ignite fires in areas which are densely wooded. In some instances, these fires can burn for periods of time, going un-noticed until ignition consumes a large area, making containment difficult. Elderly, young and individuals with breathing/health issues are more vulnerable due to smoke and particulates. Language may also be a barrier for non-English speaking populations due to the inability to understand evacuation orders, which can be very short-notice.

CHAPTER 17.
MITIGATION STRATEGY

The development of a mitigation strategy allows the community to create a vision for preventing future disasters. This is accomplished by establishing a common set of mitigation goals and objectives, a common method to prioritize actions, and evaluation of the success of such actions. Specific mitigation goals, objectives and projects were developed for Grays Harbor County and its planning partners by the Planning Team in their attempt to establish an overall mitigation strategy by which the jurisdictions would enhance resiliency of the planning area.

The CRS program credits NFIP communities points for setting goals which help reduce the impact of flooding and other known natural hazards; identifying mitigation projects that include activities for prevention, property protection, natural resource protection, emergency services, structural control projects, and public information. Establishing goals in such a manner was a primary focus of the Planning Team.

17.1 HAZARD MITIGATION GOALS AND OBJECTIVES

During the September 14, 2017 meeting, the Planning Team reviewed the 2011 existing goals. For the 2018 update, the Planning Team used the existing goals as a base, making modifications to support a countywide effort of enhanced capabilities which support resilience through protection of life, property, the economy and the environment. The goals as written for the 2018 update more accurately describe the overall direction that Grays Harbor County and its planning partners can take to work toward mitigating risk from natural hazards and avoid long-term vulnerabilities to the hazards of concern. Mitigation goals for this plan are listed below.

17.1.1 Goals

Goals for the 2018 mitigation strategy are as follows:

Goal 1 Reduce or prevent future hazard-related injuries and loss of life, property damage, environmental impact, and economic loss caused by disaster incidents.

Goal 2 Develop and implement long-term, cost-effective, and environmentally sound mitigation opportunities and projects which address all hazards of concern, with a particular focus on flood, earthquake, and tsunami.

Goal 3 Leverage partnering opportunities through enhanced community capabilities by increased public awareness and readiness (i.e., prepare, plan, protect, respond, recover, mitigate).

Goal 4 Promote disaster-resistant and resilient communities.

17.1.2 Objectives

Objectives identified for the 2018 effort are identified below.

Objective Number	Objective Statement	Applicable Goals
O-1	Acquire (purchase), retrofit, or relocate structures in high hazard areas.	1, 2, 3, 4,
O-2	Use best available data, science, and technologies to improve understanding of location and potential impacts of hazards, and to promote disaster resilient communities that minimize risk.	1, 2, 3, 4
O-3	Consider the impacts of natural hazards in all planning mechanisms that address current and future land use.	1, 2, 4
O-4	Increase resilience of identified critical facilities throughout the County.	1, 2, 3, 4
O-5	Continue to improve coordination and partnerships among all sectors to mitigate hazards, including government, local businesses, and citizens.	1, 2, 3, 4
O-6	Enhance community capabilities to prepare for, protect from, respond to, recover from, and mitigate the impact of hazards.	3, 4
O-7	Develop or improve emergency warning notifications; response and recovery operations; communication systems, and evacuation procedures.	1, 3
O-8	Provide/improve mitigation activities through various means, including things such as: public education and outreach activities; programmatic-level initiatives; and structural and environmental projects.	1, 2, 3, 4
O-9	Encourage hazard mitigation measures that result in the least adverse effect on the natural environment, and that use natural processes, while preserving and maintaining the environmental elements of the planning area.	2, 4

17.2 HAZARD MITIGATION ALTERNATIVES

After the goals and objectives were established, the Planning Team developed specific action items to further increase resilience. FEMA's 2013 catalog of *Mitigation Ideas* was presented to the Planning Team to provide ideas and concepts of possible action items. This document includes 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), and can be applied to both existing structures and new construction. The catalog provides 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. It presents 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.

Hazard mitigation initiatives recommended in this plan were selected from among the alternatives presented in the catalogs, as well as projects identified by the planning partners and interested stakeholders specific to their jurisdiction. Some were carried over from the previous plan. Some may not be feasible based on the selection criteria identified for this plan, but are included nonetheless as the Planning Team felt they are viable actions to be taken to reduce hazard influence in some manner.

17.3 SELECTED MITIGATION INITIATIVES

For the 2018 update, particular attention was given to new and existing buildings and infrastructure, and developing appropriate mitigation strategies for these facilities. Priority was also given to flood-prevention strategies. The Planning Team determined that some initiatives from the mitigation catalogs could be implemented to provide hazard mitigation benefits countywide. Table 17-1 lists the recommended countywide initiatives. Many of these initiatives are also identified by other planning partners who support the effort. Table 17-2 identifies County-specific initiatives.

17.4 ANALYSIS OF MITIGATION INITIATIVES

In addition to identifying potential funding sources available for each project, the Planning Team also developed strategies/action items that are categorized and assessed in several ways:

- By what the alternative would impact – new or existing structures, to include efforts which:
  - Manipulate/mitigate a hazard;
  - Reduce exposure to a hazard;
  - Reduce vulnerability to a hazard;
- By who would have responsibility for implementation:
  - Individuals;
  - Businesses;
  - Government (County, Local, State and/or Federal).
- By the timeline associated with completion of the project, based on the following parameters:
  - Short Term = to be completed in 1 to 5 years
  - Long Term = to be completed in greater than 5 years
  - Ongoing = currently being funded and implemented under existing programs.

- By who benefits from the initiative, as follows:
  - A specific structure or facility;
  - A local community;
  - County-level efforts;
  - Regional level benefits.

Table 17-1
Countywide Hazard Mitigation Initiatives

New or Existing assets	Hazards Mitigated	Objectives Met	Lead Agency*	Estimated Cost	Funding Sources	Timeline	In Previous Plan?	Initiative Type	Who Benefits?
CW-1 Continue data gathering for facility information to continue to improve the risk assessment and identification of infrastructure countywide.									
New/ Existing	All	2, 3, 4, 6,	EM, All planning partners	Low	HLS/EMPG, PDM, HMGP, HUD, General Funds	Ongoing	No	Structural Projects, Property Protection	Regional
CW-2 Work with County and state agencies to establish a protocol and advance permitting for transporting of hazardous materials for identification during an incident. Establish a countywide hazardous materials incident response team.									
New	Hazardous Materials	5, 6, 7, 8, 9	PH, Fire, EM, PW, WSDOT, WDOE	High	General Funds, HLS (EMPG), CDC grants	Long-Term	Partial	Prevention, Public Information and Education, Natural Resource Protection, Emergency Services/ Response	Regional
CW-3 Develop points of distribution in areas of potential isolation.									
New	All	5, 6, 7	PH, EM, PW, Local EMs	Low	EMPG, HUD	Short-Term	No	Public Information and Education, Emergency Services / Response, Recovery	Regional

Table 17-1
Countywide Hazard Mitigation Initiatives

New or Existing assets	Hazards Mitigated	Objectives Met	Lead Agency*	Estimated Cost	Funding Sources	Timeline	In Previous Plan?	Initiative Type	Who Benefits?
CW-4 Work with Public Health and Human Services to develop an information bank identifying individuals with access and functional needs. This will assist the County in determining shelter locations requiring specific resources to meet the needs of those individuals. NOTE: This is not an attempt to gather medical-related data, but rather to determine access and functional needs of citizens – e.g., citizens in wheel chairs need more space and shower/restroom facilities; hearing impaired need to have an area which allows them to be near to their signer, the use of oxygen tanks increases space requirements, etc.									
New	All	2, 3, 5, 6, 7, 8	PH, EM, HS	Low	Health and Human Service Grants, HUD, HMGP	Long-Term	No	Public Information and Education, Emergency Services / Response, Recovery	Community Level
CW-5 Coordinating with Assessor's Office, Permitting and other County offices, update Assessor's parcel data to include more building-specific information which may be utilized within the GIS and Hazus programs for enhanced risk assessments to provide a detailed loss estimation.									
New and Existing	All	2, 3, 4, 5, 6, 7	Assessor's Office; GIS; PW, EM; CD	Medium	General Fund, HMGP	Short-Term	No	Structural Projects, Property Protection, Recovery	County and Local
CW-6 Coordinate among all jurisdictions to seek out and apply for grants for site hardening of facilities. This includes back-up power at county facilities, including jail, juvenile detention, and health department.									
New/ Existing	E, EQ, F, LS, SW	1, 2, 3, 4, 5, 6, 7, 8, 9	EM	Medium	Earthquake and Tsunami Program, HMGP, PDM, HUD, DOT, EPA	Long-Term	Partial	Structural Projects, Property Protection, Natural Resource Protection	Facility Specific
CW-7 Maintain and regularly update fire hydrant layer countywide.									
New/ Existing	WF	2, 3, 5, 6, 7, 8	EM, GIS, Fire	Low	HMGP, HUD, SAFER	Long-Term	No	Property Protection, Emergency Services/ Response	Countywide

Table 17-1
Countywide Hazard Mitigation Initiatives

New or Existing assets	Hazards Mitigated	Objectives Met	Lead Agency*	Estimated Cost	Funding Sources	Timeline	In Previous Plan?	Initiative Type	Who Benefits?
CW-8 Continue implementation of public information program within Grays Harbor County to inform citizens about the hazards faced and the appropriate preparedness and response measures, including, but not limited to, NFIP, Earthquake and landslide information, insurance information, and structural projects which homeowners can undertake, such as affixing chimneys, foundations, fire-proof roofing materials, etc.									
New/ Existing	All	All	EM and Local EM, Local and County Land Use Planning, private industry.	Low	EMPG, General Fund	Ongoing	Yes	Prevention, Public Information and Education	County and Community
CW-9 Continue to expand CERT training, involving local teams in exercises and training with first responders.									
New/ Existing	All	2, 6, 7, 8	EM, Local EM, County Citizen Corps Groups,	Low	EMPG	Ongoing	Yes	Prevention, Public Information and Education, Emergency Services, Response, Recovery	County and Community
CW-10 Develop and prepare a fueling plan, addressing both automotive and heating fuels, in case of prolonged interruption of normal distribution to Grays Harbor County locations.									
New and Existing	EQ, F, LS, SW, T	2, 3, 4, 5, 6, 7, 8	EM, Local EM, Sheriff, LE, Fire, PW and Local PW	Low	General Fund, various grants.	Long-Term	No	Response, Recovery	County and Local
CW-11 Evaluate current coverage and equipment and provide a strategic emergency communications plan that provides better coverage to all areas of Grays Harbor County for first responders and emergency amateur radio communications. This includes KXPB Radio Station relocation to higher grounds with an upgraded antenna to ensure continued communication with local citizens.									
Existing	All	2, 5, 6, 7	EM and Local EM, Communica-tions Group, ARES/RACES	Low	General Funds	Short-Term	Partial	Emergency Services/ Response, Prevention, Public Information and Education	County and Local

Table 17-1
Countywide Hazard Mitigation Initiatives

New or Existing assets	Hazards Mitigated	Objectives Met	Lead Agency*	Estimated Cost	Funding Sources	Timeline	In Previous Plan?	Initiative Type	Who Benefits?
CW-12 Identify and designate emergency shelter structural and utility readiness for occupancy after a significant incident.									
New/ Existing	All	1, 2, 3, 4 5, 6, 8	EM	Medium	PDM, HMGP, General Funds	Short-Term	Yes	Prevention, Public Information Emergency Services/ Response	Regional
CW-13 Provide erosion control information and steep slope stability recommendations to citizens and homeowners. Inform owners concerning structures above steep bluffs or below steep bluffs. Increase monitoring of countywide erosion issues and bluffs.									
New/ Existing	E, EQ, F, LS, SW	1, 2, 3, 4, 5, 6, 7, 8, 9	EM, County and Local PW, WDNR	Medium	PDM, HMGP, General Funds	Long-Term	No	Structural Projects, Property Protection	County and Local
CW-14 Conduct a needs assessment to determine logistical requirements for equipment and parts for wells and water distribution sources to ensure a surplus allowing for continued supply of water in case commodity flow is impacted by a major event.									
New/ Existing	All	2, 3, 4, 5, 6, 9	PH, EM PW, WDOE	Medium	Earthquake and Tsunami Program Grant Funds, EPA, EMPG	Ongoing	Partial	Response, Recovery	County and Local
CW-15 Promote a "FireWise" program in County to increase fire safety zones around businesses and residences. Encourage owners to reduce woodland fuel loads on their property.									
New/ Existing	D, WF	2, 3, 4, 5, 6, 7, 8, 9	EM, Local EM, Fire	Low	Fire Grants, PDM, HMGP	Ongoing	No	Property Protection, Natural Resource Protection, Prevention	Local
CW-16 Work with local jurisdiction and planning partners to develop various emergency planning efforts to help ensure continuity of business and resiliency, and to develop mechanisms to ensure recovery efforts exist. This includes pre-identifying solid waste staging areas which can be utilized during disaster incidents.									
New/ Existing	All	1, 2, 3, 4, 5, 6, 7, 8	EM, Local EM, ED, Chamber	Medium	EMPG Funds, General Funds	Long-Term	Partial	Recovery	County, Local

Table 17-1
Countywide Hazard Mitigation Initiatives

New or Existing assets	Hazards Mitigated	Objectives Met	Lead Agency*	Estimated Cost	Funding Sources	Timeline	In Previous Plan?	Initiative Type	Who Benefits?
CW-17 Identify and establish redundant or back-up emergency operations center locations throughout the County in case of road closures which restrict access to areas of the County, as well as identifying public buildings which could be used as emergency shelters such restricted access occur. Ensure that such shelters are inspected to meet requirements. Work with shelter sites to establish a surplus of water, and to identify minimal food safety requirements.									
New	All	4, 5, 6, 7, 8	EM, Public Officials - County and Local; Public Health	Medium	EMPG and General Funds	Short-Term	Partial	Emergency Services/ Response, Recovery	County and Local
CW-18 Partner with Washington State Department of Transportation to expand earthquake assessment, and to expand and implement training and exercises throughout the county which support transportation-related issues and potential isolation.									
New/ Existing	All	2, 5, 6, 7, 8	EM, Local EM, PW, Shelton Roads, WSDOT	Medium	US DOT and WA DOT Grants, HLS	Long-Term	No	Emergency Services/ Response, Recovery	Regional
CW-19 Continue to promote and establish a countywide emergency management actions, projects, and programs, working with the cities and special purpose districts, to enhance resiliency and maintain consistency in mitigation activities, emergency management programs, and capabilities. This includes seeking grant funding to support such initiatives.									
New/ Existing	All	All	EM, Local EM, Fire, Hospitals	Medium	General Funds, Grant Opportunities as they arise	Long-Term	No	Prevention, Public Information and Education, Emergency Services/ Response, Recovery	County and Local
CW-20 Strive to capture time-sensitive, perishable data such as high water marks, extent and location of hazard, and loss information following hazard events to support future updates to the risk assessment and in support of future grant applications to demonstrate impact.									
New/ Existing	All	2, 3, 7	EM and Local EMs	Medium	General Funds	Long-Term	No	Emergency Services/ Response, Recovery	County and Local
CW-21 Continue to enhance local emergency planning committee (LEPC) involvement with private industry and local jurisdictions throughout the County with the goal of quarterly meetings.									
Existing	WF	5, 7, 8	EM, Local EM, Fire, Private Industry	Low	General Funds	Ongoing	No	Prevention, Emergency Services/ Response, Recovery	County and Local

Table 17-1
Countywide Hazard Mitigation Initiatives

New or Existing assets	Hazards Mitigated	Objectives Met	Lead Agency*	Estimated Cost	Funding Sources	Timeline	In Previous Plan?	Initiative Type	Who Benefits?
CW-22 Seek grant funding to develop a countywide mass care and evacuation exercise, which includes all fire and police departments, Hospital District, Public Health, County Transit, Emergency Management and search-and-rescue, as well as other planning partners as identified during exercise design.									
New and Existing	All	5, 6, 7, 8	EM, Local EM, Fire, Hospitals, PH, PW, WSDOT; Sheriff, LE	High	EMPG, DOJ Grants, Fire Training Grants, EMPG	Long-Term	No	Emergency Services/ Response, Recovery	County and Local
CW-23 Continue to integrate mitigation planning data into ongoing land-use planning to assist in providing information necessary to enforce existing building codes, floodplain and critical areas ordinances, and shoreline protection.									
New and Existing	F, E. EQ, LS, SW	1, 2, 3, 4, 5, 6, 7, 8	EM, PW	Low	FEMA	Short-Term	Yes	Prevention, Emergency Services, Planning, Response, Recovery	Local and County
CW-24 Develop countywide mutual aid agreements with both public and private agencies in support of preparedness and response activities.									
New	All	4, 5, 6	EM	Medium	General Funds	Ongoing	No	Emergency Services/ Response, Recovery	County and Local
CW-25 Capture data concerning the number of portable generators at fueling stations and local grocery outlets to determine need to acquire generators to ensure fuel availability and food items during significant events which may impact transportation flows, reducing commodities in the planning area. If necessary, seek grant opportunities to purchase generators for use during such events.									
New/ Existing	All	5, 7, 8	EM	Low	General Funds	Ongoing	No	Emergency Services/ Response, Recovery	County and Local
CW-26 Capture information concerning the surplus supply maintained by local fueling stations and grocery outlets to determine quantities available should commodities be interrupted as a result of a significant incident.									
New/ Existing	All	5, 6, 7, 8	PW	Low	General Funds	Ongoing	No	Emergency Services/ Response, Recovery	County and Local
CW-27 Develop countywide debris management plan.									
New/ Existing	E, EQ, F, LS, SW, WF	2, 3, 4, 5, 6, 7	PW	High	Grant Sources TBD	Long-Term	No	Recovery	County and Local

Table 17-1
Countywide Hazard Mitigation Initiatives

New or Existing assets	Hazards Mitigated	Objectives Met	Lead Agency*	Estimated Cost	Funding Sources	Timeline	In Previous Plan?	Initiative Type	Who Benefits?
CW-28 Work with various communications organizations within the area to identify location of cell towers and capacity to support area during disaster incidents. This includes relocation and upgrade project for KXPB Radio Station.									
New/ Existing	All	5, 6, 7, 8	PW	Low	General Funds	Ongoing	Partial	Emergency Services/ Response, Recovery	County and Local
CW-29 Update the flood profile once the Chehalis and Wynoochee Rivers Flood Insurance Study and RiskMAP products are finalized. Review existing ordinances in place to ensure continued protection and compliance. This may include the County seeking grant funding to develop a comprehensive update, including public outreach to ensure information is disseminated countywide.									
New/ Existing	All	1, 2, 3, 4, 5, 6, 7, 8, 9	DEM	High	Ecology, HMGP or PDM Grant Funds	Ongoing	Partial	Emergency Services/ Response, Recovery	County and Local
CW-30 Work with local school districts to study and retrofit school facilities to better withstand damage from earthquake, tsunami, flood, severe weather, erosion and landslide events.									
New/ Existing	All	All	DEM, Local DEM, School Districts	High	HLS/EMPG, PDM, HMGP, HUD, Dept. of Education, State Earthquake/ Tsunami Program	Ongoing	No	Structural Projects, Property Projection, Emergency Services/ Response, Recovery	Facility, County, and Local

* CD=Community Development; ED=Economic Development; EM= Emergency Management; Fire=Districts and Depts.; HS=Human Services; LE=Law Enforcement; PH=Public Health; PW=Public Works; WSDOT=Washington State Dept. of Transportation; WDOH=Washington State Dept. of Health; WDNR=Washington State Dept. of Natural Resources; WDOE=Washington Dept. of Ecology

Table 17-2
County-Specific Hazard Mitigation Initiatives

New or Existing assets	Hazards Mitigated	Objectives Met	Lead Agency	Estimated Cost	Funding Sources	Timeline	In Previous Plan?	Initiative Type	Who Benefits?
C-1 Study, retrofit or move county owned facilities to better withstand damage from earthquake, flood, severe weather. This includes the Pearsall Building (Public Health) and Juvenile Detention Center, among others.									
Existing	All	1, 2, 3, 4 5, 7, 8, 9	EM, Facilities	High	HLS/EMPG, PDM, HMGP, HUD, General Funds	Ongoing	Yes	Structural Projects, Property Protection	Facility
C-2 Evaluate and enhance the current capital improvements program for county roads, including the US 12 at Porter, Keys Road, Brooklyn Road, and Blue Slough Road. Also include, as necessary, drainage projects such as the culvert with bridge at MP 8.2 of the South Bank Road; elevating Wishkah Road; and replacing a 3-foot diameter on Barrett Road to provide better flood control in known flood problem areas, including drainage system maintenance plans and sediment and debris clearance to ensure unobstructed flow of floodwaters.									
New/ Existing	E, F, LS, SW	1, 2, 3, 4 5, 6, 7, 8, 9	PW, US DOT	High	General Funds, HLS (EMPG), CDC grants	Long-Term	Partial	Property Protection, Structural Projects, Natural Resource Protection	County and Local
C-3 Seek steep slope stability project funding or relocation funding for county roads with histories of instability, such as US 12 at Porter, Keys Road, Brooklyn Road, and Blue Slough Road.									
Existing	EQ, F, LS, SW, WF	1, 2, 3, 4 5, 6, 7, 8, 9,	PW	High	PDM, HMGP, USDOT, WADOT	Long-Term	No	Property Protection, Structural Projects, Natural Resource Protection	County
C-4. Seek grant funding for acquisition of properties in high-hazard areas, with special attention to repetitive or severe loss properties.									
Existing	All	1, 2, 4	Commis-sioners, EM	High	PDM, HMGP, FMA	Long-Term	Yes	Property Protection, Structural Projects,	Facility and County
C-5. Obtain and install river gauges on those rivers which currently have none, or for which additional gauges are needed.									
New/ Existing	F, SW	1, 2, 3, 4, 5, 6, 7, 8	EM, PW, USGS	High	HMGP, USGS Grant	Ongoing	Yes	Response, Recovery	County

Table 17-2
County-Specific Hazard Mitigation Initiatives

New or Existing assets	Hazards Mitigated	Objectives Met	Lead Agency	Estimated Cost	Funding Sources	Timeline	In Previous Plan?	Initiative Type	Who Benefits?
C-6. Seek granting fund to address areas in high landslide areas, such as the Blue Slough Road, Brooklyn Road, US 12 at Porter, and Key Road. When funding received, complete project.									
New	E, LS	1, 3, 4, 5, 6, 7, 8, 9	EM, PW/Roads, WSDOT	Low	General Fund, DOH, WSDOT	Short-Term	Yes	Prevention Public Information and Education, Response, Recovery	County and Local
C-7 Continue participation in the NFIP; considering implementing various steps which will increase CRS scores to help lower insurance premiums.									
New/ Existing	F, SW	1, 2, 3, 4, 5, 6, 7, 8, 9	EM, Planning	Medium	General Fund	Long-Term	Yes	Prevention, Mitigation	County
C-8 Continue to design and build facilities to meet or exceed seismic and code standards, including redundant essential equipment. Apply current seismic and wind load standards to all renovation or replacement of existing facilities, and/or equipment.									
New/ Existing	EQ, LS, SW	1, 2, 3, 4, 5, 6, 7, 8, 9	Planning, PW	High	PDM, HMGP	Ongoing	Partial	Structural Projects, Property Protection	County
C-9 Conduct activities that support mitigation efforts to reduce the negative influence of natural hazards impacting Grays Harbor County, such as appropriate hazard identification, warning, dissemination of relevant information and data, and public outreach.									
New	All	All	Planning, PH, EM	Low	General Fund, various grants.	Ongoing	Yes	Structural Projects, Public Information and Education, Natural Resource Protection	County, Facility, Local
C-10 Work with local public and private entities to review infrastructure control systems and ensure appropriate level of security and protection measures are in place. As appropriate, conduct audit of policies and procedures to ensure consistency and accuracy in application of security devices in place.									
Existing	All	2, 4, 5, 6, 7,	EM, PUDs, IT	Low	General Funds	Short-Term	No	Prevention, Property Protection, Emergency Services	Regional

Table 17-2
County-Specific Hazard Mitigation Initiatives

New or Existing assets	Hazards Mitigated	Objectives Met	Lead Agency	Estimated Cost	Funding Sources	Timeline	In Previous Plan?	Initiative Type	Who Benefits?
C-11 Implement cost-effective measures to address vulnerability of facilities at risk to sea level rise, extreme high tides and storm surges as they relate to potential inflow of saltwater. This includes working with local private water purveyors.									
New/ Existing	CC, EQ, F, LS, SW	1, 2, 3, 4, 5, 6, 7, 8, 9	EM, PH, PW, WDNR, WDOH, WDOE	Medium	PDM, HMGP, General Funds, Ecology, DOH, HLS	Long-Term	No	Structural Projects, Property Protection, Natural Resource Protection	County
C-12 Utilize data gathered during risk assessment to identify capital projects that, when modified, increase the resilience of the County's structures and conveyances to damage, or that allow a more expedited process for recovery from the impact of disaster incidents.									
New/ Existing	All	All	EM, PW, Planning, FEMA, WDNR	Medium	Earthquake and Tsunami Program Grant Funds, General Funds, PDM, HMGP	Short-Term	No	Structural Projects, Property Protection, Recovery	Facility, County
C-13 Consider projects enhancing resistance of county structures to impact from hazards of concern, such as seismic bracing of equipment, piping and fixtures, removal of high hazard beams, access road reinforcement, or seismic upgrades of underwater interceptors.									
New/ Existing	EQ, LS	1, 2, 3, 4, 7, 8, 9	EM, PW	High	Earthquake and Tsunami Grant Program, PDM, HMGP	Ongoing	No	Property Protection, Structural Projects	Facility, County
C-14 Implement a recovery system to ensure maximum FEMA reimbursement for disaster response, repair, mitigation and recovery, which will capture and track emergency activities, associated expenses (mileage, supplies, expendables, outside vendors, etc.), employee time and dedicated resources.									
New/ Existing	All	2, 5, 7, 8	EM, Risk, Finance	Medium	EMPG Funds, General Funds	Long-Term	No	Recovery	County
C-15 Utilize data from the current risk assessment and comprehensive land use planning effort currently underway to update GIS capacity and capabilities.									
New	All	1, 2, 3, 4, 5, 6, 8	County GIS, Planning, EM	Medium	HMGP, EMPG and General Funds	Short-Term	No	Response, Recovery	County

Table 17-2
County-Specific Hazard Mitigation Initiatives

New or Existing assets	Hazards Mitigated	Objectives Met	Lead Agency	Estimated Cost	Funding Sources	Timeline	In Previous Plan?	Initiative Type	Who Benefits?
C-16 Develop a web-based application to capture damage assessment from citizens, which can be verified by emergency personnel to expedite damage assessment. This may include an interface between the Assessor's office for property values, as well as a mechanism for rapid windshield assessment by first responders.									
New/ Existing	All	2, 5, 6, 8	IT, Assessor's Office, Risk Mgmt. EM	Medium	General Funds, HLS, HMGP	Short-Term	No	Recovery	County
C-17 Assess the County's communications systems to determine its current vulnerability. This will include a review of the number of radios necessary to allow for adequate communications during emergency situations with field units, emergency response personnel, and emergency managers.									
Existing	All	7	EM, IT, PW	Low	General Funds	Ongoing	No	Emergency Services, Response	County and Local
C-18 In accordance with OSHA/WISHA requirements for all employees performing emergency response activities (post-disaster), identify and train County staff and volunteers that will be utilized for these efforts. Training to be considered includes: ATC 20/45, Disaster Site Worker Training, and Emergency Response Training, Damage Assessment.									
New/ Existing	All	2, 4, 5, 6, 7	Commis-sioners, EM, All County Depts.	High	EMPG, DOJ Grants, Fire Training Grants,	Ongoing	No	Emergency Services, Response, Recovery	County
C-19 Develop (or update) plans to ensure response and recovery efforts. This includes working with the Board of County Commissioners to develop appropriate committees, such as a continuity of operations team, which will develop a countywide continuity of operations plan, and an emergency communications team which will look at communications and interoperability issues.									
Existing	All	3, 4, 5, 6, 7	EM, Commis-sioners	Low	Various	Long-Term	No	Response and Recovery	County
C-20 Develop public outreach which supports community participation in incentive-based programs, such as FireWise and StormReady.									
New/ Existing	All	2, 3, 5, 6, 7	EM	Low	General Funds	Ongoing	No	Public Information and Education, Emergency Services/ Response	County
C-21 Install flashing lights on tsunami-resistant structures near ocean.									
New/ Existing	T	2, 3, 4, 6, 7	EM	Medium	Grants	Ongoing	Yes	Emergency Services, Response, Public Information	Local and County

17.5 CRS ANALYSIS OF MITIGATION INITIATIVES

Each Planning Partner further reviewed its recommended initiatives to classify them based on the hazard it addresses and the type of mitigation it involves. This analysis incorporated, among others, the Community Rating System scale, identifying each mitigation action item by type. Mitigation types used for this categorization are as follows.

- Prevention - Government, administrative or regulatory actions that influence the way land and buildings are developed to reduce hazard losses. This includes planning and zoning, floodplain laws, capital improvement programs, open space preservation, and stormwater management regulations.
- Public Information and Education - Public information campaigns or activities which inform citizens and elected officials about hazards and ways to mitigate them – a public education or awareness campaign, including efforts such as: real estate disclosure, hazard information centers, and school-age and adult education, all of which bring awareness of the hazards of concern.
- Structural Projects —Efforts taken to secure against acts of terrorism, manmade, or natural disasters. Types of projects include levees, reservoirs, channel improvements, or barricades which stop vehicles from approaching structures to protect.
- Property Protection – Actions taken that protect the properties. Types of efforts include: structural retrofit, property acquisition, elevation, relocation, insurance, storm shutters, shatter-resistant glass, sediment and erosion control, stream corridor restoration, etc. Protection can be at the individual homeowner level, or a service provided by police, fire, emergency management, or other public safety entities.
- Emergency Services / Response —Actions that protect people and property during and immediately after a hazard event. Includes warning systems, emergency response services, and the protection of essential facilities (e.g., sandbagging).
- Natural Resource Protection – Wetlands and floodplain protection, natural and beneficial uses of the floodplain, and best management practices. These include actions that preserve or restore the functions of natural systems. Includes sediment and erosion control, stream corridor restoration, watershed management, forest and vegetation management, and wetland restoration and preservation.
- Recovery —Actions that involve the construction or re-construction of structures in such a way as to reduce the impact of a hazard, or that assist in rebuilding or re-establishing a community after a disaster incident. It also includes advance planning to address recovery efforts which will take place after a disaster. Efforts are focused on re-establishing the planning region in such a way as enhance resiliency and reduce impacts to future incidents. Recovery differs from response, which occurs during, or immediately after an incident. Recovery views long-range, sustainable efforts.

17.6 BENEFIT/COST REVIEW

Once the general analysis was completed for each mitigation initiative, 44 CFR requires the prioritization of the initiatives or action items according to a benefit/cost analysis of the proposed projects and their associated costs (Section 201.6.c.3iii). The benefit/cost analysis conducted during this planning process is not of the detailed variety required by FEMA for project grant eligibility under the Hazard Mitigation Grant Program (HMGP) and Pre-Disaster Mitigation (PDM) grant program. Rather, 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. Prioritization of the projects in such a manner serves as a guide for choosing and funding projects.

17.7 PRIORITIZATION OF INITIATIVES

The method for prioritizing initiatives for the 2018 update differs from the method used for the previous mitigation initiatives. While the factors involved in the ranking remain similar, there is now a consistent category or level (high/medium/low) assigned with those identified factors to ensure consistency. Table 17-3 lists the priority of each countywide initiative. Table 17-4 lists the priority for each county-specific initiative. A qualitative benefit-cost review as described above was performed for each of these initiatives.

Table 17-3
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)
1	4	H	L	Y	Y	Y	H
2	5	H	H	Y	Y	Y	H
3	3	H	L	Y	Y	Y	H
4	6	H	L	Y	Y	Y	H
5	6	H	M	Y	N	Y	M
6	9	H	M	Y	N	Y	M
7	6	M	L	Y	N	Y	M
8	9	H	L	Y	Y	Y	H
9	4	H	L	Y	Y	Y	H
10	7	H	L	Y	N	Y	H
11	4	H	L	Y	N	Y	H

Table 17-3
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)
12	7	H	M	Y	Y	Y	H
13	9	H	M	Y	Y	Y	H
14	6	M	M	Y	Y	N	M
15	8	M	L	Y	Y	N	L
16	8	M	M	Y	Y	Y	M
17	5	H	M	Y	Y	Y	M
18	5	M	M	Y	Y	N	M
19	9	H	M	Y	N	N	M
20	3	H	L	Y	Y	N	H
21	3	M	L	Y	N	Y	M
22	4	H	H	Y	Y	N	M
23	8	L	M	N	Y	N	L
24	3	H	M	Y	N	Y	M
25	3	M	L	Y	N	Y	M
26	4	M	L	Y	N	Y	M
27	6	H	H	Y	Y	N	M
28	4	M	L	Y	N	Y	M
29	9	H	M	Y	Y	Y	H
30	9	H	H	Y	Y	N	H

Table 17-4
Prioritization of County-Specific Hazard 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)
1	8	H	H	Y	Y	N	H
2	9	M	H	N	Y	N	M
3	9	H	H	Y	Y	Y	H
4	3	M	H	Y	Y	Y	M
5	8	H	H	Y	Y	N	H
6	8	H	H	Y	Y	N	H
7	9	H	L	Y	N	Y	H
8	9	H	H	Y	N	N	L
9	9	H	L	Y	Y	N	H
10	5	H	L	Y	Y	Y	H

Table 17-4
Prioritization of County-Specific Hazard 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)
11	9	M	M	Y	Y	N	M
12	9	M	M	Y	N	N	L
13	7	H	H	Y	Y	N	H
14	4	H	M	Y	N	Y	M
15	7	H	H	Y	Y	Y	H
16	4	H	M	Y	Y	Y	H
17	1	M	L	Y	N	Y	L
18	6	H	H	Y	N	Y	H
19	6	H	L	Y	Y	N	M
20	5	H	L	Y	Y	Y	H
21	5	H	M	Y	Y	N	H

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.

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.

Because this is a multi-jurisdictional plan, the prioritization of initiatives specific to the remaining jurisdictions must also be done at the individual level based on the needs and programs of that body, and accomplished as resources can be secured. Funding to complete any initiative will likely be acquired from a variety of sources, with the lack of funding alone preventing an initiative from being implemented. As such, the less formal approach used during this process is more appropriate because some projects may not be implemented for up to 10 years, and associated costs and benefits could change dramatically in that time.

The method of prioritization utilized also allows for the inclusion of new projects throughout the life cycle of this plan without having to numerically re-value each of the projects based on an assigned value of 1, 2, 3, etc. Further, it supports the plan maintenance strategy for review, addition, and reprioritization of initiatives on an annual basis, reducing the level of effort involved in a numeric system of ranking, and enhancing the likelihood that the annual review will occur as a reduced level of effort will be required.

17.8 2011 ACTION PLAN STATUS

A comprehensive review of the 2011 action plan was performed to determine which countywide actions were completed, which should carry over to the updated plan, and which were no longer feasible and should be removed from the plan. Table 17-5 identifies the results of this review for the County. Each Planning Team member's respective annex update contains information concerning their previous strategies.

Table 17-5
2018 Status of 2011 Mitigation Projects

Mitigation Strategy		Associated Hazards								2018 Project Summary	2018 Status ✓			
		Earthquake	Flood	Hazardous Materials	Landslides	Severe Weather	Tsunami	Volcano	Wildland Fire		Completed	Continual /On-going Nature	Removed /No Longer Relevant/No Action	Carried Over to 2018 Plan
1	Retrofit the Grays Harbor Hospital to withstand earthquake events.	✓								The hospital has developed its own annex this year, so they will be identifying their own strategies.			✓	
2	Retrofit Aberdeen School District buildings to current building codes	✓	✓	✓	✓	✓	✓	✓	✓	While the County will support this effort, the County has no jurisdiction over the school district.			✓	
3	Retrofit the Pearsall Building (Public Health) to current building codes.	✓	✓	✓	✓	✓	✓	✓	✓	Now included in C#1 and C#8 Strategies.	✓	✓		✓
4	Relocate utility corridors out of areas prone to severe earthquake damage	✓	✓		✓	✓	✓	✓	✓	PUD not part of the 2018 update. Will continue to work with PUD to attempt to complete.			✓	
5	Replace culvert with bridge at MP 8.2 of the South Bank Road.	✓	✓		✓	✓	✓			Carried forward to C#2				✓
6	Raise the Wishkah Road approximately 2 feet between MP 1 and 5		✓			✓				Carried forward to C#2				✓
7	Replace 3-foot diameter with 10-foot diameter culvert on Barrett Road West at MP 0.1, ½ mile west of Brady.		✓			✓				Carried forward to C#2		✓		✓
8	Locate, design, permit, and construct a solid waste staging area.	✓	✓		✓	✓	✓		✓	Carried forward CW#16				✓
9	Replace the Grays Harbor Fire District 11 Fire Station with a tsunami/earthquake resistant structure.	✓						✓		Removed from County's plan; this is a FD 11 project			✓	

Table 17-5
2018 Status of 2011 Mitigation Projects

Mitigation Strategy		Associated Hazards									2018 Status ✓			
		Earthquake	**Flood**	**Hazardous Materials**	**Landslides**	**Severe Weather**	**Tsunami**	**Volcano**	**Wildland Fire**	**2018 Project Summary**	**Completed**	**Continual /On-going Nature**	**Removed /No Longer Relevant/No Action**	**Carried Over to 2018 Plan**
10	Build the KXPB radio station on higher ground and upgrade antenna (North Beach).		✓			✓	✓			Became CW#11 and #28				✓
11	Construct road maintenance shop in hazard-free "safe zone" to store equipment and supplies for hazard response.	✓	✓	✓	✓	✓	✓	✓		As equipment and supplies become available, they have been stored in various road maintenance shop locations.		✓		
12	Relocate power lines underground in areas prone to blow-down during high wind storms.					✓				Several of the planning partners (Fire Districts) have identified this as a viable project. As the PUD was not part of this effort, this project was removed from the County's plan, and incorporated within the various annex templates.			✓	
13	Upgrade back-up power at county facilities, including Jail, Juvenile Detention, and Health Department.	✓	✓	✓	✓	✓	✓	✓	✓	Integrated into CW #6.		✓		✓
14	Assist homeowners in making their buildings flood, earthquake, and severe storm proof (chimneys, foundations, roofs).	✓	✓			✓				During public outreach events, information concerning mitigation efforts which individuals can complete are presented. Insurance information is also presented as a method in which citizens can more fully recover after a hazard event. CW #8.		✓		✓
15	Do LiDAR flyovers to identify natural and converted areas capable of providing natural storage of floodwaters.		✓			✓	✓			This request was made for the RiskMap Project for the Chehalis and Wynoochee Rivers.				✓

Table 17-5
2018 Status of 2011 Mitigation Projects

Mitigation Strategy		Associated Hazards									2018 Status ✓			
		Earthquake	Flood	Hazardous Materials	Landslides	Severe Weather	Tsunami	Volcano	Wildland Fire	2018 Project Summary	Completed	Continual /On-going Nature	Removed /No Longer Relevant/No Action	Carried Over to 2018 Plan
16	Install flashing lights on tsunami-resistant structures near ocean.						✓			CW #21				✓
17	Identification of public buildings that could be used as emergency shelters.	✓	✓	✓	✓	✓	✓	✓	✓	CW #12, 17				✓
18	Ensure shelter sites are served by approved public water and develop minimal food safety requirements.	✓	✓	✓	✓	✓	✓	✓	✓	CW #12, 17				✓
19	Create work group to develop a plan that coordinates the use of emergency water resources during a hazard event.	✓	✓		✓	✓	✓		✓	Most of the jurisdictions have water plans in place.	✓			
20	Use Grays Harbor Community Hospital's Pillar Talk newsletter, website, and Speaker Series to communicate about risks and preparing for hazard events.	✓	✓	✓	✓	✓	✓	✓	✓	GH Hospital is part of the 2018 plan development, and has provided information concerning the HMP and the risk assessment, providing another avenue of information exchange since the last plan was completed.				✓
21	Ensure that homeowners with on-site water and septic systems receive information about maintenance and hazard mitigation activities.	✓	✓	✓	✓	✓	✓			Public Health activity. This is a continual and on-going process for Public Health. CW#21		✓		
22	Update the countywide Comprehensive Plan to encourage development in areas less vulnerable to all natural disasters.	✓	✓	✓	✓	✓	✓	✓	✓	The County's Comp Plan was partially updated in 2017. Information from this HMP will be utilized as future updates occur, and as	✓			

Table 17-5
2018 Status of 2011 Mitigation Projects

Mitigation Strategy		Associated Hazards: Earthquake	Flood	Hazardous Materials	Landslides	Severe Weather	Tsunami	Volcano	Wildland Fire	2018 Project Summary	2018 Status ✓: Completed	Continual /On-going Nature	Removed /No Longer Relevant/No Action	Carried Over to 2018 Plan
										regulatory authority is developed.				
23	Update the Shoreline Master Program to manage development adjacent to shorelines to reduce the risk of hazard events to structures.		✓			✓				Comprehensive Land Use Plans underwent update during life cycle of HMP. Data from this plan will continue to be used for these purposes.	✓	✓		
24	Update the Critical Areas Ordinance to retain enrollment in the National Flood Insurance Program to position the county towards enrollment in the Community Rating System.		✓			✓				During the recent update to portions of the County's Comprehensive Land Use Plan, certain portions of the Critical Areas Ordinance were reviewed and updated as appropriate. In addition, several of the local jurisdictions have also recently updated their respective ordinance as well to ensure NFIP compliance. This will continue to be an on-going effort countywide. CW#29	✓			✓
25	Establish a countywide hazardous materials incident response team.			✓						The county sought grant funding to help develop this plan, but has not received an award. They will continue to work on this effort with the local Fire Districts. CW #2				✓
26	Identify public buildings that could be used as emergency shelters.	✓	✓	✓	✓	✓	✓	✓	✓	Combined with CW #17.				✓

17.9 ADDITIONAL MITIGATION ACTIVITIES:

In addition to the projects identified above, additional efforts include:

- Project Safe Haven is the Nation's first tsunami vertical evacuation center located in Westport, Washington, in the Ocosta School District. This voter-approved initiative which cost in excess of $13 million dollars serves to protect the lives of not only the children who attend the school, but also the citizens and visitors in the Westport area should a tsunami occur. The new structure replaced an outdated elementary building, and is strong enough to shelter approximately 1,500 people (see Figure 17-1).

Figure 17-1 Ocosta Elementary School Vertical Evacuation
Photo: Pete Eckert

- Erosion Study – a coordinated effort between FEMA, State Department of Ecology, Grays Harbor County, and its local jurisdictions to identify areas of erosion and develop mitigation efforts to reduce the impacts of erosion. Several of the local jurisdictions have completed various types of mitigation projects in an effort to slow down the erosion process, one of which was completed by Ocean Shores, who installed sand-filled geobags to protect dunes from continued erosion during a 2016 wintertime event (see Figure 7-2).
- The cities of Aberdeen and Hoquiam are also in the process of developing a level to help control the area from flooding (see Figure 17-3 below).

Figure 17-2 Ocean Shores Mitigation Effort to protect dune area

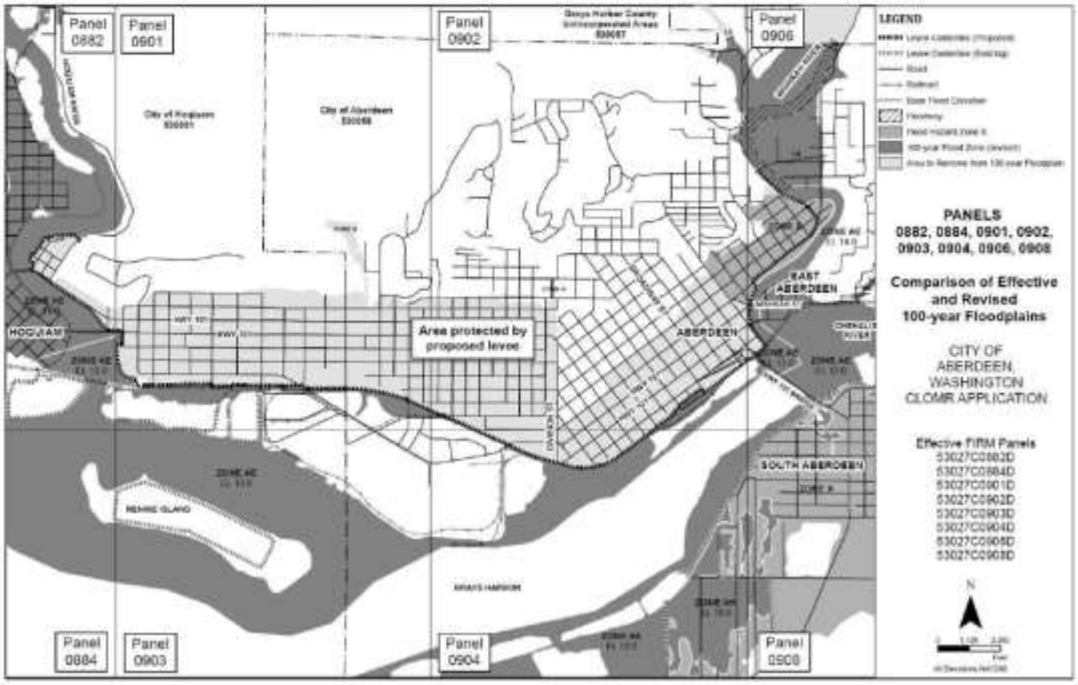


Figure 17-3 Study Area for Proposed Aberdeen-Hoquiam North Shore Levee
Source: KPFF Consulting Engineers May 9, 2017 Report

17.10 FUNDING OPPORTUNITIES

Although a number of the mitigation projects listed may not be eligible for FEMA funding, Grays Harbor County and its planning partners may secure alternate funding sources to implement these projects in the future including federal and state grant programs, and funds made available through the county. In order to be eligible for some of those grant funds, completion of a hazard mitigation plan may be required. Table 17-6 identifies some of those grant requirements. Additional funding sources identified in Table 17-7 are also available which support various types of mitigation efforts on a countywide basis.

Alternate funding sources which may further support mitigation efforts of various types include, but are not limited to, the following:

- **U.S. Department of Housing and Urban Development, Community Development Block Grants (CDBG)—**The CDBG program is a flexible program that provides communities with resources to address a wide range of community development needs. CDBG money can be used to match FEMA grant money. More information: http://www.hud.gov/offices/cpd/communitydevelopment/programs/
- **U.S. Fish & Wildlife Service Rural Fire Assistance Grants—** The U.S. Fish & Wildlife Service (USF&W) provides Rural Fire Assistance grants to fire departments to enhance local wildfire protection, purchase equipment, and train volunteer firefighters. USF&W staff also assist with community projects. These efforts reduce the risk to human life and better permit US F&W firefighters to interact with community fire organizations when fighting wildfires. The Department of the Interior receives a budget each year for the Rural Fire Assistance grant

program. The maximum award per grant is $20,000. The assistance program targets rural and volunteer fire departments that routinely help fight fire on or near Department of Interior lands. More information: http://www.fws.gov/fire/ living_with_fire/rural_fire_assistance.shtml

Table 17-6
Grant Opportunities

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

☑ = Hazard Mitigation Plan Required
☐ = No Hazard Mitigation Plan Required

Table 17-7
Countywide Fiscal Capabilities which Support Mitigation Efforts

Financial Resources	Accessible or Eligible to Use?
Community Development Block Grants	Y
Capital Improvements Project Funding	Y
Authority to Levy Taxes for Specific Purposes	Y
User Fees for Water, Sewer, Gas or Electric Service	Y
Incur Debt through General Obligation Bonds	Y
Incur Debt through Special Tax Bonds	Y
Incur Debt through Private Activity Bonds	Y
Withhold Public Expenditures in Hazard-Prone Areas	Y

Table 17-7 Countywide Fiscal Capabilities which Support Mitigation Efforts	
Financial Resources	Accessible or Eligible to Use?
State Sponsored Grant Programs	Y
Development Impact Fees for Homebuyers or Developers	Y

- **U.S. Department of Homeland Security—**Enhances the ability of states, local and tribal jurisdictions, and other regional authorities in the preparation, prevention, and response to terrorist attacks and other disasters, by distributing grant funds. Localities can use grants for planning, equipment, training and exercise needs. These grants include, but are not limited to areas of critical infrastructure protection, equipment and training for first responders, and homeland security. More information: http://www.dhs.gov/
- **FEMA, Hazard Mitigation Grant Program (HMGP)—**The HMGP provides grants to states, Indian tribes, local governments, and private non-profit organizations to implement long-term hazard mitigation measures after a major disaster declaration. The purpose of the HMGP is to reduce the loss of life and property due to natural disasters and to enable mitigation measures to be implemented during the immediate recovery from a disaster. More information: http://www.fema.gov/ government/grant/hmgp/
- **FEMA, Pre-Disaster Mitigation (PDM) Competitive Grant Program—**The PDM program provides funds to states, territories, Indian tribal governments, communities, and universities for hazard mitigation planning and the implementation of mitigation projects prior to a disaster event. Funding these plans and projects reduces overall risks to the population and structures, while also reducing reliance on funding from actual disaster declarations. PDM grants are to be awarded on a competitive basis and without reference to state allocations, quotas, or other formula-based allocation of funds. More information: http://www.fema.gov/government/grant/pdm/index.shtm
- **U.S. Bureau of Land Management (BLM), Community Assistance Program—**BLM provides funds to communities through assistance agreements to complete mitigation projects, education and planning within the wildland urban interface. More information: http://www.blm.gov/nifc/st/en/prog/fire/community_assistance.html
- **U.S. Department of Agriculture Community Facilities Loans and Grants—**Provides grants (and loans) to cities, counties, states and other public entities to improve community facilities for essential services to rural residents. Projects can include fire and rescue services. Funds have been provided to purchase fire-fighting equipment for rural areas. No match is required.
- **General Services Administration Sale of Federal Surplus Personal Property—**This program sells property no longer needed by the federal government. The program provides individuals, businesses and organizations the opportunity to enter competitive bids for purchase of a wide variety of personal property and equipment. Normally, there are no restrictions on the property purchased. More information: http://www.gsa.gov/portal/category/21045
- **FEMA Readiness, Response and Recovery Directorate, Fire Management Assistance Grant Program—**Program provides grants to states, tribal governments and local governments for the mitigation, management and control of any fire burning on publicly (non-federal) or privately owned forest or grassland that threatens such destruction as would constitute a major disaster. The grants are made in the form of cost sharing with the federal share being 75 percent of total eligible costs. Grant approvals are made within 1 to 72 hours

from time of request. More information is available at: http://www.fema.gov/government/grant/fmagp/index.shtm

- **Hazardous Materials Emergency Preparedness Grants—**Grant funds are passed through to local emergency management offices and Hazmat teams having functional and active local emergency planning committees. More information: http://www.phmsa.dot.gov/hazmat/grants

CHAPTER 18.
CAPABILITY ASSESSMENT

18.1 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 as referenced and identified in its specific jurisdictional annexes presented in Volume 2.

18.1.1 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.

Endangered Species Act

The 1973 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.

Coastal Zone Management Act

All states with federally approved coastal programs delineate a coastal zone consistent with the general standards act set forth in the Coastal Zone Management Act of 1972 (CZMA). According to the CZMA, the coastal zone area should encompass all important coastal resources including transitional and intertidal areas, salt marshes, beaches, coastal waters, and adjacent shorelines where activities could have the potential to impact the coastal waters. Federal land is excluded from the state coastal zone by the CZMA. Washington State has established the Washington State Coastal Zone Management Program, which was approved by the federal government in 1976, making it the first to be approved, applying to 15 coastal counties which front on salt water.

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 its Cities and Towns participate in the NFIP and have adopted regulations that meet the NFIP requirements. At the time of the preparation of this 2018 edition, all participating jurisdictions in the partnership were in good standing with NFIP requirements. Also occurring at the time of this update was the expected delivery of updated flood maps for the Chehalis and Wynoochee River Basins, with an anticipated delivery of final maps mid- to late-2018. Preliminary maps for the Basins were included in this study, although such reference does not indicate adoption by the County or any of its planning partners. Additional NFIP data can be found within the Flood Hazard Profile, and within each partners' annex document.

Presidential Disaster Declarations

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

18.1.2 State-Level Planning Initiatives

Washington State Enhanced Mitigation Plan

The Washington State Enhanced Hazard Mitigation Plan approved by FEMA in 2013 provides guidance for hazard mitigation throughout Washington. The plan identifies hazard mitigation goals, objectives, actions and initiatives for state government to reduce injury and damage from natural hazards. By meeting federal requirements for an enhanced state plan (44 CFR parts 201.4 and 201.5), the plan allows the state to seek significantly higher funding from the Hazard Mitigation Grant Program following presidential declared disasters (20 percent of federal disaster expenditures versus 15 percent with a standard plan).

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.

Coastal Zone Management Program

Washington State has established the Washington State Coastal Zone Management Program in conjunction with the federal Coastal Zone Management Act, which was approved by the federal government in 1976, making it the first to be approved, applying to 15 coastal counties which front on salt water.

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.

Wild and Scenic River

A federal designation that is intended to protect the natural character of rivers and their habitat without adversely affecting surrounding property.

Zero-Rise Floodway

A 'zero-rise' floodway is an area reserved to carry the discharge of a flood without raising the base flood elevation. Some communities have chosen to implement zero-rise floodways because they provide greater flood protection than the floodway described above, which allows a one foot rise in the base flood elevation.

Washington State Building Code

The Washington State Building Code Council adopted the 2015 editions of national model codes, with some amendments. The Council also adopted changes to the Washington State Energy Code and Ventilation and Indoor Air Quality Code. Washington's state-developed codes are mandatory statewide for residential and commercial buildings.

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 previously been funded for $4 million per biennium, with additional amounts provided after severe flooding events; however, those amounts can be modified by the state Legislature.

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.

18.1.3 Local Programs

Each planning partner has prepared a jurisdiction-specific annex to this plan contained in Volume 2, which identifies its regulatory, technical and financial capability to carry out proactive mitigation efforts. Additional jurisdiction-specific information is available for review within each of those annexes. The following sections present additional regulatory information that applies to the planning partnership.

Comprehensive Land Use Plans

Comprehensive plans are long-range in nature and serve as policy guides for how a jurisdiction plans to manage growth and development with respect to the natural environment and available resources. Washington State law (36.70A.040 RCW) requires that jurisdictions operating under the Growth Management Act develop comprehensive plans and development regulations that are consistent with the comprehensive plans and implement them (36.70A RCW).

The GMA requires that comprehensive plans consist of the following elements: land use, housing, capital facilities, utilities, rural (for counties), transportation, economic development, and park and recreation (RCW 36.70A.070). A comprehensive plan may also include additional optional elements that relate to physical development, such as conservation, historic preservation, and subarea plans (RCW 36.70A.080).

Grays Harbor County's last completed major update to its Comprehensive Land Use Plan as required under the GMA was made in September 2017. In response to new county policies and state requirements, the County is currently in the process of updates to the existing plan (September 2017 draft plan completed). Since the original plan was written, amendments to various elements of the comprehensive plan have been made on an almost-annual basis as allowed by law (RCW 36.70A.130(2)(a)). The GMA requires that jurisdictions periodically review their comprehensive plans and implementing development regulations in their entirety and revise them if needed. Grays Harbor County is required to have this review and revision completed every eight years thereafter (RCW 36.70A.130(5)(b)). Opportunities for public participation in this process will be provided (see RCW 36.70A.035).

Critical Areas Ordinance

Washington's Growth Management Act requires local governments to protect five types of critical areas: important fish and wildlife habitat areas, wetlands, critical aquifer recharge areas, frequently flooded areas, and geologically hazardous areas, such as bluffs. Grays Harbor County's critical areas regulations are a response to that law; they regulate how development and redevelopment can safely occur on lands that contain critical areas.

Although Washington's Watershed Management Act does not require planning, Grays Harbor County and local governments have undertaken related planning activities. The Washington Department of Ecology is providing technical and financial support for the effort. Grays Harbor County has participated in watershed planning for its WRIAs, as follows:

- WRIA 16: Skokomish-Dosewallips (2012)
- WRIA 21: Queets-Quinault Watershed
- WRIA 22: Lower Chehalis Watershed
- WRIA 23: Upper Chehalis Watershed
- WRIA 24: Willapa

18.2 MITIGATION-RELATED REGULATORY AUTHORITY

Hazard mitigation builds on a community's existing capabilities in place, including financial, regulatory, programmatic and planning capabilities. the County's capabilities to implement mitigation projects include community planners, engineers, floodplain managers, GIS personnel, emergency managers, and financial, legal and regulatory requirements (zoning, building codes, subdivision regulations, and floodplain management ordinances). These resources have the responsibility to provide overview of past, current, and ongoing pre- and post-disaster mitigation planning projects, including capital improvement programs, wildfire mitigation programs, stormwater management programs, and NFIP compliance projects. The following information and tables identify the County's capabilities with respect to (mitigation) efforts of varying types. Each planning partner also completed the same tables within their respective Annex documents.

Building Codes

The Grays Harbor County Building Division has adopted and enforces, as mandated by the State of Washington, the current editions of the International Code Council's Building, Residential, Fire, Mechanical, Fuel Gas and Existing Building codes the Washington State Energy Code and the Uniform Plumbing Code with State and local amendments.

Grays Harbor County adopted the 2015 Building Codes Effective July 1, 2016. Title 15 of the Grays Harbor County Code includes the 2015 editions of the International Building, Residential, Mechanical, Fire, Existing Building and Fuel Gas codes and the 2015 editions of the Uniform Plumbing Code and Washington State Energy Code will become effective July 1st, 2016.

Washington State Farmland Preservation

Washington State, through the Department of Revenue, provides tax incentives for open space enrollment of designated as farmlands. The program is one tool for making farmland more affordable, thus keeping it out of development.

Current use classification lowers the taxable value of farm and agricultural lands and other resource lands relative to other land uses. Land that would be assessed at $10,000 an acre for its "highest and best use" might be valued at perhaps $3,000 an acre as farmland. The effect of this lower valuation is to lower the tax assessed on lands classified as "current use," thereby making the land more affordable to keep in farm production. Since 2011, Grays Harbor County saw a 3.9 percent decline, or 1,027 fewer acres in enrollment.

In 2013, the percent value reduction was 70% - overall statewide, the 20 year average of 69% (Washington State Dept. of Revenue 2016 Report).[61]

Regulatory, Technical, Community Organizations, Programs and Social Systems

Regulatory capabilities currently available are summarized in Table 18-1. In addition to the financial and regulatory capabilities summarized in Table 18-2, there are other programs available, some of which provide incentives for citizens. Such programs further enhance resiliency throughout the County. Two such programs include the National Flood Insurance Program, and the Community Rating System, both of which are discussed in detail in Chapter 8 – Flood.

Social systems can be defined as community organizations and programs that provide social and community-based services, such as health care or housing assistance, to the public. In planning for natural hazard mitigation, it is important to know what social systems exist within the community because of their existing connections to the public.

Table 18-1
Grays Harbor County Legal and Regulatory Capability

	Local Authority	Other Jurisdictional Authority	State Mandated	Comments
Codes, Ordinances & Requirements				
Building Code Version Year	Yes	Yes	Yes	2015 International Building Code as required by the State
Zoning Ordinance	Yes		Yes	
Subdivision Ordinance	Yes		Yes	
Floodplain Ordinance	Yes	Yes	Yes	FEMA Requirements
Stormwater Management	Yes			
Post Disaster Recovery				
Real Estate Disclosure	No	No	Yes	
Growth Management	Yes		Yes	Partial participant.
Critical Areas Ordinance	Yes		Yes	Critical Areas identified and regulatory authority established.
Site Plan Review	Yes			
Public Health and Safety	Yes	Yes	Yes	
Coastal Zone Management	Yes	Yes	Yes	
Climate Change Adaptation				
Shoreline Master Program	Yes			Adopted RCW 90.58

[61] WA Department of Revenue Property Tax Statistics. http://dor.wa.gov/content/aboutus/statisticsandreports/stats_proptaxstats_report.aspx

Table 18-1
Grays Harbor County Legal and Regulatory Capability

	Local Authority	Other Jurisdictional Authority	State Mandated	Comments
Natural Hazard Specific Ordinance (stormwater, steep slope, wildfire, etc.)	Yes		Yes	Grays Harbor County Resource Ordinance
Environmental Protection	Yes	Yes	Yes	
Planning Documents				
General or Comprehensive Plan	Yes		Yes	
Is the plan equipped to provide linkage to this mitigation plan? Yes				
Floodplain or Basin Plan	Yes			(See below)
Stormwater Plan	Yes			Various plans are in place
Capital Improvement Plan	Yes		Yes	
Habitat Conservation Plan	No			Critical Areas Ordinance and Shoreline Master Plan only.
Economic Development Plan	Yes		Yes	
Shoreline Management Plan	Yes		Yes	
Community Wildfire Protection Plan	Yes		No	
Transportation Plan	Yes		Yes	
Response/Recovery Planning				
Comprehensive Emergency Management Plan	Yes		Yes	
Threat and Hazard Identification and Risk Assessment	Yes		No	Homeland Security Region 3 Plan
Terrorism Plan	Yes			
Post-Disaster Recovery Plan	No			
Continuity of Operations Plan	Draft			
Public Health Plans	Yes			Various public health plans are in place both through the Health Department and through the hospital districts.
Administration, Boards and Commission				
Planning Commission	Yes		Yes	
Mitigation Planning Committee	Yes			
Maintenance programs to reduce risk (e.g., tree trimming, clearing drainage systems, chipping, etc.)	Yes			Various programs in place, including tree trimming, drainage systems, etc.

Table 18-2
Administrative and Technical Capability

Staff/Personnel Resources	Available?	Department/Agency/Position
Planners or engineers with knowledge of land development and land management practices	Y	
Professionals trained in building or infrastructure construction practices (building officials, fire inspectors, etc.)	Y	
Engineers specializing in construction practices?	Y	
Planners or engineers with an understanding of natural hazards	Y	
Staff with training in benefit/cost analysis	Y	
Surveyors	Y	
Personnel skilled or trained in GIS applications	Y	
Personnel skilled or trained in Hazus use	Y	
Scientist familiar with natural hazards in local area	Y	The county has hazard-specific subject matter experts on staff in various departments, available via contracting mechanisms, and available through state resources.
Emergency Manager	Y	Emergency Management Department with trained personnel and volunteers.
Grant writers	Y	Various County departments have internal personnel who write grants; county staff monitors grants.
Warning Systems/Services (Reverse 9-1-1, outdoor warning signs or signals, flood or fire warning program, etc.?)	Y	Alert Sense (no reverse 9-1-1); Public Works signage available as needed.
Hazard data and information available to public	Y	Planning Unit
Maintain Elevation Certificates	Y	Through Planning Department.

Often, actions identified by the plan involve communicating with the public or specific subgroups within the population (e.g. elderly, children, low income). The County and its planning partners can use existing social systems as resources for implementing such communication-related activities because these service providers already work directly with the public on a number of issues, one of which could be natural hazard preparedness and mitigation.

The following highlights organizations and programs that are active within Grays Harbor County, which may be potential partners for implementing mitigation actions. The various tables include information on each organization or program's service area, types of services offered, populations served, and how the organization or program could be involved in natural hazard mitigation. The three involvement methods are defined below.

- Education and outreach – organizations could partner with the community to educate the public or provide outreach assistance on natural hazard preparedness and mitigation.

- Information dissemination – organizations could partner with the community to provide hazard-related information to target audiences.
- Plan/project implementation – organizations may have plans and/or policies that may be used to implement mitigation activities or the organization could serve as the coordinating or partner organization to implement mitigation actions. Table 16-3 identifies several of the ongoing efforts which assist in notification and social service programs, further enhancing the resilience of the County.

Table 18-3
Education and Outreach

Program/Organization	Available ?	Department/Agency/Position and Brief Description
Local citizen groups or non-profit organizations focused on emergency preparedness?	Y	CERT and SAR trained personnel
Local citizen groups or non-profit organizations focused on environmental protection?	Y	Grays Harbor County Conservation District
Organization focused on individuals with access and functional needs populations	N	
Ongoing public education or information program (e.g., responsible water use, fire safety, household preparedness, environmental education)	Y	Various agencies at the county and state levels which promote educational efforts such as Firewise, Forestland-Urban Interface Fire Protection Act, and Fire Adapted Communities from the National Cohesive Wildfire Strategy.
Natural disaster or safety related school programs?	Y	Pursuant to the RCW, schools are required to develop and exercise hazard-specific response plans.
Public-private partnership initiatives addressing disaster-related issues?	Y	Various public education outreach; provide information and presentations; NFIP insurance; outreach for Continuity Planning.
Multi-seasonal public awareness program?	Y	The County maintains information on its website to address specific hazards at issue; also, as situations arise, the website, email lists and local area broadcasting provides public service announcements and information.
Other		

18.3 WASHINGTON STATE RATING BUREAU LEVELS OF SERVICE

In Washington, the Washington State Rating Bureau (WSRB) helps determine standards on which insurance rates are set. WSRB, like most other states, utilizes the Insurance Service Office, Inc. (ISO) to determine levels of protection based on a prescribed level of service. Two such levels of services assessed are the Public Protection Classification Program and the Building Code Effectiveness Grading Schedule.

18.3.1 Public Protection Classification Program

The Public Protection Classification (PPC) program recognizes the efforts of communities to provide fire protection services for citizens and property owners. A community's investment in fire mitigation is a proven and reliable predicator of future fire losses. Insurance companies use PPC information to help establish fair premiums for fire insurance — generally offering lower premiums in communities with better protection. By offering economic benefits for communities that invest in their firefighting services, the program provides an additional incentive for improving and maintaining public fire protection.

In order to establish appropriate fire insurance premiums for residential and commercial properties, insurance companies utilize up-to-date information about the Community's fire-protection services. Through analysis of relevant data, communities are able to evaluate their public fire-protection services, and secure lower fire insurance premiums for communities with better protection. This program provides incentives and rewards in those areas with improved firefighting services. This program has gathered extensive information on more than 46,000 fire-response jurisdictions. Once all of the data is reviewed and analyzed, communities are assigned a PPC from 1 to 10. Class 1 generally represents superior property fire protection, while Class 10 indicates that the area's fire-suppression program is not as robust.

The most significant benefit of the PPC program is its effect on losses. Statistical data on insurance losses bears out the relationship between excellent fire protection — as measured by the PPC program — and low fire losses. PPC helps communities prepare to fight fires effectively. The program also provides help for fire departments and other public officials as they plan, budget for, and justify improvements.

Table 18-4 identifies the Public Protection Classification for Grays Harbor County Fire Districts and the various city fire departments.

Table 18-4
Countywide Public Protection Classification

Community	Protection Class Grade
Grays Harbor 1	6
Grays Harbor 2	6
Grays Harbor 3	6
Grays Harbor 4	8
Grays Harbor 5	6
Grays Harbor 6	7
Grays Harbor 7	8
Grays Harbor 8	6
Grays Harbor 10	7
Grays Harbor 11	7
Grays Harbor 12	6
Grays Harbor 14	7
Grays Harbor 15	8
Grays Harbor 16	8
Grays Harbor 17	8
Aberdeen	5
Bowerman Field	5
Cosmopolis	6
Elma	5

Table 18-4
Countywide Public Protection Classification

Community	Protection Class Grade
Hoquiam	5
McCleary	5
Montesano	4
Oakville	5
Ocean Shores	5
Quinault Reservation	9

Data effective as of October 2017

18.3.2 Building Code Effectiveness Grading Schedule

The Building Code Effectiveness Grading Schedule (BCEGS) assesses building codes and amendments adopted in a community and evaluates that community's commitment to enforce them. The concept is simple: Municipalities with well-enforced, up-to-date codes should demonstrate better loss experience, and insurance rates can reflect that. The prospect of reducing damage and ultimately lowering insurance costs provides an incentive for communities to enforce their building codes rigorously. Table 18-5 identifies the BCEGS for the planning partnership.

Table 18-5
Countywide Building Code Effectiveness Grading

Community	Commercial	Dwelling
Grays Harbor 1	4	4
Grays Harbor 2	4	4
Grays Harbor 3	4	4
Grays Harbor 4	4	4
Grays Harbor 5	4	4
Grays Harbor 6	4	4
Grays Harbor 7	4	4
Grays Harbor 8	4	4
Grays Harbor 10	4	4
Grays Harbor 11	4	4
Grays Harbor 12	4	4
Grays Harbor 14	4	4
Grays Harbor 15	4	4
Grays Harbor 16	4	4
Grays Harbor 17	4	4
Aberdeen	4	4
Bowerman Field	4	4
Cosmopolis	4	4
Elma	4	3

Table 18-5
Countywide Building Code Effectiveness Grading

Community	Commercial	Dwelling
Hoquiam	4	3
McCleary	3	3
Montesano	4	4
Oakville	5	5
Ocean Shores	3	3
Quinault Reservation	4	4
Westport	3	3

Data effective as of October 2017

18.3.3 Public Safety Programs

Access and Functional Needs

One of the most important roles of local government is to protect their citizens from harm, including helping people prepare for and respond to emergencies. Making local government emergency preparedness and response programs accessible to people with special needs is a critical part of this responsibility. Grays Harbor County Department of Emergency Management (DEM) has the mission to assess and plan for all hazards and emergencies, and works with other public safety and local government agencies to ensure public welfare for all of its citizens.

Grays Harbor County Fire Districts

Grays Harbor County has a total of 17 fire districts serving its citizens, in addition to the local municipalities' fire departments. Within these fire districts and departments, there are a total of 26 fire stations which protect the county during emergency situations. The purpose of Grays Harbor County Fire Districts is the provision of fire prevention services, fire suppression services, emergency medical services, and for the protection of life and property. Fire prevention in Grays Harbor County is mainly focused on rural and wildland areas and is done through a Firewise community program in coordination with the WA DNR, USFS, and American Community Enrichment (ACE). ACE has partnered with the County to assist local jurisdictions wishing to take part in the Firewise Community Program, helping to complete applications and provide necessary information to the municipalities. Public outreach efforts have also occurred throughout the County, including partnerships with the YMCA and various school districts, where Firewise information and mitigation-related projects are presented by ACE and fire staff.

Grays Harbor County is a StormReady® and TsunamiReady® County

Grays Harbor County is also a recognized StormReady® and TsunamiReady® County under the National Weather Service Program. Achieving such status requires a significant level of effort. Being part of a Weather-Ready Nation is about preparing for your community's increasing vulnerability to extreme weather and water events. The two programs help arm America's communities with the communication and safety skills needed to save lives and property--before, during and after the event. StormReady and Tsunami Ready helps community leaders and emergency managers strengthen local safety programs. In addition to County recognition, the cities of Aberdeen, Hoquiam, Ocean Shores, and Westport are also participating communities.

Response Plans

Grays Harbor County and its jurisdictions have developed various response plans to be utilized during incident-specific events. Plans such as the various Tsunami Response Plan and Flood Response Plans provide guidance to first responders and community members in what actions need to be taken during such event. These plans, once completed, go through a training and exercise phase to help ensure quick response when the plans are activated.

CHAPTER 19.
PLAN MAINTENANCE STRATEGY

In accordance with 44 CFR 201.6(c)(4), a hazard mitigation plan must present a plan maintenance process that includes the following:

- A section describing the method and schedule of monitoring, evaluating and updating the mitigation plan over its five year life-cycle
- A process by which local governments incorporate the requirements of mitigation plans into other planning mechanisms, such as comprehensive land use plans (as appropriate)
- A discussion on how the community will continue to engage public participation in mitigation planning `efforts.

The CRS program credits NFIP communities points for adopting the Plan; establishing a procedure for implementation, review, and updating the Plan; and submitting an annual evaluation report.

This section of the plan is focused on the plan maintenance strategy, and details the formal process that will ensure that the Grays Harbor County Hazard Mitigation Plan remains an active and relevant document and that the planning partners maintain their eligibility for applicable funding sources. The maintenance process identified for Grays Harbor County and its planning partners includes a schedule for monitoring and evaluating the plan and producing a plan revision 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.

The Grays Harbor County Emergency Management Coordinator will maintain 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).

19.1 MONITORING, EVALUATION AND UPDATING THE PLAN

19.1.1 Progress Report - 2011 Plan Status

The 2011 Hazard Mitigation Plan identified a maintenance strategy which included regular reviews during the life cycle of the plan. To a large extent, those reviews did occur; however, the County and its current planning partners were heavily engaged in developing a tsunami evacuation structure – Project Safe Haven – during the life cycle of the 2011 plan. That effort required a very large level of involvement by the Emergency Management Department, as well as other departments within the County, and its planning partners. In addition, during this period, FEMA and several state agencies, such as Department of Natural Resources and Department of Ecology, both conducted significant studies in the region for the various hazards of concern. All of these efforts impeded the County's ability to do a comprehensive annual review and update. While the plan review did not occur as intended, the County nonetheless was effective in completing several of the strategies and action items identified in the plan. The status of the County's previous mitigation projects are shown in Chapter 17. Significant projects completed since 2011 include the following:

- Public Education—The County and its planning partners have been very active in this area. Regular (almost monthly) outreach sessions have occurred where risk and updated hazard specific data are discussed. The County completes approximately 25 outreach efforts per year, where hazards of concern and potential mitigation efforts are discussed.
- Flood Reduction - During the life cycle of the 2011-2016 plan, the County and its planning partners worked with FEMA on the RiskMap project to update the coastal flood hazard maps within the County. Those maps were adopted in February 2017. Currently, NFIP maps for the Chehalis and Wynoochee Rivers are under development, with preliminary maps utilized within this plan. The 2017 study included several mitigation projects which may be completed during the life cycle of this 2018 plan. Many of these are joint efforts involving federal, state, county, and tribal entities.
- Community Emergency Response Team (CERT) Training—The County and its planning partners have continued to provide CERT training throughout the area, with the CERT team now reaching approximately 50 trained individuals who will be able to provide safe and effective assistance to their communities after a disaster incident occurs.
- Flood Hazard - Enhance county roads and drainage projects—The Grays Harbor County Public Works Department has completed several upgrades to enhance county roads and drainage issues, and continues to work with citizens throughout the county to help ensure safety. Public works also work with homeowners to provide information concerning proper drainage to reduce slides resulting from hydrologic issues associated with high water tables and large amounts of water traveling through the ground, causing and exacerbating slides in the area.
- Landslide and Erosion Hazard – Working with Washington State Department of Natural Resources and Ecology, several studies are underway to identify areas of concern, and develop long-range strategies to assist in reducing the potential impacts from both landslide and erosion issues. To date, the Washington State Department of Transportation has worked with the County, and several roadways throughout the County have been shored up with bank stabilization to help reduce the potential for landslides, allowing for evacuation in areas previously impacted by slides which occurred as a result of heavy rains.

19.1.2 Plan Implementation and Maintenance

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 partners have established goals and objectives and have prioritized mitigation actions that will be implemented through existing plans, policies, and programs.

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). The Grays Harbor County partnership intends to update the hazard mitigation plan on a 5-year cycle from the date of initial plan adoption. This cycle may be accelerated to less than 5 years based on the following triggers:

- A presidential disaster declaration that impacts the planning area.
- A hazard event that causes loss of life.
- A comprehensive update of the County or participating city/town'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 Planning Team.
- 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 portions of the updated plan.

The hazard mitigation plan will be reviewed annually and a progress report prepared. These reviews may be more or less frequent, as deemed necessary by the Emergency Management Deputy Director, but there will be a minimum of one review per year. 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. 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.

A template to guide the planning partners in preparing a progress report has been created as part of this planning process (see Appendix D). The Emergency Management Coordinator will then prepare a formal annual report on the progress of the plan. This report should be used as follows:

- Posted on the Grays Harbor 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.

Use 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, completion of the annual review will reduce the level of effort involved in future plan updates, and is highly encouraged by FEMA.

In addition to the annual review, three years after adoption of the hazard mitigation plan, the Deputy Director may decide to apply for a planning grant through FEMA to start the 2023 update. Upon receipt of funding, the County will solicit bids under applicable contracting procedures and hire a contractor to assist with the project. The proposed schedule for completion of the plan update is one year from award of a contract, to coincide with the five-year adoption date of the 2018 hazard mitigation plan update.

The Deputy Director will be responsible for the plan update. Before the end of the five-year period, the updated plan will be submitted to FEMA for approval. When concurrence is received that the updated plan complies with FEMA requirements, it will be submitted to the Board of County Commissioners, the local jurisdiction councils, and the Special Purpose District Commissioners for adoption. The County will send an e-mail to individuals and organizations on the stakeholder list to inform them that the updated plan is available on the County website.

19.2 IMPLEMENTATION THROUGH EXISTING PROGRAMS

Grays Harbor County will have the opportunity to implement hazard mitigation projects through existing programs and procedures through plan revisions or amendments. The hazard mitigation plan will be incorporated into the plans, regulations and ordinances as they are updated in the future or when new plans are developed.

The County's Comprehensive Plan and the comprehensive plans of the planning partners are considered to be integral parts of this plan. The County and its jurisdictional partners, through adoption of comprehensive plans and zoning ordinances, have planned for the impact of natural hazards. The plan development process provided the County and its 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 Grays Harbor County. An update to a comprehensive plan may trigger an update to the hazard mitigation plan.

All planning partners are committed to creating a linkage between the hazard mitigation plan and their individual comprehensive and other plans by identifying a mitigation initiative to do so 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
- Building 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
- Coastal Zone Atlas information
- Landslide reports and planning
- Evacuation planning
- Transportation planning

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.

19.3 CONTINUED PUBLIC INVOLVEMENT

Grays Harbor County is dedicated to involving the public directly in review and updates of the hazard mitigation plan. The public will continue to be apprised of the plan's progress through the county's website and the annual progress reports that will be provided to the media. All planning partners have agreed to provide links to the Hazard Mitigation Plan website on their websites to increase avenues of public access to the plan. The Grays Harbor County Department of Emergency Management has agreed to maintain the hazard mitigation plan website. This site will not only house the final plan, it will become the one-stop shop for information regarding the plan, the partnership and plan implementation. Upon initiation of future update processes, a new public involvement strategy will be initiated. 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 social media and local media outlets within the planning area.

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APPENDIX A
ACRONYMS AND DEFINITIONS

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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 constructed 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 down gradient 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.

Grays Harbor County
Multi-Jurisdiction Hazard Mitigation Plan 2018 Update

APPENDIX B
PUBLIC OUTREACH MATERIALS AND RESULTS

APPENDIX B
PUBLIC OUTREACH MATERIALS AND RESULTS

Attached as a separate document due to size.

APPENDIX C
PLAN ADOPTION RESOLUTIONS FROM PLANNING PARTNERS

APPENDIX C
PLAN ADOPTION RESOLUTIONS FROM PLANNING PARTNERS

To Be Provided With Final Release

Grays Harbor County
Multi-Jurisdiction Hazard Mitigation Plan 2018 Update

APPENDIX D
EXAMPLE TEMPLATE FOR FUTURE PROGRESS REPORTS

APPENDIX D
EXAMPLE TEMPLATE FOR FUTURE PROGRESS REPORTS

Grays Harbor County
Hazard Mitigation Plan
Annual Progress Report

Reporting Period: (Insert reporting period)

Background: Grays Harbor 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 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:

Insert web address

Summary Overview of the Plan's Progress: The performance period for the hazard mitigation plan became effective on ____, 2017, 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 ______, 2022. As of this reporting period, the performance period for this plan is considered to be __ percent 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 Grays Harbor 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 Grays Harbor 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 Planning Team: The Hazard Mitigation Plan Planning Team, 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 Planning Team would remain in service to oversee maintenance of the plan. At a minimum, the Planning Team will provide technical review and oversight on the development of the annual progress report. It is anticipated that there will be turnover in the membership annually, which will be documented in the progress reports. For this reporting period, the Planning Team membership is as indicated in Table 1.

TABLE 1
PLANNING TEAM MEMBERS

Name	Title	Jurisdiction/Agency

Natural Hazard Events within the Planning Area: During the reporting period, there were __ natural hazard events in the planning area that had a measurable impact on people or property. A summary of these events is as follows:

- ____________________________
- ____________________________

Changes in Risk Exposure in the Planning Area: *(Insert brief overview of any natural hazard event in the planning area that changed the probability of occurrence or ranking of risk for the hazards addressed in the hazard mitigation plan)*

Mitigation Success Stories: *(Insert brief overview of mitigation accomplishments during the reporting period)*

Review of the Action Plan: Table 2 reviews the action plan, reporting the status of each initiative. Reviewers of this report should refer to the hazard mitigation plan for more detailed descriptions of each initiative and the prioritization process.

Address the following in the "status" column of the following table:

- *Was any element of the initiative carried out during the reporting period?*
- *If no action was completed, why?*
- *Is the timeline for implementation for the initiative still appropriate?*
- *If the initiative was completed, does it need to be changed or removed from the action plan?*

TABLE 2
ACTION PLAN MATRIX

Action Taken? (Yes or No)	Time Line	Priority	Status	Status (X, O,✓)
Initiative #__—_____________________[description]				
Initiative #__—_____________________[description]				
Initiative #__—_____________________[description]				
Initiative #__—_____________________[description]				
Initiative #__—_____________________[description]				
Initiative #__—_____________________[description]				
Initiative #__—_____________________[description]				
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Initiative #__—_____________________[description]				
Initiative #__—_____________________[description]				

TABLE 2
ACTION PLAN MATRIX

Action Taken? (Yes or No)	Time Line	Priority	Status	Status (X, O,✓)
Initiative #__—______________________[description]				
Initiative #__—______________________[description]				
Initiative #__—______________________[description]				
Initiative #__—______________________[description]				
Initiative #__—______________________[description]				
Initiative #__—______________________[description]				
Initiative #__—______________________[description]				
Initiative #__—______________________[description]				
Initiative #__—______________________[description]				

Completion status legend:
✓= Project Completed
O = Action ongoing toward completion
X = No progress at this time

Changes That May Impact Implementation of the Plan: *(Insert brief overview of any significant changes in the planning area that would have a profound impact on the implementation of the plan. Specify any changes in technical, regulatory and financial capabilities identified during the plan's development)*

Recommendations for Changes or Enhancements: Based on the review of this report by the Hazard Mitigation Plan Planning Team, the following recommendations will be noted for future updates or revisions to the plan:

- ____________________________
- ____________________________
- ____________________________
- ____________________________
- ____________________________

Public review notice: The contents of this report are considered to be public knowledge and have been prepared for total public disclosure. Copies of the report have been provided to the governing boards of all planning partners and to local media outlets and the report is posted on the Grays Harbor County hazard mitigation plan website. Any questions or comments regarding the contents of this report should be directed to:

INSERT NAME AND ADDRESS