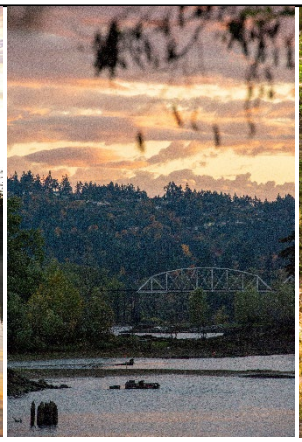
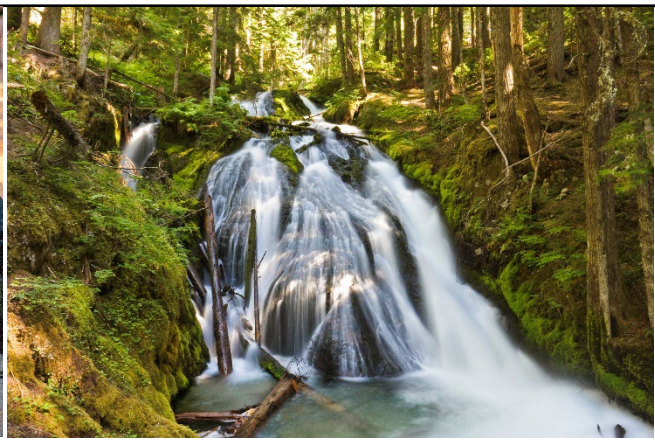
Clackamas County Multi-Jurisdictional Hazard Mitigation Plan

Clackamas County and the Jurisdictions of: Canby, Estacada, Gladstone, Happy Valley, Lake Oswego, Milwaukie, Molalla, Oregon City, Sandy, West Linn, Wilsonville, Clackamas Fire District #1, Clackamas River Water, Colton Water District, and Oak Lodge Water Services

Photos courtesy of Clackamas County

Effective: September 12, 2024 – September 11, 2029

Prepared for

Clackamas County Disaster Management

CLACKAMAS COUNTY

Prepared by

The University of Oregon
Institute for Policy Research & Engagement
School of Planning, Public Policy, and Management

UNIVERSITY OF OREGON | Institute for Policy Research and Engagement

Planning grant funding provided by:

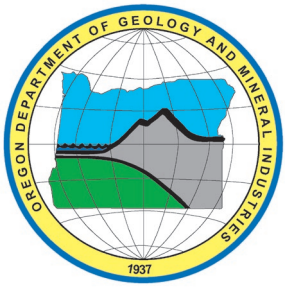
FEMA

Federal Emergency Management Agency (FEMA)

Hazard Mitigation Grant Program

Project Award Number: DR-4562-39-P-OR

Additional Support Provided by:



Special Thanks & Acknowledgments

Clackamas County developed this Multi-Jurisdictional Natural Hazards Mitigation Plan (NHMP) through a regional partnership funded by the Federal Emergency Management Agency's (FEMA) Hazard Mitigation Grant Program (HMGP): HMGP-DR-4562-39-P-OR. This updated NHMP is a collaboration between Clackamas County and the Cities of Canby, Estacada, Gladstone, Happy Valley, Lake Oswego, Milwaukie, Molalla, Oregon City, Sandy, West Linn, Wilsonville, Clackamas Fire District #1, Clackamas River Water, Colton Water District, and Oak Lodge Water Services. Planning process, plan templates, and plan development support provided by the Oregon Partnership for Disaster Resilience (OPDR) at the University of Oregon's Institute for Policy Research and Engagement (IPRE).

Special thanks to Jay Wilson, Clackamas County Resilience Coordinator for his vision, passion, and positive outlook throughout the plan update process.

Hazard Mitigation Advisory Committee

County Representatives

- Convener, Jay Wilson, Resilience Coordinator, Disaster Management
- Convener, Gianna Alessi, Natural Hazard Mitigation Planning Specialist, RARE AmeriCorps
- Molly Caggiano, Resilience Planner, Disaster Management
- Mike Bezner, Assistant Director of Transportation, Development & Transportation Department
- Ben Blessing, Floodplain Manager, Development & Transportation Department
- Leah Fisher, Built & Natural Environment Analyst, Public Health,
- Steve Hanschka, Floodplain Manager, Development & Transportation Department (retired)
- Jennifer Hughes, Planning Manager, Development & Transportation Department
- Kirsten Ingersoll, Public Health
- Leah Johanson, Senior Civil Engineer, Water Environment Services
- Gerald Murphy, Chair, Clackamas County Planning Commission
- Daniel Nibouar, Interim Director, Disaster Management
- Devin Paterson, Engineering Tech 4, Development & Transportation Department
- Ron Wierenga, Assistant Director, Water Environment Services

Jurisdiction Representatives

- Jerry Nelzen Public Works Director, City of Canby
- Jorge Tro, Police Chief, City of Canby
- Elaina Turpin, Assistant City Manager, City of Estacada
- Justin Poyser, Public Works Utility Manager, City of Gladstone
- Steve Campbell, Director of Community Services, City of Happy Valley
- Bonnie Hirshberger, Citizen Information and Emergency Management Specialist, City of Lake Oswego

- Dan Harris, Events and Emergency Management Coordinator, City of Milwaukie
- Dan Huff, City Manager, City of Molalla
- Vance Walker, Assistant Public Works Director, City of Oregon City
- Jeff Aprati, Deputy City Manager, City of Sandy
- Dylan Digby, Assistant to the City Manager, City of West Linn
- Delora Kerber, Public Works Director, City of Wilsonville
- Brian Stewart, Assistant Chief, Clackamas Fire District #1
- Beth McGinnis, Emergency Manager, Clackamas River Water
- Teresa Bricker, Board Member, Colton Water District
- Lara Christensen, Water Quality Coordinator, Oak Lodge Water Services
- Kim Swan, Clackamas River Water Providers
- Tom Gaskill, Greater Oregon City Watershed Council
- Laura Rost, North Clackamas Watershed Council

Other Representatives:

- Jeff Rubin, Chair, Clackamas County Emergency Preparedness Committee
- Marian Lahav, OR Department of Land Conservation and Development
- Christina Appleby, OR Department of Geology and Mineral Industries (DOGAMI)
- Stephen Richardson, OR Department of Emergency Management
- Jon Wiebe, OR Department of Emergency Management
- Anthony Vendetti, Metro
- Julie Hernandez, Portland General Electric
- Brooke Brownlee, Portland General Electric
- Jeremy Goers, US Forest Service

Institute for Policy Research and Engagement

- Michael Howard, Director, Oregon Partnership for Disaster Resilience
- Amanda Ferguson, Planning Policy and Practice Lead

Student Researchers

- Brendan Adamczyk, Research Associate
- Morgan Driggs, Research Associate
- Sophie Bybee, Research Associate

About the Institute for Policy Research and Engagement

The Institute for Policy Research & Engagement (IPRE) is a research center affiliated with the School of Planning, Public Policy, and Management at the University of Oregon. It is an interdisciplinary organization that assists Oregon communities by providing planning and technical assistance to help solve local issues and improve the quality of life for Oregon residents. The role of IPRE is to link the skills, expertise, and innovation of higher education with the transportation, economic development, and environmental needs of communities and regions in the State of Oregon, thereby providing service to Oregon and learning opportunities to the students involved.

About the Oregon Partnership for Disaster Resilience

The Oregon Partnership for Disaster Resilience (OPDR) is a coalition of public, private and professional organizations working collectively toward the mission of creating a disaster resilient and sustainable state. Developed and coordinated by the Institute for Policy Research and Engagement at the University of Oregon, the OPDR employs a service-learning model to increase community capacity and enhance disaster safety and resilience statewide.

About the Resource Assistance for Rural Environments

RARE is an AmeriCorps program administered through the University of Oregon's Institute for Policy Research and Engagement. RARE is currently supported through grants from AmeriCorps, The Ford Family Foundation, Oregon Food Bank, Federal Emergency Management Agency, United States Department of Agriculture, and an array of other agencies. In addition, each participating community provides $25,000 of approximately $45,000 needed to place, train, and support a full-time RARE member.

NHMP Template Disclaimer

This NHMP is based in part on a plan template developed by the Oregon Partnership for Disaster Resilience. The template is structured to address the requirements contained in Title 44 CFR Section 201.6; where language is applicable to communities throughout Oregon, OPDR encourages the use of standardized language. As part of this regional planning initiative, OPDR provided copies of the plan templates to communities for use in developing or updating their hazards mitigation plans. OPDR hereby authorizes the use of all content and language provided to Clackamas County and participating jursidictions in the plan template.

This page is intentionally left blank

Table of Contents – Volume I

List of Tables

List of Figures

List of Maps

Volume I

This page is intentionally left blank

Plan Summary

Clackamas County updated this Multi-Jurisdictional Natural Hazards Mitigation Plan (NHMP) to prepare for the long-term effects resulting from hazards. The County portion of the plan includes Volume I and III. Volume II is reserved for Special Districts and Cities. It is impossible to predict exactly when these hazards will occur, or the extent to which they will affect the community. However, with careful planning and collaboration among public agencies, private sector organizations and residents within the community, it is possible to create a resilient community that will benefit from long-term recovery planning efforts.

> *44 CFR 201.6 – The local mitigation plan is the representation of the jurisdiction's commitment to reduce risks from natural hazards, serving as a guide for decision makers as they commit resources to reducing the effects of natural hazards. . . .*

FEMA defines mitigation as ". . . the effort to reduce loss of life and property by lessening the impact of disasters . . . through risk analysis, which results in information that provides a foundation for mitigation activities that reduce risk." Put another way, hazard mitigation is a method of permanently reducing or alleviating the losses of life, property, and injuries resulting from hazards through long and short-term strategies. Example strategies include policy changes (e.g., updated ordinacnes), captial projects (e.g., seismic retrofits to critical facilities), and education and outreach to targeted audiences (e.g., non-English speaking residents or the elderly). In this way, hazard mitigation impacts and influences the "Whole Community", which FEMA defines as, "private and nonprofit sectors, including businesses, faith-based and disability organizations and the public, in conjunction with the participation of local, tribal, state, territorial and Federal governmental partners."

Why Develop this Mitigation Plan?

> *44 CFR 201.6(a)(1) – A local government must have a mitigation plan approved pursuant to this section in order to receive HMGP project grants . . .*

The Disaster Mitigation Act of 2000 (DMA2K) and the regulations contained in 44 CFR 201 require that jurisdictions maintain an approved NHMP in order to receive FEMA Hazard Mitigation Assistance (HMA) funds for mitigation projects. To that end, Clackamas County is involved in a broad range of hazard and emergency management planning activities. Local and federal approval of this NHMP ensures that the County and listed jurisdictions will (1) remain eligible for pre- and post-disaster mitigation project grants and (2) promote local mechanisms to accomplish risk reduction strategies.

What is Mitigation?

"Any sustained action taken to reduce or eliminate long-term risk to life and property from a hazard event."

-U.S. Federal Emergency Management Agency

Who Participated in Developing the Plan?

The Clackamas County NHMP is the result of a collaborative effort between the County, cities, special districts, community members, public agencies, non-profit organizations, the private sector and regional organizations. County and City Hazard Mitigation Advisory Committees (HMACs) guided the NHMP development process.

For a list of specific County HMAC participants, refer to the acknowledgements section above. The update process included representatives from the following jurisdictions and agencies:

Table PS-1 HMAC Participants

County Representatives	Participating Cities	Participating Special Districts	Other Partner Organizations
Disaster Management	City of Canby	Clackamas Co. Fire District #1	Clackamas Soil and Water Conservation District
Planning Commission	City of Estacada	Clackamas River Water	Clackamas River Water Providers
Public Health	City of Gladstone	Colton Water District	Greater Oregon City Watershed Council
Public Works	City of Happy Valley	Oak Lodge Water Services	Metro
Transportation and Development	City of Lake Oswego		North Clackamas Watersheds Council
Water Environment Services	City of Milwaukie		Oregon Department of Geology and Mineral Industries
	City of Molalla		Oregon Department of Land Conservation and Development
	City of Oregon City		Oregon Office of Emergency Management
	City of Sandy		Portland General Electric
	City of West Linn		United States Army Corps of Engineers
	City of Wilsonville		United States Forest Service

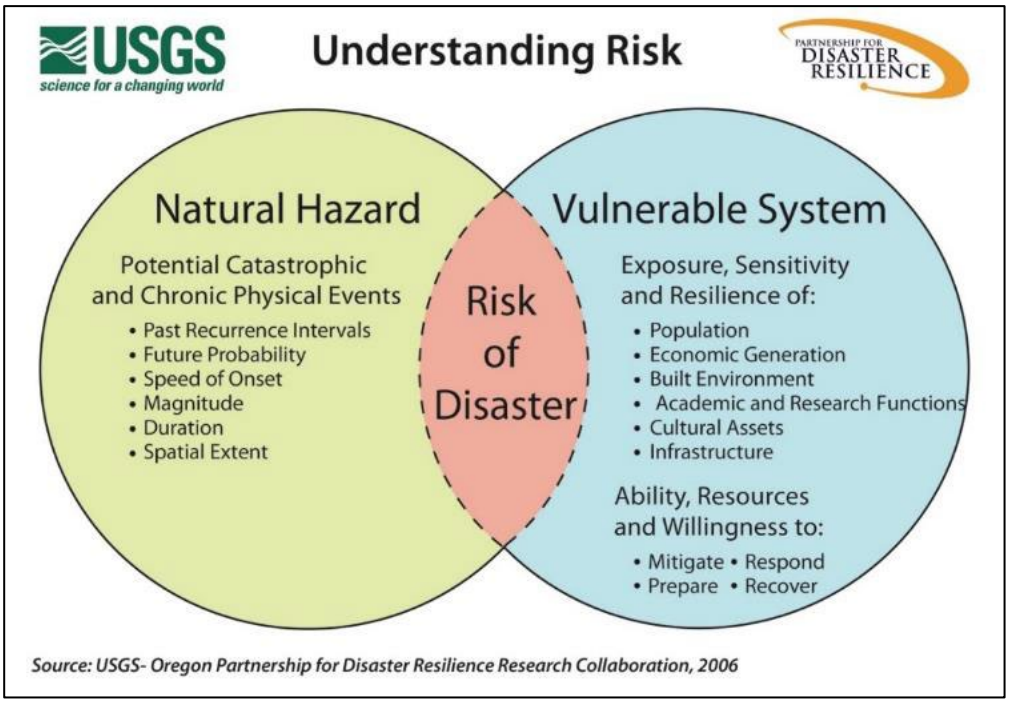
44 CFR 201.6(c)(1) – Documentation of the planning process used to develop the plan, including how it was prepared, who was involved in the process and how the public was involved.

The Clackamas County Resilience Coordinator convened the planning process and will take the lead in implementing, maintaining and updating the County NHMP. Each of the participating cities and special districts have also named a local convener who is responsible for implementing, maintaining and updating the Jurisdictional Addenda (see addenda for specific names and positions). Clackamas County is dedicated to directly involving the public in the continual review and update of the NHMP. The County achieves this through systematic engagement of a wide variety of active groups, organizations or committees, public and private infrastructure partners, watershed and neighborhood groups and numerous others. Although members of the HMAC represent the public to some extent, the public will continue to provide feedback about the NHMP throughout the implementation and maintenance period.

How Does this NHMP Reduce Risk?

The NHMP is intended to assist Clackamas County reduce the risk from hazards by identifying resources, information and strategies for risk reduction. It is also intended to guide and coordinate mitigation activities throughout the County that contribute toward building community resilience. Through the NHMP, Clackamas County also conducts a risk assessment, which seeks to identify and understand the relationship between hazards, vulnerable systems, and exisiting capacity. The risk assessment is conducted by assessing three elements: the natural hazards that pose as a threat to a community, the vulnerable systems within the community, and identifying in which ways do those natural hazards pose as a risk to these vulnerable systems, as illustrated in Figure PS-1. Through understanding these relationships between natural hazards, vulnerable systems and exisiting capcity, and the risk that exist in Clackamas County, we are better equiped to develop and implement actions and strategies aimed at reducing community risk to natural hazards and enhancing community resiliency.

Figure PS-1 Understanding Risk



What is Clackamas County's Risk to Natural Hazards?

Clackamas County reviewed and updated the risk assessment to evaluate the probability of each hazard as well as the vulnerability of the community to that hazard.

44 CFR 201.6(c)(2) – A Risk Assessment that provides the factual basis for activities proposed in the strategy . . .

Table PS-2 presents the updated hazard analysis matrix for Clackamas County. To view the Hazard Analysis Matrix each participating City and special district see Volume II. The hazards are listed in rank order from high to low based on the overal risk they pose to the unincorporated parts of the county. The updated 2024 Hazard Analysis Matrix determines that the top hazards threats that pose the greatest risk to the County (top tier) include Wildfire, Earthquake (Cascadia Subduction Zone and Crustal), Winter Storm, and Extreme Heat Event. Hazards that fall within the middle of the Matrix and pose moderate risk to the county (middle tier) include Drought, Flood, and Windstorm. And the hazards that fall in lowest in the matrix and thus post the least risk to the County (bottom tier) include Landslide and Volcanic Event.

Table PS-2 Hazard Analysis Matrix

Hazard	History	Vulnerability	Maximum Threat	Probability	Total Threat Score	Hazard Rank	Hazard Tiers
Wildfire	18	35	80	56	189	1	*Top Tier*
Earthquake - Cascadia	2	45	100	35	182	2	
Earthquake - Crustal	6	50	100	21	177	3	
Winter Storm	12	30	70	49	161	4	
Extreme Heat Event	10	35	70	35	150	5	
Drought	10	15	50	56	131	6	Middle Tier
Flood	16	20	30	56	122	7	
Windstorm	14	15	50	42	121	8	
Landslide	14	15	20	63	112	9	Bottom Tier
Volcanic Event	2	25	50	7	84	10	

Source: Clackamas County Hazard Mitigation Advisory Committee 2024

What is the NHMP's Mission

The mission of the Clackamas County NHMP is to:

Enhance county resiliency and capacity to address natural hazards by promoting sound public policy and effective mitigation strategies designed to equitably reduce risk and impacts on community members, community lifelines, historic and cultural resources property, and ecological systems.

This can be achieved by increasing public awareness, documenting the resources for risk reduction and loss-prevention, and identifying activities to guide the county towards building a safer, more sustainable community.

What are the NHMP Goals?

The plan goals describe the overall direction that the participating jurisdiction's agencies, organizations and community members can take toward mitigating risk from all known hazards. The goals of the Clackamas County NHMP are organized under several broad categories. The goals are:

44 CFR 201.6(c)(3)(i) – A description of mitigation goals to reduce or avoid long-term vulnerabilities to the identified hazards.strategy . . .

Goal 1: Protect Life and Property

- Develop and implement mitigation and climate adaptation projects and policies that aid in protecting lives by making homes, businesses, community lifelines, and other property more resilient to natural hazards and impacts from climate change.
- Establish mitigation projects and policies that minimize losses and repetitive damages from recurring disasters while promoting insurance coverage for severe hazards
- Improve hazard identification and risk assessment information to inform and provide recommendations for enhanced resilience in new development decisions, and promote preventative measures for existing development in areas vulnerable to natural hazards.

Goal 2: Enhance Natural Systems

- Incorporate natural hazard mitigation planning and activities into watershed planning, natural resource management, natural systems enhancement, and land use planning to protect life, property, and ecological system.

Goal 3: Augment Emergency Services

- Strengthen emergency operations by enhancing communication, collaboration, and coordination of natural hazard mitigation activities and policies across agencies at all levels and regions of government, sovereign tribal nations, and the private sector.

Goal 4: Encourage Partnerships for Implementation

- Improve communication, coordination, and participation among and with public agencies, community members, community lifelines, and private sector organizations to prioritize and implement hazard mitigation activities and policies.
- Enhance efforts toward identifying and optimizing opportunities across state agencies, surrounding communities, and private entities for resource sharing, mutual aid, and funding sources/support.

Goal 5: Promote Public Awareness

- Build community resilience and awareness, and reduce the effects of natural hazards and climate change through community-wide engagement, collaboration, resource-sharing, learning, leadership-building, and identifying mitigation project-related funding opportunities.

Goal 6: Advance Equity and Inclusion

- Mitigate the inequitable impacts of natural hazards by prioritizing the directing of resources and efforts to build resilience and engagement in the most vulnerable communities least able to prepare, respond, and recover.

- Strengthen efforts aimed at increasing engagement, outreach, and collaboration with community and cultural organizations and agencies that are dedicated to providing services and support to vulnerable and underserved communities.

How are the Action Items Organized

The action items are organized within an action matrix included within Section 3, Mitigation Strategy.

> *44 CFR 201.6(c)(3)(ii) – A section that identifies and analyzes a comprehensive range of specific mitigation actions . . .*

Data collection, research and the public participation process resulted in the development of the action items. The Action Item Matrix portrays the plan framework and identifies linkages between the plan goals and actions. The matrix documents the title of each action along with, the coordinating organization, timeline and the NHMP goals addressed. City specific action items are included in Volume II, Jurisdictional Addenda.

Comprehensive Action Plan

Action items are detailed recommendations for activities that local departments, community members, and others could engage in to reduce risk. The HMAC will prioritize the following actions to focus their attention, and resource availability, upon an achievable set of high leverage activities over the next five-years.

Education and Outreach

- **Flood (FL) #1:** Identify opportunities to raise public awareness and implement education campaigns for community members within Clackamas County's public and private flood-prone properties.
- **Severe Weather (SW) #1:** Maintain a public awareness campaign regarding severe weather mitigation measures and the importance of personal safety.
- **Wildfire (WF) #2:** Encourage private landowners to create and maintain defensible space around homes and other buildings and make home hardening improvements.

GIS/Mapping

- **Multi-Hazard (MH) #4:** Utilize knowledge of natural ecosystems and hazards to link natural resource management and land use organizations with potential mitigation activities and provide technical assistance in high-risk locations.
- **Flood (FL) #6:** Identify and respond to problematic surface water drainage sites in all parts of unincorporated Clackamas County.

Maintenance/Planning

- **Multi-Hazard (MH) #1:** Integrate the goals and action items from the Clackamas County Natural Hazard Mitigation Plan into existing regulatory documents and programs.
- **Severe Weather (SW) #2:** Monitor and implement programs to mitigate potentially hazardous trees from endangering lives, property, and public infrastructure.
- **Wildfire (WF) #1:** Promote and support wildfire mitigation action items through the Clackamas County Community Wildfire Protection Plan.

- **Wildfire (WF) #3:** Update county and jurisdiction wildfire codes and ordinances in accordance with guidelines provided by OSFM/DLCD/ODF/BCD as part of SB 762 (2021) and SB 80 (2023).

Critical Infrastructure/Essential Facilities

- **Multi-Hazard (MH) #6:** Support/encourage electrical utilities to use underground construction methods where possible.
- **Multi-Hazard (MH) #8:** Develop and maintain risk assessment and Emergency Operation Plans for state-regulated dams identified as high hazard potential dams (private, public, and non-profit).
- **Flood (FL) #3:** Improve and refine existing flood warning systems by integrating flood monitoring, detection, and alert/notification systems.

Land Use/Development

- **Flood (FL) #2**: Recommend revisions to the requirements, limitations, and exclusions for new development within the floodplains that have designated channel migration zones (CMZ).
- **Flood (FL) #5:** Encourage and facilitate the use of mitigation strategies in the management of existing flood-prone properties, either through home elevation or property acquisition.

How Will the NHMP be Implemented?

44 CFR 201.6(c)(3)(iii) – An action plan describing how the actions . . . will be prioritized, implemented and administered . . .

44 CFR 201.6(c)(4) – A plan maintenance process . . .

The implementation and maintenance section (Section 4) details the formal process that will ensure that the Clackamas County NHMP remains an active and relevant document. The Clackamas County Resilience Coordinator is the designated convener (NHMP Convener) and is responsible for overseeing the review and implementation processes (see jurisdictional addenda for city and special district conveners). The NHMP maintenance process includes a schedule for monitoring and evaluating the NHMP semi-annually and revising the NHMP every five years. This section also describes how the communities will integrate public participation throughout the implementation and maintenance process

The accomplishment of the NHMP goals and actions depends upon regular HMAC participation and adequate support from County, city, and special district leadership. Comprehensive familiarity with this NHMP will result in the efficient and effective implementation of appropriate mitigation activities and a reduction in the risk and the potential for loss from future natural hazard events.

Mitigation Successes

Clackamas County has several examples of hazard mitigation including the following projects funded through FEMA Hazard Mitigation Assistance and the Oregon Infrastructure Finance Authority's Seismic Rehabilitation Grant Program[1].

FEMA Funded Mitigation Successes

- 2023:BRIC, Mount Hood Resiliency Project, PGE ($80,000,000) – *Pending Selection*
- 2020: HMGP-FM5327-13, *Upper Sandy River Flood Warning System Improvements* ($94,408)
- 2020: HMGP-5195-01, *Flood Acquisition* (no cost provided)
- 2017: HMGP-1956-05, *Upper Sandy River Basin Flood Warning System* ($45,046)
- 2016: FMA-PJ-10-OR-2016-003, *Flood Mitigation Elevation* (no cost provided)
- 2015: HMGP-1956-03, *Sandy River Erosion (Channel Migration) Study* ($125,000)
- 2014: HMGP-1956-02 Phase 2, *Flood Acquisition* ($315,609)
- 2013: HMGP-1824-08, Landslide Hazard Mapping/Risk Assessment ($121,876)
- 2013: HMGP-1956-02 Phase 1, *Flood Acquisition* ($101,925)
- 2013: HMGP-1956-02 Phase 1, *Flood Acquisition* ($266,614)
- 2012: HMGP-1824-03 Phase 3, *Flood Acquisition* ($353,606)
- 2012: HMGP-1824-03 Phase 4, *Flood Acquisition* ($243,868)
- 2010: HMGP-1824-03 Phase 1, *Flood Acquisition* ($140,763)
- 2010: HMGP-1824-03 Phase 2, *Flood Acquisition* ($281,445)
- 2003: PDMC-PJ-10-OR-2003-001, *CCOM/EOC Seismic Upgrade* ($272,000)
- 2003: PDMC-PJ-10-OR-2003-004, *WES Tri-City Wastewater Seismic Upgrade* ($333,290)
- 2007: FMA-PJ-10-OR-2007-001, *Flood Mitigation Elevation* ($128,672)
- 2005: PDMC-PJ-10-OR-2005-002, *Clackamas WES Pipe-Bridge Erosion/Scour Relocation Project* (no cost provided)
- 2005: EMS-2005-FM-E002, *Flood Mitigation Elevation* ($194,000)
- 2005: HMGP-1510-03, *Partners For Loss Prevention Pre-School Seismic Safety* ($1,527)
- 2005: HMGP-1510-09, *Hazard Tree Mitigation Assistance – Oregon Department of Forestry* ($10,000)
- 2005: PDMC-PJ-10-OR-2005-002, *WES Pipe bridge Erosion/Scour Relocation* ($2,057,133)

Seismic Rehabilitation Grant Program Mitigation Successes

- 2019: North Campus Sabin-Schellenberg, North Clackamas School District ($2,500,000)
- 2017: Molalla Fire District Station 82, ($1,189,967)
- 2017: Sunnyside Elementary (Community of Clackamas), North Clackamas School District, ($1,500,000)
- 2017: Whitcomb Elementary, North Clackamas School District ($1,500,000).
- 2014: Clackamas Fire District Fire Station #12 (Logan) ($94,552)
- 2014: Clackamas Fire District Fire Station #13 (Clarkes), ($71,582)

Other mitigation success regardless of funding

- South End Road, installed slope inclinometers and vibrating wire piezometers

See city addenda for mitigation successes within each city and special district.

[1] The Seismic Rehabilitation Grant Program (SRGP) is a state of Oregon competitive grant program that provides funding for the seismic rehabilitation of critical public buildings, particularly public schools, and emergency services facilities.

NHMP Adoption

Once the NHMP is locally reviewed and deemed complete, the NHMP Convener (or their designee) submits it to the State Hazard Mitigation Officer at the Oregon Department of Emergency Management (OEM). OEM reviews the NHMP and submits it to FEMA Region X for pre-approval. This review will address the federal criteria outlined in 44 CFR Part 201.6. Once pre-approved by FEMA, the County, cities, and special districts may formally adopt it via resolution.

The Clackamas County NHMP Convener will be responsible for ensuring local adoption of the NHMP and providing the support necessary to ensure NHMP implementation. Once the resolution is executed at the local level and documentation is provided to FEMA, the NHMP will be formally approved by FEMA and the County, participating cities, and special districts will regain eligibility for Hazard Mitigation Assistance (HMA) grant programs

44 CFR 201.6(c)(5) – Documentation that the plan has been formally adopted by the governing body of the jurisdiction . . .

44 CFR 201.6(d) – Plan review [process] . ..

The HMACs for Clackamas County and participating cities and special districts each met to review the NHMP update process and their governing bodies adopted the NHMP as shown below:

County Date of Adoption and Approval

Clackamas County adopted the NHMP on **August 15, 2024.**

FEMA Region X approved the Clackamas County NHMP on **September 12, 2024.** With approval of this NHMP, the entities listed above are now eligible to apply for the Robert T. Stafford Disaster Relief and Emergency Assistance Act's hazard mitigation project grants **through September 11, 2029].**

For the date of adoption for each participating city and special district see Volume II.

This page is intentionally left blank

Section I: Introduction

This section provides a general introduction to natural hazard mitigation planning in Clackamas County. In addition, it addresses the planning process requirements contained in 44 CFR 201.6(b) thereby meeting the planning process documentation requirement contained in 44 CFR 201.6(c)(1). The section concludes with a general description of how the NHMP is organized.

What is Natural Hazard Mitigation?

The Federal Emergency Management Agency (FEMA) defines mitigation as ". . . the effort to reduce loss of life and property by lessening the impact of disasters . . . through risk analysis, which results in information that provides a foundation for mitigation activities that reduce risk."[2] Said another way, natural hazard mitigation is a method of permanently reducing or alleviating the losses of life, property and injuries resulting from natural hazards through long and short-term strategies. Example strategies include policy changes, such as updated ordinances, projects, seismic retrofits to critical facilities and education and outreach to targeted audiences, such as Spanish speaking residents or the elderly. Natural hazard mitigation is the responsibility of the "Whole Community"; individuals, private businesses and industries, state and local governments and the federal government.

Engaging in mitigation activities provides jurisdictions (counties, cities, special districts, etc.) with many benefits, including reduced loss of life, property, essential services, critical facilities and economic hardship; reduced short-term and long-term recovery and reconstruction costs; increased cooperation and communication within the community through the planning process; and increased potential for state and federal funding for recovery and reconstruction projects.

Why Develop a Mitigation Plan?

Clackamas County updated this Multi-Jurisdictional Natural Hazard Mitigation Plan (NHMP) to reduce future loss of life and damage to property resulting from natural hazards. It is impossible to predict exactly when natural hazard events will occur, or the extent to which they will affect community assets. However, with careful planning and collaboration among public agencies, private sector organizations and residents within the community, it is possible to minimize the losses that can result from natural hazards.

In addition to establishing a comprehensive community-level mitigation strategy, the Disaster Mitigation Act of 2000 (DMA2K) and the regulations contained in 44 CFR 201, require that jurisdictions maintain an approved NHMP to receive federal funds for mitigation projects. Local adoption and federal approval of this NHMP ensures that the County and listed cities will remain eligible for pre- and post-disaster mitigation project grants.

[2] FEMA, What is Mitigation? http://www.fema.gov/what-mitigation

What Federal Requirements Does This NHMP Address?

DMA2K reinforces the importance of mitigation planning and emphasizes planning for natural hazards before they occur. As such, this Act established the Pre-Disaster Mitigation (PDM) grant program (often referred to as the non-disaster grant program) and new requirements for the national post-disaster Hazard Mitigation Grant Program (HMGP). Section 322 of the Act specifically addresses mitigation planning at the state and local levels. State and local jurisdictions must have approved mitigation plans in place to qualify to receive post-disaster HMGP funds. Mitigation plans must demonstrate that State and local jurisdictions' proposed mitigation measures are based on a sound planning process that accounts for the risk to the individual and State and local jurisdictions' capabilities.

Title 44 Code of Federal Regulations (CFR), section 201.6, also requires a local government to have an approved NHMP in order to receive HMGP project grants.3 Pursuant of Title 44 CFR, the NHMP planning processes shall include opportunity for the public to comment on the NHMP during review and the updated NHMP shall include documentation of the public planning process used to develop the NHMP.4 The NHMP update must also contain a risk assessment, mitigation strategy and a NHMP maintenance process that has been formally adopted by the governing body of the jurisdiction.5 Lastly, the NHMP must be submitted to the Oregon Office of Emergency Management (OEM) for initial review and then sent to FEMA for federal approval.6 Additionally, the way OEM administers the Emergency Management Performance Grant (EMPG), which helps fund local emergency management programs, also requires a FEMA-approved NHMP.

What is the Policy Framework for Natural Hazard Planning in Oregon?

Planning for natural hazards is an integral element of Oregon's statewide land use planning program, which began in 1973. All Oregon cities and counties have comprehensive plans and implementing ordinances that are required to comply with the statewide planning goals. The challenge faced by state and local governments is to keep this network of local plans coordinated in response to the changing conditions and needs of Oregon communities.

Statewide land use planning Goal 7: Areas Subject to Natural Hazards calls for local plans to include inventories, policies and ordinances to guide development in or away from hazard areas. Goal 7, along with other land use planning goals, has helped to reduce losses from natural hazards. Through risk identification and the recommendation of risk-reduction actions, this NHMP aligns with the goals of the jurisdiction's Comprehensive Plan and helps each jurisdiction meet the requirements of statewide land use planning Goal 7.

The primary responsibility for the development and implementation of risk reduction strategies and policies lies with local jurisdictions. However, additional resources exist at the state and federal levels. Some of the key agencies in this area include OEM, Oregon Building Codes Division (BCD), Oregon

[3] Code of Federal Regulations, Title 44, Part 201, Section 201.6, subsection (a).
[4] ibid, subsection (b).
[5] ibid, subsection (c).
[6] ibid, subsection (d).

Department of Forestry (ODF), Oregon Department of Geology and Mineral Industries (DOGAMI) and the Department of Land Conservation and Development (DLCD).

How was the NHMP Developed?

The NHMP was developed by the Clackamas County NHMP Hazard Mitigation Advisory Committee (HMAC) and the HMACs for the participating jurisdictions (cities and special districts). The Clackamas County HMAC formally convened on four occasions to discuss and revise the NHMP. Each of the participating city and special district HMACs met at least once formally. HMAC members contributed by reviewing and updating the community profile, risk assessment, action items, and implementation and maintenance plan.

An open public involvement process is essential to the development of an effective NHMP. To develop a comprehensive approach to reducing the effects of natural disasters, the planning process shall include opportunity for the public, neighboring communities, local and regional agencies, as well as, private and non-profit entities to comment on the NHMP during review.[7] Clackamas County provided an accessible project website for the public to provide feedback on the draft NHMP: https://www.clackamas.us/dm/naturalhazard.html. In addition, Clackamas County provided a press release on their website to encourage the public to offer feedback on the NHMP update. The County and city websites continue to be a focal point for distribution natural hazard information using hazard viewers, emergency alerts, hazard preparation, and annual natural hazard progress reports. In addition, the County administered a survey (see Appendix H) that was used to inform the prioritization of action items, as well as identification of potential future project sites.

A variety of community organizations and commmunity members were involved and included the following:

- Local and regional agencies involved in hazard mitigation activities, such as public works, emergency management, local floodplain administration and Geographic Information Systems (GIS) departments.
- Agencies that have the authority to regulate development, such as zoning, planning, community and economic development departments; building officials; planning commissions; or other elected officials.
- Neighboring communities, such as adjacent local governments, including special districts that are affected by similar hazard events or may share a mitigation action or project that crosses boundaries. Also, neighboring communities may be partners in hazard mitigation and response activities, or may be where critical assets, such as dams, are located.
- Representatives of businesses, academia, and other private organizations, such as private utilities or major employers that sustain community lifelines.
- Representatives of nonprofit organizations, community-based organizations, and agencies focused on housing, healthcare, and social services and that work directly with and/or provide support to underserved communities and socially vulnerable populations.

Making and providing opportunities to be involved in the planning process means that these groups and commmunity members are invited to be engaged in this process, such as asking them to provide input and information that will be used inform the plan's content and priorities. Different communities types

[7] Code of Federal Regulations, Title 44. Section 201.6 (b)

may necessitate more targeted and intentional outreach and engagement, especially underserved and historically-marginalized communities.

How is the NHMP Organized?

Each volume of the NHMP provides specific information and resources to assist readers in understanding the hazard-specific issues facing county and city residents, businesses and the environment. Combined, the sections work in synergy to create a mitigation plan that furthers the community's mission to reduce or eliminate long-term risk to people and their property from hazards and their effects. This NHMP structure enables commmunity members to use the section(s) of interest to them.

Volume I: Basic Plan

Plan Summary

The NHMP summary provides an overview of the FEMA requirements, planning process and highlights the key elements of the risk assessment, mitigation strategy and implementation and maintenance strategy.

Section 1: Introduction

The Introduction briefly describes the countywide mitigation planning efforts and the methodology used to develop the NHMP.

Section 2: Hazard Identification and Risk Assessment

The Hazard Identification and Risk Assessment provide the factual basis for the mitigation strategies contained in Volume I, Section 3. (Additional information is included within Volume III, Appendix C, which contains an overall description of Clackamas County and participating jurisdictions), and includes a brief description of community sensitivities and vulnerabilities. The Risk Assessment also allows readers to gain a deeper understanding of each jurisdiction's vulnerability and overal risk and resilience to each of the identified natural hazards.

Furthermore, a hazard summary is provided for each of the hazards addressed in the NHMP, and includes information on hazard history, location, extent, vulnerability, impacts and probability, and future climate projects (for climate-related hazards). This NHMP assesses the same nine hazards identified and assessed in the 2020 State of Oregons Natural Hazard Mitigation Plan – Region 2: North Willamette Valley/Portland Metro[8], and they are as follows:

- Drought
- Earthquake
- Flood
- Landslide
- Severe Weather
  - Extreme Heat
  - Windstorm
  - Winter Storm
- Volcanic Event
- Wildfire

[8] DLCD, Oregon Natural Hazards Mitigation Plan – Region 2: Willamette Valley/Portland Metro (2020)

Section 3: Mitigation Strategy

This section documents the NHMP vision, mission, goals and actions (mitigation strategy) and describes the components that guide implementation of the identified actions. Actions are based on community sensitivity and resilience factors and the risk assessments in Volume I, Section 2 and Volume II.

Section 4: Plan Implementation and Maintenance

This section provides information on the implementation and maintenance of the NHMP. It describes the process for prioritizing projects and includes a suggested list of tasks for updating the NHMP, to be completed at the semi-annual and five-year review meetings

Volume II: Jurisdictional Addenda

Volume II of the NHMP is reserved for any city or special district addenda developed through this multi-jurisdictional planning process. Each of the cities with a FEMA approved addendum went through an update to coincide with the county's update. As such, the five- year update cycle will be the same for all the cities and the county.

The NHMP includes addenda for the following cities and special districts:

Cities		Special Districts
Canby	Molalla	Clackamas Fire District #1
Estacada	Oregon City	Clackamas River Water
Gladstone	Sandy	Colton Water District
Happey Valley	West Linn	Oak Lodge Water Services
Lake Oswego	Wilsonville	
Milwaukie		

Note 1: Johnson City elected not to particpate and update their NHMP. Applicable content has been incorporated into the County portion of the NHMP.
Note 2: Addenda were developed for Colton Water District and Oak Lodge Waters Services in this version of the NHMP.
Note 3: Johnson City and additional special districts may elect to participate in future versions of the NHMP.

Volume III: Appendices

The appendices are designed to provide the users of the Clackamas County NHMP with additional information to assist them in understanding the contents of the NHMP and provide them with potential resources to assist with NHMP implementation.

Appendix A: Action Item Forms

This appendix contains the detailed action item forms for each of the mitigation strategies identified in this NHMP.

Appendix B: Planning and Public Process

This appendix includes documentation of all the countywide public processes utilized to develop the NHMP. It includes agendas and attendees of HMAC meetings as well as any other public involvement and outreach methods.

Appendix C: Community Profile

The community profile describes the County from several perspectives to help define and understand the region's sensitivity, vulnerability, and overall resiliency to natural hazards. The information in this section represents a snapshot in time of the current sensitivity and resilience factors in the region when the NHMP was updated.

Appendix D: Community Risk Profiles

Appendix D provides a list of Community Lifelines and their vulnerability status to the identified natural hazards per the DOGAMI Multi-Hazard Risk Report.

Appendix E: Natural Hazard and Base Maps

This appendix includes base and natural hazard maps that are cited throughout the NHMP, particularly within Volume I, Section 2 and Volume III, Appendix C. Additional maps for participating cities and special districts are provided in Volume II.

Appendix F: Economic Analysis of Natural Hazard Mitigation Projects

This appendix describes the FEMA requirements for benefit cost analysis in natural hazards mitigation, as well as various approaches for conducting economic analysis of proposed mitigation activities.

Appendix G: Grant Programs and Resources

This appendix lists state and federal fuding sources, resources and programs by the hazard-type it addresses.

Appendix H: Community Survey

This appendix includes the survey instrument and results from the community survey administered by Clackamas County.

.

Section 2: Hazard Identification and Risk Assessment

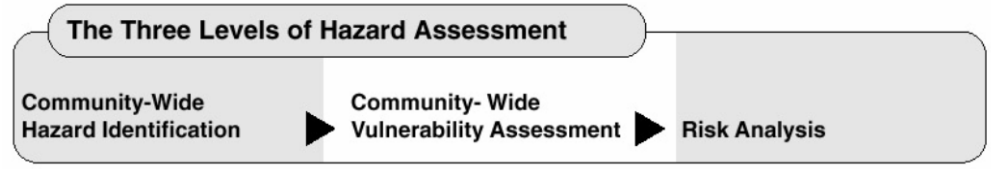
This section of the NHMP addresses 44 CFR 201.6(c)(2) - Risk Assessment. The Risk Assessment applies to Clackamas County and the city addenda included in the NHMP. We address city specific information where relevant. In addition, this section can assist with addressing Oregon Statewide Planning Goal 7 – Areas Subject to Natural Hazards.

We use the information presented in this section, along with community characteristics presented in Volume III, Appendix C to inform the risk reduction actions identified Volume I, Section 3. shows how we conceptualize risk in this NHMP. Ultimately, the goal of hazard mitigation is to reduce the area where hazards and vulnerable systems overlap.

What is a Risk Assessment

A risk assessment consists of three phases: hazard identification, vulnerability assessment and risk analysis (Figure 2-1).

Figure 2-1 Three Phases of a Risk Assessment



Source: Planning for Natural Hazards: Oregon Technical Resource Guide, 1998

This three-phase approach to developing a risk assessment should be conducted sequentially because each phase builds upon data from prior phases. However, gathering data for a risk assessment need not occur sequentially.

- Phase 1: Identify hazards that can affect the jurisdiction. This includes an evaluation of potential hazard impacts – type, location, extent, etc.
- Phase 2: Identify important community assets and system vulnerabilities. Example vulnerabilities include people, businesses, homes, roads, historic places and drinking water sources.
- Phase 3: Evaluate the extent to which the identified hazards overlap with, or have an impact on, the important assets identified by the community.

Hazard Identification

Clackamas County identifies nine natural hazards that could have an impact on the County and participating jurisdictions. Table 2-1 lists the hazards identified in the County in comparison to the hazards identified in the Oregon NHMP for the Northern Willamette Valley/Portland Metro (Region 2), which includes Clackamas County.

Table 2-1 Clackamas County Hazard Identification

Clackamas County	State of Oregon NHMP Region 2: Northern Willamette Valley/Portland Metro
Drought	Drought
Earthquake	Earthquake
Extreme Heat	Extreme Heat
Flood	Flood
Landslide	Landslide
Volcanic Event	Volcano
Wildfire	Wildfire
Windstorm	Windstorm
Winter Storm	Winter Storm

Source: Clackamas County NHMP Hazard Mitigation Advisory Committee (2024) and State of Oregon NHMP Region 2: Northern Willamette Valley/Portland Metro (2020)

Risk Analysis

Multi-jurisdictional Risk Assessment - §201.6(c) (2) (iii): For multi-jurisdictional plans, the risk assessment must assess each jurisdiction's risks where they vary from the risks facing the entire planning area.

Hazard Analysis Matrix and Methodology

For local governments, conducting the hazard analysis is a useful step in planning for hazard mitigation, response and recovery. The method provides the jurisdiction with a sense of hazard priorities but does not predict the occurrence of a hazard.

For the purposes of this NHMP, the County and cities utilized the Oregon Department of Emergency Management (OEM) Hazard Analysis methodology. The hazard analysis methodology in Oregon was first developed by FEMA circa 1983 and gradually refined by OEM over the years.

The methodology produces scores that range from 24 (lowest possible) to 240 (highest possible). Vulnerability and probability are the two key components of the methodology. Vulnerability examines both typical and maximum credible events and probability endeavors to reflect how physical changes in the jurisdiction and scientific research modify the historical record for each hazard. Vulnerability accounts for approximately 60% of the total score and probability approximately 40%. We include the hazard analysis summary here to ensure consistency between the EOP and NHMP.

The Oregon hazard analysis method provides the jurisdiction with a sense of hazard priorities and/or relative risk. It doesn't predict the occurrence of a hazard, but it does "quantify" the risk of one hazard compared with another, and involves estimating the damage, injuries, and costs likely to be incurred in a geographic area over time due to a natural hazard occuring. By doing this analysis, planning can first be focused which hazard poses the greatest overall risk to the community and where that risk is greatest. When measuring risk, there are two measurable components to consider: (1) the magnitude of the harm that may result, defined through the vulnerability assessment (assessed in the previous sections) and (2) the likelihood or probability of the harm occurring.

In Oregon's hazard analysis method, these components of overall risk can be measured through an approach that apply severity ratings and weight factors to four pre-determined categories: History (past historical events), Vulnerability, Maximum Threat (worst-case scenario) and Probability (the likelihood of a hazard event occuring).

Table 2-1 presents the updated hazard analysis matrix for Clackamas County. The hazards are listed in rank order from high to low based on the overal risk they pose on the county. The updated 2024 Hazard Analysis Matrix determines that the top hazards threats that pose the greatest risk to the County (top tier) include Wildfire, Earthquake (Cascadia Subduction Zone and Crustal), Winter Storm, and Extreme Heat Event. Hazards that fall within the middle of the Matrix and pose moderate risk to the county (middle tier) include Drought, Flood, and Windstorm. And the hazards that fall in lowest in the matrix and thus post the least risk to the County (bottom tier) include Landslide/Debris Flow and Volcanic Event.

Table 2-1 Hazard Analysis Matrix

Hazard	History	Vulnerability	Maximum Threat	Probability	Total Threat Score	Hazard Rank	Hazard Tiers
Wildfire	18	35	80	56	189	1	*Top Tier*
Earthquake - Cascadia	2	45	100	35	182	2	
Earthquake - Crustal	6	50	100	21	177	3	
Winter Storm	12	30	70	49	161	4	
Extreme Heat Event	10	35	70	35	150	5	
Drought	10	15	50	56	131	6	Middle Tier
Flood	16	20	30	56	122	7	
Windstorm	14	15	50	42	121	8	
Landslide	14	15	20	63	112	9	Bottom Tier
Volcanic Event	2	25	50	7	84	10	

Source: Clackamas County Hazard Mitigation Advisory Committee 2024

Jurisdiction Specific Risk Assessment

Each participating jurisdiction (cities and special districts) in Clackamas County completed a jurisdiction specific hazard analysis that assessed each jurisdiction's risks, specifically focusing on where they vary from the risks facing the entire planning area, i.e., the county. The multi-jurisdictional risk assessment information is located within the addenda of Volume II.

Probability and Vulnerability

The Hazard Profiles in this Section present the probability scores for each of the natural hazards present in Clackamas County. Probability assesses the likelihood that a hazard event will take place in the future. Vulnerability assesses the extent to which people are susceptible to injury or other impacts resulting from a hazard as well as the exposure of the built environment or other community assets (social, environmental, economic, etc.) to hazards. The exposure of community assets to hazards is critical in the assessment of the degree of risk a community has to each hazard. Identifying the populations, facilities and infrastructure at risk from various hazards can assist the County in prioritizing resources for mitigation and can assist in directing damage assessment efforts after a hazard event has occurred. The exposure of County assets to each hazard and potential implications are explained in each hazard section.

Vulnerability includes the percentage of population and property likely to be affected under an "average" occurrence of the hazard. Clackamas County evaluated the best available vulnerability data to develop the vulnerability scores presented below.

Community vulnerabilities are an important component of the NHMP risk assessment. Changes to population, economy, built environment, community lifelines, and infrastructure have not significantly influenced vulnerability. New development has complied with the standards of the Oregon Building Code and the county's development code including their floodplain ordinance. For more in-depth information regarding specific community vulnerabilities see Volume III, Appendix C.

Inter-Hazard Impact and Outcomes

Natural hazard events typically do not occur in isolation from one another. Rather they may have external effects and impacts on the occurrence or severity of another natural hazard, whether directly, indirectly, or a combination of both.[9] Additionally, a natural hazard may trigger the immediate onset of another natural hazard or exacerbate the severity of an already occurring natural hazard. For example, an extreme heat event occurring in an area already experiencing drought could further exacerbate it, thus increasing the severity of the drought.[10]

In contrast, the impact of one natural hazard on another natural hazard may be delayed, or other factors may need to be triggered alongside the first natural hazard in order to initiate the onset of the new natural hazard. For example, wildfire may cause burn scarring that leaves an area dry and sparsely vegetated. Such conditions may increase the risk of flooding and/or land sliding during times of high precipitation.[11]

Furthermore, climate-related natural hazards are exacerbated by the growing impacts of climate change, which triggers those climate-related hazards to increase in occurrence and severity. In return, more opportunities are created for climate-related natural hazards to occur.[12]

Recognizing these relationships between natural hazards impacts and outcomes will allow planners to identify and implement mitigation actions that are focused more on long-term resiliency and

[9] Nature, "*How do natural hazards cascade to cause disasters?*", 2018
[10] Nature Climate Change, "*Precipitation trends determine future occurrences of compound hot-dry events*", 2022
[11] National Flood Insurance Program, "*Flood After Fire Fact Sheet*", 2012
[12] USGS, "*How can climate change affect natural disasters?*", accessed June 2023

multipurpose solutions, rather than focusing on solutions for independent natural hazards. In this way, mitigation planning can position itself as climate adaptation in order to build climate resilience.

Table 2-2 shows the relationship between inter-hazard impacts, and is to be used as a tool to use when developing mitigation actions that can mitigate the risks associated with multiple natural hazards, as well as considering how to incorporate climate adaptation into mitigation actions.

On the vertical axis (y-axis) are the hazards posing as "the cause", meaning it is the hazard subject we are looking at, and thus analyzing how that specific hazard impacts other hazards.

On the horizontal axis (x-axis) are the hazard posing as "the effect", meaning we are understanding how this hazard could potential be caused and/or exacerbated by "the cause" hazard.

Rather than simply noting "impact" as a general term, "impact" is broken into three categories, which are defined as the following:

- **Direct Impact:** The hazard occurs as a direct result of "the cause" hazard.

  Example: Extreme Heat has a direct Impact on Drought.
- **Indirect Impact**: The hazard occurs as a secondary impact or cascading effect of "the cause" hazard.

  Example: Wildfire has an indirect impact on Flooding.
- **Both:** The hazard occurs as both a direct and indirect result of "the cause" hazard.

  Example: Volcanic Event has both a direct and indirect impact on Earthquake.

Table 2-2 Inter-Hazard Impact Table

Direct / Indirect / Both — The Cause	The Effect: Drought	Earthquake	Extreme Heat	Flooding	Landslide	Volcanic Event	Wildfire	Windstorm	Winter Storm
Drought				I*			I	I	
Earthquake				I	I	B	I		
Extreme Heat	D			I			I		
Flood					B				
Landslide				B					
Volcanic Event		B			B				
Wildfire				I	I				
Windstorm							D		D
Winter Storm				B	B				

Source: Clackamas County Hazard Mitigation Advisory Committee (2024)
Bold - Natural Hazard Vulnerability/ Impact Increased due to Effects of Climate Change

DOGAMI Natural Hazard Risk Report for Clackamas County

A Multi-Hazard Risk Report for Clackamas County (2024) was developed by the Oregon Department of Geology and Mineral Industries (DOGAMI).

In addition, DOGAMI developed a Risk Report for portions of unincorporated Clackamas County within the Lower Columbia-Sandy Watershed (2020, O-20-06).

The purpose of these projects are to provide communities in Clackamas County detailed risk assessments of natural hazards that affect them and to enable communities to compare hazards and act to reduce their risk. The risk assessments contained in this project quantify the impacts of natural hazards to these communities and enhance the decision-making process in planning for disaster.

This study was conducted through completing three primary tasks:

1. Compiling an asset database
2. Identifying and using best available hazard data
3. Performing natural hazard risk assessment

The Natural Hazard Risk Report for Clackamas County will be a principal risk assessment reference for the 2024 plan update.

DOGAMI Vulnerability Assessment

Estimated to begin in 2025 DOGAMI will conduct a vulnerability assessment of Clackamas County. The vulnerability assessment will give a detailed examination of assets, infrastructure, community lifelines, and socially vulnerable population groups that are more susceptible to damage or harm from natural disasters. A historical overview of hazards for the county will provide the context for which these vulnerable structures and population groups exist. Understanding these vulnerabilities can be a resource that communities can use to increase their resilience (or coping) from natural hazards. The primary purpose of this study is to develop a set of best practices for conducting vulnerability assessments related to multi-hazard risk assessments so that this work can be repeated in other parts of the state. The specific topics that will be examined/inventoried are:

- Community Lifelines (critical facilities, infrastructure, and post disaster operations)
- High hazard dams
- Repetitive loss structures from flood
- Unreinforced masonry building inventory (non-residential)
- Rapid Visual Screening for critical facilities (update)
- Socially vulnerability population groups from natural hazards
- Threatened cultural, historical, and natural resources
- Impacts from climate change to vulnerable structures or population groups

This project will contribute resources concerning vulnerable assets and people that can be used to identify opportunities for mitigation actions. Quantitative analysis will be used to assess the vulnerability of structures, people, community lifelines, and infrastructure threatened by high hazard dams, flood (repetitive loss), and impacts from climate change to aid in reducing risk to natural hazards. Based on information DOGAMI provides, communities can increase resilience from natural hazards.

Federal Disaster and Emergency Declarations

Reviewing past events can provide a general sense of the hazards that have caused significant damage in the county. Where trends emerge, disaster declarations can help inform hazard mitigation project priorities.

President Dwight D. Eisenhower approved the first federal disaster declaration in May 1953 following a tornado in Georgia. Since then, federally declared disasters have been approved within every state because of natural hazard related events. As of January 2024, FEMA has approved a total of 40 major disaster declarations, 101 fire management assistance declarations and four (4) emergency declarations in Oregon.[13] When governors ask for presidential declarations of major disaster or emergency, they stipulate which counties in their state they want included in the declaration.

Table 2-3 summarizes the major disasters declared in Oregon that affected Clackamas County, since 1955. The table shows that there have been thirteen (13) major disaster declarations for the County (three since 2018). Most of which were related to weather events resulting primarily in flooding, snow, heat, and landslide related damage. There has been one disaster declaration for earthquake (1993 Scott Mills).

Table 2-4 summarizes fire management assistance and emergency declarations. Fire Management (FM) Assistance may be provided after a State submits a request for assistance to the FEMA Regional Director at the time a "threat of major disaster" for a fire emergency exists. There are six (6) fire management assistance declarations on record for the county.

An Emergency Declaration (EM) is more limited in scope and without the long-term federal recovery programs of a 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. Clackamas County has four recorded Emergency Declarations related to the 1977 Drought, 2005 Hurricane Katrina evacuation, the Covid-19 Pandemic, and the 2020 Oregon Wildfires.

[13] FEMA, *Declared Disasters by Year or State*, https://www.fema.gov/disaster/declarations. Accessed April 20, 2023.

Table 2-3 FEMA Major Disaster (DR) for Clackamas County

Declaration Number	Declaration Date	Incident Period From	Incident Period To	Incident	Individual Assisstance	Public Assistance Categories
DR-184	12/24/1964	12/24/1964	12/24/1964	Heavy rains and flooding	Yes	A, B, C, D, E, F, G
DR-319	1/21/1972	1/21/1972	1/21/1972	Severe storms, Flooding	Yes	A, B, C, D, E, F, G
DR-413	1/25/1974	1/25/1974	1/25/1974	Severe Storms, Snowmelt, Flooding	Yes	A, B, C, D, E, F, G
DR-985	4/26/1993	3/25/1993	3/25/1993	Earthquake	None	A, B, C, D, E, F, G
DR-1099	2/9/1996	2/4/1996	2/21/1996	High Winds, Severe Storms/Flooding	Yes	A, B, C, D, E, F, G
DR-1510	2/19/2004	12/26/2003	1/14/2004	Severe winter storms	None	A, B, C, D, E, F, G
DR-1632	3/20/2006	12/18/2005	1/21/2006	Severe Storms, Flooding, Landslides, and Mudslides	None	A, B, C, D, E, F, G
DR-1824	3/2/2009	12/13/2008	12/26/2008	Severe Winter Storm, Record and Near Record Snow	None	A, B, C, D, E, F, G
DR-1956	2/17/2011	1/13/2011	1/21/2011	Severe Winter Storm, Flooding, Mudslides, Landslides, and Debris Flows	None	A, B, C, D, E, F, G
DR-4258	2/17/2016	12/6/2015	12/23/2015	Oregon Severe Winter Storms, Straight-line Winds, Flooding, Landslides, and Mudslides	None	A, B, C, D, E, F, G
DR-4499	3/28/2020	1/20/2020	5/11/2023	Oregon Covid-19 Pandemic	Yes	B
DR-4562	9/15/2020	9/7/2020	11/3/2020	Wildfire and Straight-line Winds	Yes	A, B, C, D, E, F, G
DR-4599	5/4/2021	2/11/2021	2/15/2021	Severe Winter Storm	None	A, B, C, D, E, F, G

Source: FEMA, Oregon Disaster History. Major Disaster Declarations

Table 2-4 FEMA Fire Management (FM) and Emergency Declaration (EM)

Declaration Number	Declaration Date	Incident Period From	Incident Period To	Incident	Individual Assisstance	Public Assistance Categories
FM-2043	9/15/1981	9/5/1981	-	Peavine Peak Fire	None	-
FM-5080	9/16/2014	9/15/2014	9/26/2014	36 Pit Fire	None	-
FM-5454	9/10/2022	9/10/2022	-	Milo Mciver Fire	None	B, H
FM-5370	9/10/2020	9/8/2020	10/6/2020	Clackamas County Fire Complex	None	B, H
FM-5366	9/9/2020	9/8/2020	10/15/2020	Riverside Fire	None	B, H
FM-5356	9/8/2020	9/7/2020	10/15/2020	Beachie Creek Lionshead Complex	None	B, H
EM-3039	4/29/1977	4/29/1977	4/29/1977	Drought	None	A, B
EM-3228	9/7/2005	8/29/2005	10/1/2005	Hurricane Katrina Evacuation	None	B
EM-3429	3/13/2020	1/20/2020	5/11/2023	Oregon Covid-19	None	B
EM-3542	9/10/2020	9/8/2020	9/15/2020	Oregon Wildfires	None	B

Source: FEMA, Oregon Disaster History. Major Disaster Declarations.

Federal Disaster and Emergency Declarations

Table 2-5 lists Oregon Executive Orders from 2006-2024. There have been 17 state declared disasters, 9 have also been Federally declared.

Table 2-5 State of Oregon Executive Orders (2006-2024)

Executiver Order #	Declaration Date	Incident Period		Incident	FEMA Emergency Type	FEMA Emergency Number
		From	To			
06-16	11/7/2006	11/5/2006	-	Heavy rain, flooding, landslides, and erosion	DR	1683
08-28	12/23/2008	12/23/2008	-	Severe winter weather, heavy snow, freezing rain, ice, and damaging winds	DR	1824
09-01	1/5/2009	1/2/2009	-	Severe winter weather, heavy rain, snow melt, debris, and flooding	-	-
11-01	2/3/2011	1/13/2011	2/3/2011	Severe winter weather, flooding, landslides, and wind	DR	1956
12-02	2/6/2012	1/17/2012	-	snow, freezing rain, torrential rain, snow melt, and record	DR	4055
12-06	5/8/2012	3/11/2012	-	Severe weather, damaging winds, heavy rains, flooding, mudslides, and landslides	-	-
14-13	9/17/2014	9/15/2014	9/26/2014	36 Pit Fire	FM	5080
16-02	1/25/2015	12/7/2014		Severe winter storm, heavy rains, high winds, flooding, landslides, and erosion	-	-
17-06	4/13/2017	12/4/2016	3/1/2017	temperatures, heavy snow and	DR	4296
20-47	9/15/2020	9/8/2020	10/6/2020	North Cascades Complex Fire (Riverside Fire)	FM	5370
20-50	9/25/2020	9/8/2020	10/15/2020	Riverside Fire	FM	5366
21-02	2/13/2021	2/11/2021	2/15/2021	Severe winter storm, heavy snow and ice accumulation, high winds, flooding, and landslides	DR	4599
21-26	7/29/2021	7/29/2021	7/31/2021	Excessive high temperatures	-	-
22-01	1/26/2022	12/30/2021	1/10/2022	Severe winter storm, heavy rains, high winds, flooding, landslides, and erosion	-	-
22-13	7/25/2022	7/25/2022	7/30/2022	Excessive high temperatures	-	-
23-07	3/9/2023	12/22/2022	1/6/2023	Severe winter storm, heavy rain, high winds, flooding, ice accumulation, landslides, and erosion	-	-
24-05	1/19/2024	1/12/2024	1/26/2024	temperatures, snow, freezing	-	-

Hazard Profiles

The following subsections briefly describe relevant information for each hazard. For additional background on the hazards, vulnerabilities and general risk assessment information for hazards in Clackamas County, refer to the State of Oregon NHMP, Region 2, Northern Willamette Valley/Portland Metro Risk Assessment (2020).

Drought

Drought Summary		Significant Changes Since Previous Update	Applicable Action Items
Hazard Ranking:	6	Content updated per 44 CFR 201.6(c)(2). A section on Future Projections added.	Priority: MH #1
Total Threat Score:	131		
Probability:	High		Other: MH #5
Vulnerability:	Low		

Characteristics

A drought is a period of drier than normal conditions. Drought occurs in virtually every climatic zone, but its characteristics vary significantly from one region to another. Drought is a temporary condition, though it can bbecome chronic overtime; and it differs from aridity, which is restricted to low rainfall regions and is a permanent feature of climate. Typically, droughts occur as regional events and often affect more than one city and county.

Location and Extent

Droughts occur in every climate zone and can vary from region to region. Though droughts are uncommon throughout Clackamas County, when drought counditions do occur, the impacts are widespread and can grow in severity when both winter snow and spring/summer rainfal are low. The effects of drougt on Clackamas County can further have profound effects on the economy, particularly the agricultural and hydro-power sectors. Reasons for why drought can have such broad and signficant impacts on Clackamas County include:

- Higher population density and growing population throughout Clackamas County and the Willamette Valley;
- Ever growing dependence on surface water supplies for many jurisdictions and municipalities, agriculture, and industries from large flood control reservoirs in the Willamette and Clackamas river system;
- Increase in frequency of toxic algal blooms in the Willamette and Clackamas river system reservoirs, resulting in restrictions on the use of water from these reservoirs for drinking, as well as potentially being unsafe for agricultural irrigation and other uses. Algal blooms can necessitate purchasing and transporting water from alternative sources;
- As drought is typically accompanied by earlier onset of snowmelt (e.g., during flood control or early storage season), little or no snowmelt runoff is stored until later;
- Earlier start of growing season, before the start of irrigation season, which means that crops may not be irrigated until the irrigation season begins; and
- Insufficient number of farm workers available to work during the early onset growing season, as they are scheduled to arrive during the onset of irrigation season.

These are growing concerns, will be further exacerbated with the future changes in climate, as will the extent of the impacts from drought.

The extent of drought depends upon the degree of moisture deficiency, and the duration and size of the affected area. Typically, droughts occur as regional events and often affect more than one county. In

severe droughts, environmental and economic consequences can be significant. Volume III, Appendix E includes maps detailing average precipitation (Map E-2) and river sub-basins (Map E-4).

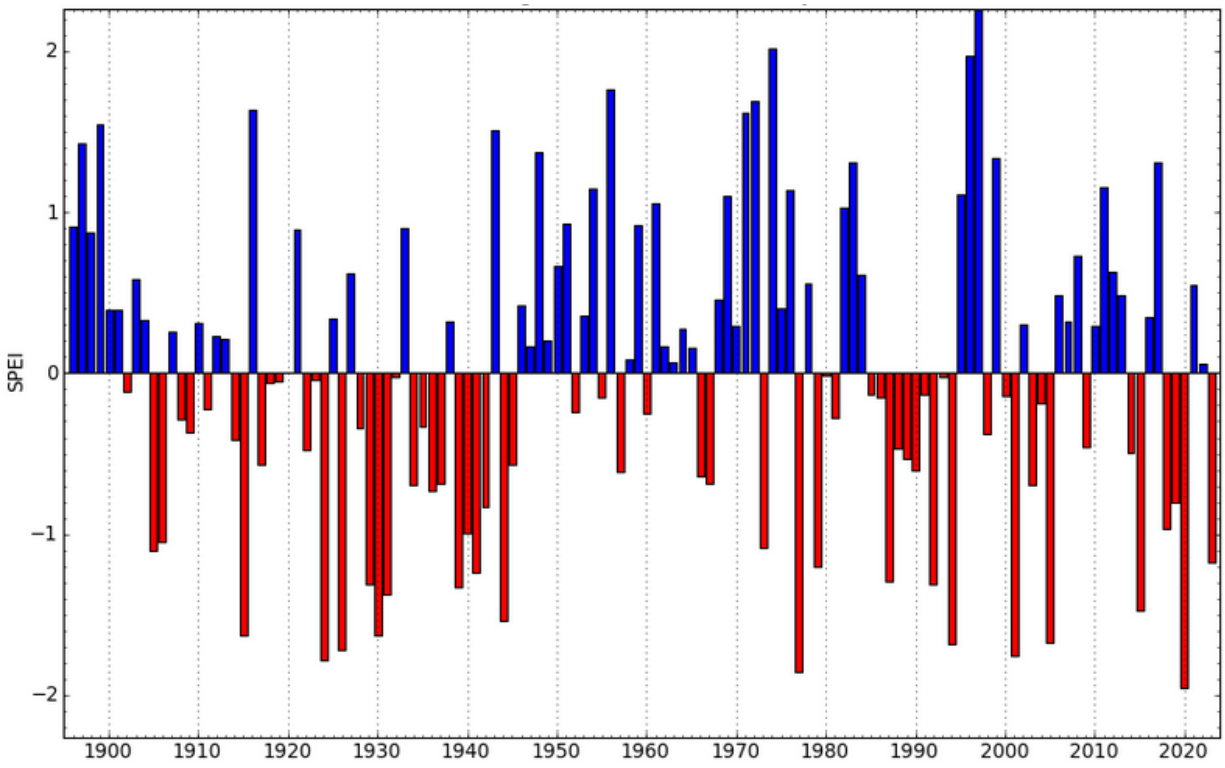
History

Clackamas County experiences annual dry conditions typically during the summer months from July through September, though the length of these dry seasons are extending as greater changes in climate occur, including less snow fall and earlier onset of snowmelt. Drought is typically measured in terms of water availability in a defined geographical area. It is common to express drought with a numerical index that ranks severity. Most federal agencies use the Palmer Method which incorporates precipitation, runoff, evaporation and soil moisture. However, the Palmer Method does not incorporate snowpack as a variable. Therefore, it is not believed to provide a very accurate indication of drought conditions in Oregon and the Pacific Northwest.

The Standardized Precipitation-Evapotranspiration Index (SPEI) is an index of water conditions throughout the state. The index is designed to account for precipitation and evapotranspiration to determine drought. The lowest SPEI values, below -2.0, indicate extreme drought conditions. Severe drought occurs at SPEI values between -2.0 and -1.5, and moderate drought occurs between -1.5 and -1.0.

Figure 2-2 shows the water year (October 1 – September 30) history of SPEI from 1895 to 2022 for Clackamas County. The SPEI record indicates that the county has not experienced extreme drought, has experienced and 10 years of severe drought (water years 1915, 1924, 1926, 1930, 1939, 1944, 1977, 1994, 2001, 2005, and 2020). In addition, there are 11 years of moderate drought and 42 years of mild drought.

Figure 2-2 Standardized Precipitation-Evapotranspiration Index, 12-Months Ending in September, Jackson County, OR (1895-2022)



Source: Western Regional Climate Center. West Wide Drought Tracker. https://wrcc.dri.edu/wwdt/time/.
Created November 21, 2023. Data retrieval method: Counties.

El Niño/La Nina

El Niño Southern Oscillation (ENSO) weather patterns can increase the frequency and severity of drought. During El Niño periods, alterations in atmospheric pressure in equatorial regions yield an increase in the surface temperature off the west coast of North America. This gradual warming sets off a chain reaction affecting major air and water currents throughout the Pacific Ocean; La Niña periods are the reverse with sustained cooling of these same areas. In the North Pacific, the Jet Stream is pushed north, carrying moisture laden air up and away from its normal landfall along the Pacific Northwest coast. In Oregon, this shift results in reduced precipitation and warmer temperatures, normally experienced several months after the initial onset of the El Niño. These periods tend to last nine to twelve months, after which surface temperatures begin to trend back towards the long-term average. El Niño periods tend to develop between March and June, and peak from December to April. ENSO generally follows a two to seven-year cycle, with El Niño or La Niña periods occurring every three to five years. However, the cycle is highly irregular, and no set pattern exists. The last major El Niño was during 1997-1998, and in 2015-2016 Oregon experience a "super" El Niño (the strongest in 15 years, the two previous events occurred in 1982-1983 and 1997-1998) that included record rainfall and snowpack in areas of the state.[14]

Probability Assessment

Based on the available data and research the Hazard Mitigation Advisory Committee (HMAC) assessed the probability of experiencing a locally severe drought as "**High**," meaning one incident is likely within the next 10 to 35 years. *This rating has not changed since the previous NHMP*.

Droughts are not uncommon in the State of Oregon, nor are they just an "east of the mountains" phenomenon. They occur in all parts of the state, in both summer and winter. Oregon's drought history reveals many short-term and a few long-term events. The average recurrence interval for severe droughts in Oregon is somewhere between 8 and 12 years.

Future Projections[15] [16]

According to the Oregon Climate Change Research Institute "Future Climate Projections, Clackamas County," drought, as represented by low summer soil moisture, low spring snowpack, low summer runoff, and low summer precipitation, is projected to become more frequent in Clackamas County by the 2050s.

Increasingly frequent droughts will have economic and social impacts upon those who depend upon predictable growing periods (ranches, farms, vineyards, gardeners) as well as upon the price and availability of fresh vegetables. It may also stress local jurisdiction's ability to provide water for irrigation or commercial and household use.

[14] Cho, Renne. "El Nino and global warming – what's the connection." Phys.org, February 3, 2016. https://phys.org/news/2016-02-el-nino-global-warmingwhat.html
[15] Oregon Climate Change Research Institute (OCCRI), 6th Oregon Climate Assessment Report (2023). https://blogs.oregonstate.edu/occri/oregon-climate-assessments/
[16] OCCRI, "Future Climate Projections Clackamas County, Oregon"

Vulnerability Assessment

The HMAC rated the County as having a "**low**" vulnerability to drought hazards, meaning it is expected that less than 1% of the unincorporated County's population or assets would be affected by a major drought emergency or disaster. *This rating has not changed since the previous NHMP*.

The environmental and economic consequences can be significant, especially for the agricultural sector. Drought also increases the probability of wildfires – a major natural hazard concern for Clackamas County. Drought can affect all segments of Clackamas County's population, particularly those employed in water-dependent activities (e.g., agriculture, hydroelectric generation, recreation, etc.). Also, domestic water-users may be subject to stringent conservation measures (e.g., rationing) as per the County's water management plan.

Certain areas and issues in Oregon are of greater concern regarding the impacts of drought, including impact on drinking water systems, power and water enterprises, residential and community wells in rural areas, fire and emergency response capabilities, and the well-being of fish and wildfire. Drought's impact is far and wide and has impacted many different sectors and area of Clackamas County. In Clackamas County, drought poses the greatest threat many impact categories, with the most prevalent being among agriculture activities, followed by business & industry and plans & wildlife. Table 2-6 summarizes the distribution of report drought impacts based on impact category in Clackamas County.

Table 2-6 Reported Drought Impacts since 2000 in Clackamas County basd on Impact Category

Impact Category	Number of Instances
Agriculture	13
Business & Industry	6
Energy	0
Fire	2
Plants & Wildlide	5
Relief, Response, & Restrictions	2
Society & Public Health	0
Tourism & Recreation	0
Water Supply & Quality	1

Source: National Drought Mitigation Center, Drought Impact Reporter Dashboard

Inter-Hazard Impact and Outcomes – Drought[17][18]

As the primary natural hazard, a.k.a "the cause", drought has indirect impacts on several other hazards, a.k.a. "the effect", and as a climate hazard, its impacts are further exacerbated by the effects of climate change.

[17] Scientific Report, A shift from drought to extreme rainfall drives a stable landslide to catastrophic failure, 2019
[18] Drought.gov -, Wildfire Management, *Drought Impacts on Wildfire Management*, 2023

- Flood – Indirect: As drought dries out the ground and soil, leaving a barer and arid landscapes, water is unable to adequately be saturated into the ground, leading to higher chances of flash floods during times of rain.
- Landslide – Indirect: As with flood, the bare and arid landscape that results from a drought leaves water unable to adequately be saturated into the ground, thus with the presence of high amounts of precipitation on drought-impacted land, the ground can become stressed and can trigger unstable sliding of landslides.
- Wildfire – Indirect: Causing a bare and arid landscape, drought leaves can cause vegetation to die and dry-up, and thus able to act as potential fuel for wildfire. Also, droughts can reduce the amount of water that is available to fight wildfires.

Earthquake

Earthquake Summary			Significant Changes Since Previous Update	Applicable Action Items
Earthquake Event:	CSZ	Crustal		
Hazard Ranking:	2	3	Content updated per 44 CFR 201.6(c)(2). Quantitative risk assessment added (DOGAMI Risk Report).	Priority: MH #1, MH #6
Total Threat Score:	182	177		
Probability:	Moderate	Low		Other: MH #3, MH #5, MH #7, EQ #1, EQ #2
Vulnerability:	High	High		

Characteristics

The Pacific Northwest in general is susceptible to earthquakes from four sources: 1) the offshore Cascadia Subduction Zone, 2) deep intraplate events within the subducting Juan de Fuca Plate, 3) shallow crustal events within the North American Plate, and 4) earthquakes associated with volcanic activity.

Crustal Fault Earthquakes

Crustal fault earthquakes are the most common earthquakes and occur at relatively shallow depths of 6-12 miles below the surface.[19] While most crustal fault earthquakes are smaller than magnitude 4 and generally create little or no damage, they can produce earthquakes of magnitudes up to 7, which cause extensive damage. Clackamas County has seven documented crustal faults that could cause serious damage to buildings and infrastructure. These include: Portland Hills, Sandy River, Bolton, Mount Angel, Grant Butte, Clackamas Creek, and Mount Hood. These faults could generate earthquakes 6.5 or larger. *Note: The hazards associated with the Portland Hills and Mount Hood faults area discussed in more detail within this profile.*

Deep Intraplate Earthquakes

Occurring at depths from 25 to 40 miles below the earth's surface in the subducting oceanic crust, deep intraplate earthquakes can reach up to magnitude 7.5.[20] The February 28, 2001 earthquake in Washington State was a deep intraplate earthquake. It produced a rolling motion that was felt from Vancouver, British Columbia to Coos Bay, Oregon and east to Salt Lake City, Utah. A 1965 magnitude 6.5 intraplate earthquake centered south of Seattle-Tacoma International Airport caused seven deaths.[21]

Subduction Zone Earthquakes

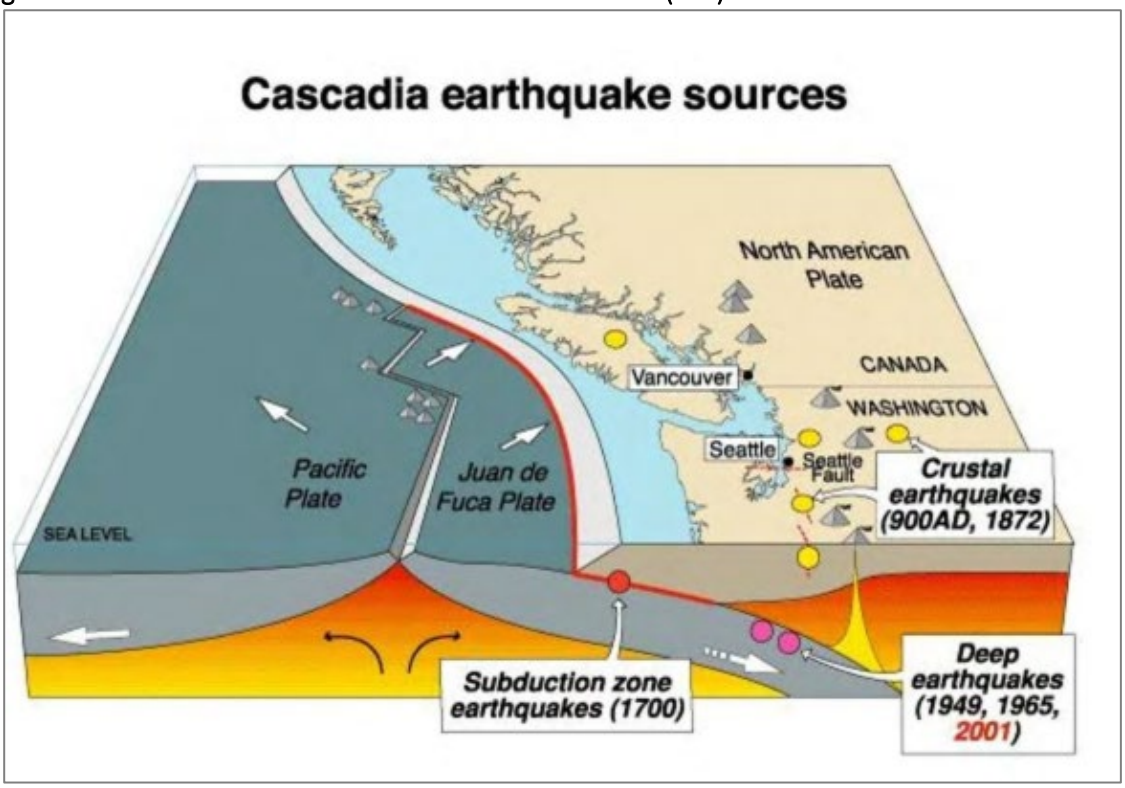
The Cascadia Subduction Zone (CSZ) refers to a region of the Pacific Ocean roughly 70-100 miles off the Oregon Coast where the Pacific Tectonic Plate is sinking beneath the North American Tectonic Plate. Currently two plates are converging at a rate of about 1-2 inches per year, with the North American Plate moving in a southwest direction, overriding the Pacific and Juan de Fuca Plates. Subduction zone earthquakes are caused by the abrupt release of slowly accumulated stress when the plates “snap”

[19] Madin, Ian P. and Zhenming Wang. Relative Earthquake Hazard Maps Report. (1999) DOGAMI.
[20] Planning for Natural Hazards: The Oregon Technical Resource Guide, Department of Land Conservation and Development (July 2000), Ch. 8, pp. 8.
[21] The Oregonian. "*A region at risk*." March 4, 2001.

from the pressure.[22] Subduction zones like the CSZ have produced catastrophic earthquakes with tsunamis occuring as an effect. These earthquakes can have magnitudes ranging from an 8 or higher. Historic subduction zone earthquakes include the 1960 Chile (magnitude 9.5) and 1964 southern Alaska (magnitude 9.2) earthquakes[23] with more recent events being the 2004 Indian Ocean (magnitude 9.1) and 2011 Japan (magnitude 9).

Figure 2-3 shows a cross-sectional view of the CSZ and demonstrates how the tectonic plates off the Pacific Coast interact to generate subterranean pressure. Included are other prominent sources of earthquake activity in the Pacific Northwest as well as dates of notable past events.

Figure 2-3 Cross-Section of the Cascadia Subduction Zone (CSZ)



Source: U.S. Geological Survey

Volcanic Earthquakes

Volcanic earthquakes are usually smaller than magnitude 2.5, roughly the threshold for shaking felt by observers close to the event. Swarms of small earthquakes may persist for weeks to months before eruptions, but little or no earthquake damage would occur to buildings in surrounding communities. Some volcanic related swarms may include earthquakes as large as about magnitude 5.

While all four types of earthquakes have the potential to cause major damage, local crustal faults are expected to be more damaging primarily because of their proximity to densely populated areas.[24]

[22] Questions and Answers on Earthquakes in Washington and Oregon (February 2001) www.geophys.washington.edu/seis/pnsn/info_general/faq.html.
[23] The Oregonian. "*A region at risk*." March 4, 2001.
[24] Bauer, John, William Burns, and Ian Madin. Earthquake Regional Impact Analysis for Clackamas, Multnomah, and Washington Counties, Oregon. (2018). DOGAMI

Location and Extent

The seismic hazard for Clackamas County arises predominantly from major earthquakes on the Cascadia Subduction Zone. Large (M6.8-7.0M), crustal earthquakes in or near Clackamas County could be more damaging than a CSZ earthquake but the likelihood of these events is considerably less. Additional fault zones throughout the county and region may produce localized crustal earthquakes up to 6.0. Table 2-7 presents a list of the different Class A and B fault lines throughout the county. In addition, the Mount Hood Fault (Class C) is located near Mount Hood and runs approximately 55 kilometers north from Clear Lake to the Columbia River.[25] A local earthquake of M 6.0 or a regional M 9.0 earthquake is likely to cause substantial structural damage to bridges, buildings, utilities, and communications systems, as well as the following impacts to infrastructures and the environment:

- Floods and landslides
- Fires, explosions, and hazardous materials incidents
- Disruption of vital services such as water, sewer, power, gas, and transportation routes
- Disruption of emergency response systems and services
- Displaced Households
- Economic losses for buildings
- Economic loss to highways, airports, communications
- Generated debris
- Illness, injury, and death
- Significant damage to critical and essential facilities, including schools, hospitals, fire stations, police departments, city hall

For more information on Class A and B faults located in Clackamas County see the US Geological Survey, Quaternary Fault and Fold Database: https://www.usgs.gov/programs/earthquake-hazards/faults.

The extent of the earthquake hazard is measured in magnitude. Map 2-1 shows a generalized geologic map of Clackamas County and includes the areas for potential low and moderate liquefaction. The figure also shows that recent earthquakes have registered as Magnitude 5 or less (earthquakes at this magnitude are often felt but cause no damage, or only minor damage). Clackamas County can expect similar earthquake magnitudes to occur in the future. The Cascadia Subduction Zone earthquake has the capacity to cause a magnitude 8.5 or greater earthquake; however, due to the distance from Clackamas County the damage locally is expected to be significant, but less than a local crustal fault. Volume III, Appendix E includes additional maps detailing soil liquefaction (Map E-8), soil amplification (Map E-9), and relative earthquake hazard (Map E-10).

[25] Scott, W.E., and Gardner, C.A., 2017, Field trip guide to Mount Hood, Oregon, highlighting eruptive history and hazards. U.S. Geological Survey Scientific Investigations Report 2017-5022-G.

Table 2-7 Class A and B Faults Located in or near Clackamas County

Name	Class	Fault ID	Primary County, State	Length (km)	Recent Deformation	Slip-Rate Category
Canby-Molalla Fault	A	716	Clackamas County	50km	Latest Quaternary (<15ka)	Less than 0.2 mm/yr
Clackamas River Fault Zone	A	864	Marion County	29km	Quaternary (<1.6 Ma)	Less than 0.2 mm/yr
Bull Run Thrust	B	868	Clackamas County	9km	Quaternary (<1.6 Ma)	Less than 0.2 mm/yr
Mount Angel Fault	A	873	Marion County	30km	Latest Quaternary (<15ka)	Less than 0.2 mm/yr
Bolton Fault	B	874	Clackamas County	9km	Quaternary (<1.6 Ma)	Less than 0.2 mm/yr
Oatfield Fault	A	875	Washington County	29km	Quaternary (<1.6 Ma)	Less than 0.2 mm/yr
East Bank Fault	A	876	Multnomah County	29km	Latest Quaternary (<15ka)	Less than 0.2 mm/yr
Portland Hills Fault	A	877	Columbia County	49km	Quaternary (<1.6 Ma)	Less than 0.2 mm/yr
Damascus-Tickle Creek Fault Zone	A	879	Multnomah County	17km	Middle and Late Quaternary (<750ka)	Less than 0.2 mm/yr

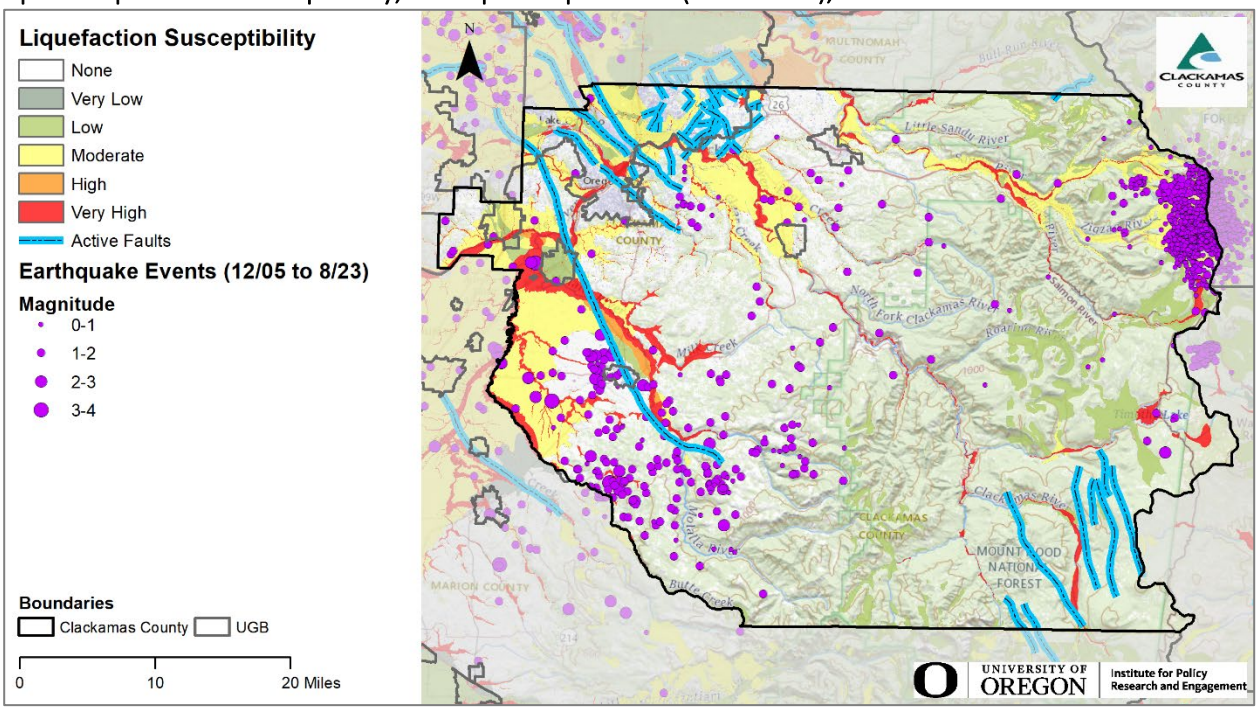
Source: US Geological Survey (USGS), Quaternary Fault and Fold Database

Liquefaction

Liquefaction occurs when ground shaking causes wet granular soils to change from a solid state to a liquid state. This results in the loss of soil strength and the soil's ability to support weight. Buildings and their occupants are at risk when the ground can no longer support these buildings and structures.

To develop a regional liquefaction hazard map (Volume II, Appendix E, Map E-8) for Clackamas County, DOGAMI started by collecting the best available geologic information. Hazard groupings were primarily based on lithologies and checked with individual data points. With the available information compiled, DOGAMI assigned liquefaction susceptibility classes based on the dominant lithologies for each geologic unit in the study area, checked source data boundaries, and simplified the GIS outputs into four relative hazard classes: None/Very Low, Low, Moderate, and High. Areas with Moderate to High liquefaction susceptibilities are concentrated along the rivers and flood plains in the Willamette Valley, Cascade Range tributaries, and major stream valleys within the Cascade Range. Older river terrace and Missoula Flood deposits in the Willamette Valley were assigned a lower liquefaction hazard yet are still considered susceptible to liquefaction in larger earthquakes. It is important to note that the quality and scale of the available base maps precluded identification of all liquefaction hazard areas, particularly in the eastern portion of the county.

Map 2-1 Liquefaction Susceptibility, Earthquake Epicenters (2005-2023), and Active Faults



Source: Oregon Partnership for Disaster Resilience. Oregon Department of Geology and Mineral Industries.
Note: To view detail click this link to access Oregon HazVu.

Amplification

Soils and soft sedimentary rocks near the earth's surface can modify ground shaking caused by earthquakes. One of these modifications is amplification. Amplification increases the magnitude of the seismic waves generated by the earthquake. The amount of amplification is influenced by the thickness of geologic materials and their physical properties. The degree of amplification greatly affects the performance of infrastructure in earthquake. Buildings and structures built on soft and unconsolidated soils, for example, face greater risk. Amplification can also occur in areas with deep sediment filled basins and on ridge tops.

DOGAMI developed the ground shaking amplification map (Volume III, Appendix E, Map E-9) based generally on the NEHRP 1997 method of categorizing relative hazards and simplified the GIS outputs into relative hazard classes – Low, Moderate, and High. The resulting map is not intended to be used in place of site-specific studies. The high hazard soils are located along and adjacent to streams and rivers in Clackamas County. The eastern portion of the county is varied, with competent bedrock areas mapped as Low hazard, dense soil areas mapped as Moderate hazard, and younger landslide and alluvial deposit areas mapped as High hazard for ground shaking amplification.[26]

DOGAMI and Clackamas County GIS worked together to combine the ground shaking, amplification, and liquefaction data to develop a composite Relative Earthquake Hazard Map (Volume III, Appendix E, Map E-10). This map represents the overall earthquake hazards in Clackamas County.

[26] Hofmeister, Hasenberg, Madin, Wang, 2003. "Earthquake and Landslide Hazard Maps and Future Earthquake Damage Estimates for Clackamas County, Oregon: Oregon Department of Geology and Mineral Industries Open-File Report 0-03-10."

Due to the expected pattern of damage resulting from a CSZ event, the Oregon Resilience Plan divides the State into four distinct zones and places Clackamas County predominately within the "Valley Zone" (Valley Zone, from the summit of the Coast Range to the summit of the Cascades).

DOGAMI, in partnership with other state and federal agencies, has undertaken a rigorous program in Oregon to identify seismic hazards, including active fault identification, bedrock shaking, tsunami inundation zones, ground motion amplification, liquefaction and earthquake induced landslides. DOGAMI has published a number of seismic hazard maps that are available for communities to use. The maps show liquefaction, ground motion amplification, landslide susceptibility and relative earthquake hazards. OPDR used the DOGAMI Statewide Geohazards Viewer to present a visual map of recent earthquake activity, active faults and liquefaction; ground shaking is generally expected to be higher in the areas marked by soft soils in the map above. The severity of an earthquake is dependent upon a number of factors including: 1) the distance from the earthquake's source (or epicenter); 2) the ability of the soil and rock to conduct the earthquake's seismic energy; 3) the degree (i.e., angle) of slope materials; 4) the composition of slope materials; 5) the magnitude of the earthquake; and 6) the type of earthquake.

For more information, see the following reports:

- Multi-Hazard Risk Report for the Clackamas County, Oregon: Including the cities of Barlow, Canby, Estacada, Gladstone, Happy Valley, Johnson City, Lake Oswego, Milwaukie, Molalla, Oregon City, Rivergrove, Sandy,West Linn, and Wilsonville and the unincorporated communities of Molalla Prairie, Mulino Hamlet, Stafford Hamlet, and The Villages at Mt Hood (2024).
- Multi-Hazard Risk Report for the Lower Columbia-Sandy Watershed, Oregon: Including the cities of Gresham, Sandy, and Troutdale and Unincorporated Communities of Government Camp and The Villages at Mt Hood (2020, O-20-06).
- Coseismic landslide susceptibility, liquefaction susceptibility, and soil amplification class maps, Clackamas, Columbia, Multnomah, and Washington Counties, Oregon: For use in Hazus: FEMA's methodology for estimating potential losses from disasters (2019, O-19-09).
- Earthquake regional impact analysis for Clackamas, Multnomah, and Washington Counties, Oregon (2018, O-18-02).
- Statewide Cascadia earthquake hazard data (2013, O-13-06)
- Cascadia Subduction Zone earthquakes: A magnitude 9.0 earthquake scenario, (2012, O-12-22)
- Multi-Hazard and Risk Study for the Mount Hood Region (2011, O-11-16). Portions of the earthquake section superseded by the Multi-Hazard Risk Report for the Lower Columbia-Sandy Watershed.
- Statewide seismic needs assessment: Implementation of Oregon 2005 Senate Bill 2 relating to public safety, earthquakes, and seismic rehabilitation of public buildings, (2007, O-07-02).
- Map of selected earthquakes for Oregon: 1841-2002 (2003, O-03-02).
- Interpretive Map Series: IMS-9 - Relative earthquake hazard maps for selected urban areas in western Oregon (2000, IMS-9).

Additional reports are available via DOGAMI's Publications Search website:

https://www.oregon.gov/dogami/pubs/Pages/pubsearch.aspx

Other agency/ consultant reports:

Oregon Resilience Plan (2013)

The Mount Hood Fault Zone – Late Quaternary and Holocene fault features newly mapped with high-resolution lidar Imagery (p. 100-109).

History

Dating back to 1841, there have been more than 6,000-recorded earthquakes in Oregon, most with a magnitude below three. Map 2-1 shows earthquake epicenters for the Clackamas County region since 2005. Portland and its surrounding region is potentially the most seismically active area within Oregon. The Portland metropolitan region has encountered seventeen earthquakes of an estimated magnitude of four and greater, with major earthquakes in. 1877 (magnitude 5.3), 1962 (magnitude 5.2), and 1993 (magnitude 5.6). Although seismograph stations were established as early as 1906 in Seattle and 1944 in Corvallis, improved seismograph coverage of the Portland region did not begin until 1980, when the University of Washington expanded its regional network into northwestern Oregon.

Geologic evidence shows that the Cascadia Subduction Zone has generated great earthquakes, most recently about 300 years ago. It is generally accepted to have been magnitude 9 or greater. The average recurrence interval of these great Cascadia earthquakes is approximately 500 years, with gaps between events as small as 200 years and as large as almost 800 years. Table 2-8 provides a list of notable CSZ earthquakes that have occurred and the recurrence interval of the event. As of 2024, it has been 324 years since the last CSZ event.

Table 2-8 History of Cascadia Subduction Zone Earthquake Events

Approximate Year	Recurrence Intervals (Years)
1700 CE	312
920 CE	780
650 CE	270
280 CE	370
530 BCE	790
840 BCE	310
1180 BCE	340

Source: USGS, "Earthquake recurrance inffered from paleoseismology", 2003

Probability Assessment

Based on the available data and research the HMAC determined the probability of experiencing a Cascadia Subduction Zone (CSZ) is "**moderate**", meaning one incident may occur within the next 35 to 75 years. The HMAC determined the probability of experiencing a crustal earthquake is "**low**", meaning one incident may occur within the next 75 to 100 years. *These ratings have not changed since the previous NHMP.*

Clackamas County is susceptible to deep intraplate events within the Cascadia Subduction Zone (CSZ), where the Juan de Fuca Plate is diving beneath the North American Plate and shallow crustal events within the North American Plate.

According to the Oregon NHMP, the return period for the largest of the CSZ earthquakes (Magnitude 9.0+) is 530 years with the last CSZ event occurring 323 years ago in January of 1700. The probability of a 9.0+ CSZ event occurring in the next 50 years ranges from 7 - 12%. Notably, 10 - 20 "smaller" Magnitude 8.3 - 8.5 earthquakes occurred over the past 10,000 years that primarily affected the

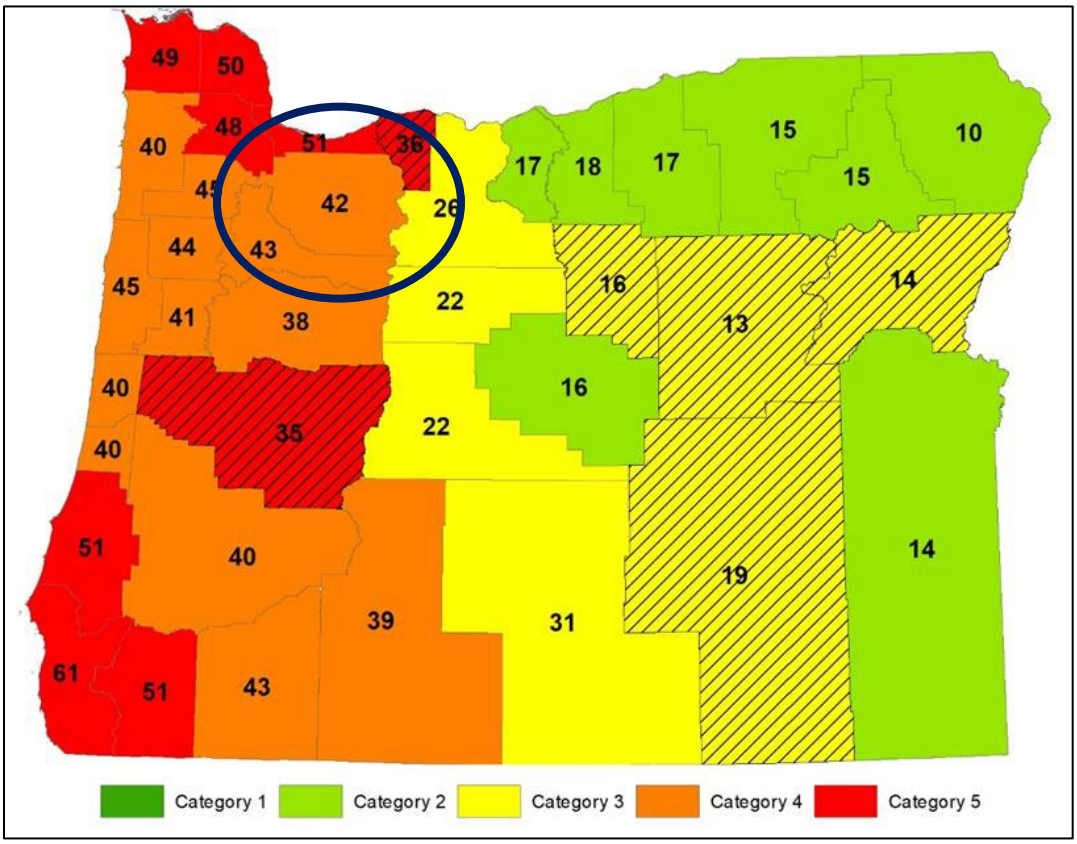
southern half of Oregon and northern California. The average return period for these events is roughly 240 years. The combined probability of any CSZ earthquake occurring in the next 50 years is 37 - 43%.[27]

Additionally, DOGAMI has developed a new probability ranking for Oregon counties that is based on the average probability of experiencing damaging shaking during the next 100 years. Ranking was categorized into 5 categories, each with a probability percentage range assigned based on mean county value of the probability of damaging shaking. The categories are as follows:

- **Category 1** 100-year probability < 10%
- **Category 2** 100 year probability 10-20%
- **Category 3** 100 year probability 21-31%
- **Category 4** 100 year probability 32-45%
- **Category 5** 100 year probability > 45%

Map 2-2 shows the categories for each of the counties, with Clackamas County scoring a 42%, placing it as a Category 4. This means that the probability of damaging shaking occurring during the next 100 years is 42%, putting it at a high probability.

Map 2-2 2020 Oregon Earthquake Probability Ranking Based on Mean County Value of the Probability of Damaging Shaking



Source: DOGAMI, 2020; State of Oregon Natural Hazard Mitigation Plan (2020), Region 2

[27] DLCD, Oregon Natural Hazards Mitigation Plan (2020).

Establishing a probability for crustal earthquakes is difficult given the small number of historic events in the region. However, both of the faults used to inform this report (Portland Hills and Mount Hood) have a low probability of rupture. Earthquakes generated by volcanic activity in Oregon's Cascade Range are possible, but likewise unpredictable. For more information, see the DOGAMI reports cited previously.

Future Projections

Future development (residential, commercial, or industrial) within Clackamas County will be at risk to earthquake impacts, although this risk can be mitigated by the adoption and enforcement of high development and building standards. Reducing risks to vulnerable populations should be considered during the redevelopment of existing properties.

Vulnerability Assessment

The HMAC rated the County as having a "**high**" vulnerability to the Cascadia Subduction Zone (CSZ) earthquake hazard meaning that more than 10% of the unincorporated County's population or assets would be affected by a major CSZ event. The HMAC rated the County as having a "**high**" vulnerability to a crustal earthquake hazard, meaning that more than 10% of the unincorporated County's population or assets would be affected by a major crustal earthquake event. *These ratings have not changed since the previous NHMP.*

The local crustal faults, the county's proximity to the Cascadia Subduction Zone, potential slope instability and the prevalence of certain soils subject to liquefaction and amplification combine to give the county a high-risk profile.

Factors included in an assessment of earthquake risk include population and property distribution in the hazard area, the frequency of earthquake events, landslide susceptibility, buildings, infrastructure and disaster preparedness of the region. This type of analysis can generate estimates of the damages to the county due to an earthquake event in a specific location.

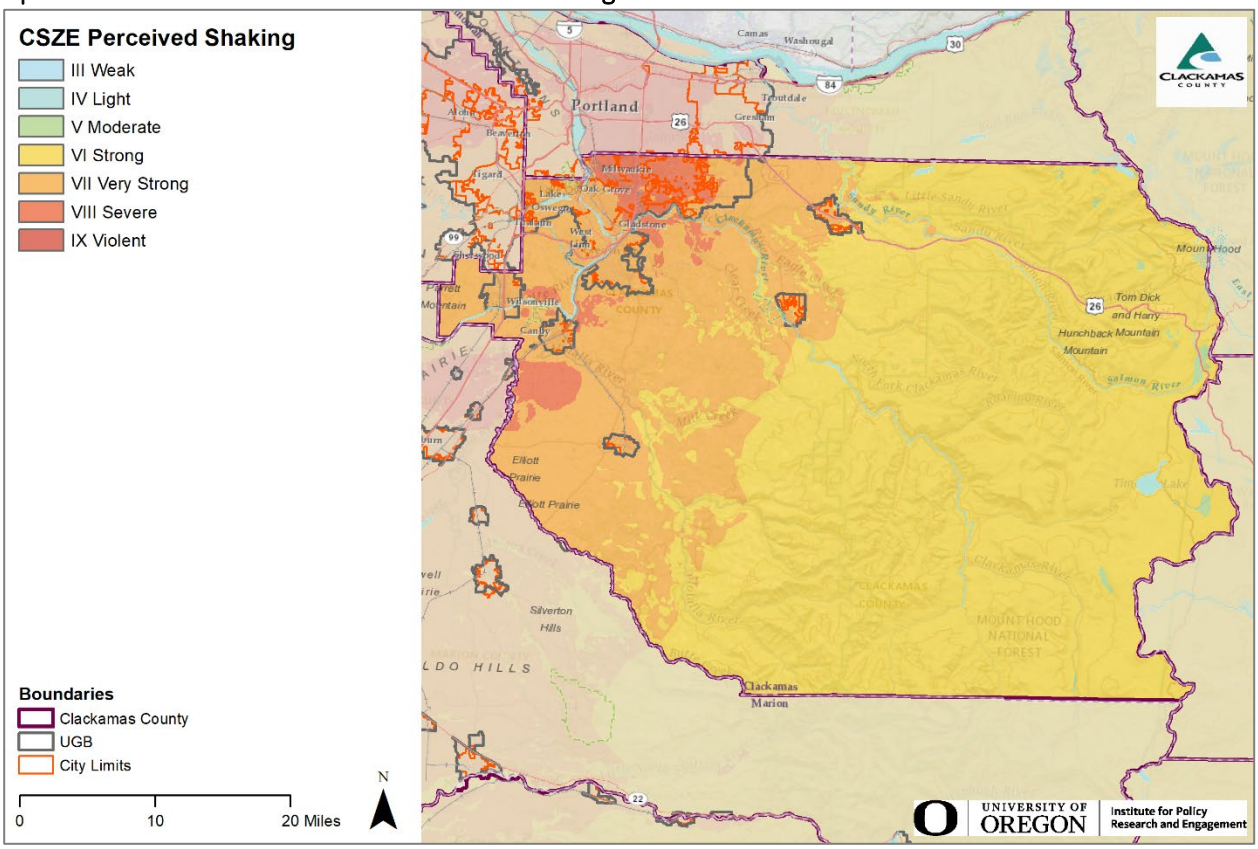
Seismic activity can cause great loss to businesses, either a large-scale corporation or a small retail shop. Losses not only result in rebuilding cost, but fragile inventory and equipment can be destroyed. When a company is forced to stop production for just a day, business loss can be tremendous. Residents, businesses and industry all suffer temporary loss of income when their source of finances is damaged or disrupted.

Map 2-3 shows the expected shaking/damage potential for Clackamas County as a result of a Cascadia Subduction Zone (CSZ) earthquake event. The figure shows that the county will experience "moderate" to "severe" shaking that will last two to four minutes. The strong shaking will be extremely damaging to lifeline transportation routes including I-5. For more information on expected losses due to a CSZ event see the Oregon Resilience Plan and the Risk Report information provided below. Analysis of the Relative Earthquake Hazard Map (Volume III, Appendix E, Map E-10)

Clackamas County considers two main earthquake related vulnerability categories: Life and Property and Critical Facilities and Infrastructure. Both categories are discussed in further detail below.

The amount of property in the relative earthquake high hazard area, as well as the type and value of structures on those properties, is calculated to provide a working estimate for potential losses. Table 2-7 shows potentially impacted parcels, critical and critical facilities, vulnerable populations, and infrastructure within Clackamas County.

Map 2-3 Cascadia Subduction Zone Perceived Shaking



Source: Oregon Partnership for Disaster Resilience. Oregon Department of Geology and Mineral Industries.
Note: To view detail click this link to access Oregon HazVu

Inter-Hazard Impact and Outcomes – Earthquake[28][29]

As the primary natural hazard, a.k.a "the cause", earthquake has both direct and indirect impacts on several other hazards, a.k.a. "the effect".

- Flood – Indirect: Earthquakes can potentially indirectly influence floods by causing disturbances to physical infrastructure, such as causing a dam or levee to rupture and flood.
- Landslide – Indirect: Earthquakes can potentially indirectly influence landslides by putting stress on unstable and steep slopes, due to ground shaking, which is a driving factor that contributes to potential landslides.
- Volcanic Event - Both: Earthquakes can potentially directly and indirect influence a volcanic event to occur. The occurrence of an earthquake trigger a volcanic eruption that are already poised due to erupt due to shifting of tectonic plates or affecting crustal pathways by which magma moves. Furthermore, the occurrence of an earthquake can disturb gases within a magma chamber, and this strain could evolve after an earthquake, and resulting a volcanic event later down the line.
- Wildfire – Indirect: Due to the disruption that an earthquake can have on physical infrastructure, such as electrical and gas lines, can lead to the release or exposure of flammable and/or

[28] Geosciences, Effects of Earthquakes on Flood Hazards: A Case Study From Christchurch, New Zealand, 2020
[29] USGS, Can earthquakes trigger volcanic eruptions?, accessed April 20, 2023

combustible material. Such material can either serve as an ignition source and/or a fuel source to exacerbate a fire.

Natural Hazard Risk Reports for Clackamas County

The **Risk Reports** (DOGAMI, 2024 and 2020) provide hazard analysis summary tables that identify populations and property within the Lower Columbia-Sandy River Watershed Study Area and countywide that are vulnerable to the Cascadia subduction zone earthquake and a local crustal earthquake event associated with the Mount Hood fault or the Canby-Molalla Fault. Volume III, Appendix D provides detailed Community Risk Profile tables for the unincorporated area of Clackamas County.

According to the Risk Reports the following population and property within the study area may be impacted by the profiled events (*where data is provided in both reports the newer data is presented below)*:

Unincorporated Clackamas County[30]

Cascadia Subduction Zone event (M9.0 Deterministic): 9,616 buildings are expected to be damaged (59 critical facilities) for a total potential loss of $5.18 billion (a loss ratio of about 14%). In addition, 5,497 residents may be displaced (about 3% of the population).

Crustal event (Canby-Molalla M6.8 Deterministic): 9,481 buildings are expected to be damaged (22 critical facilities) for a total potential loss of $3.24 billion (a loss ratio of about 9%). In addition, 4,020 residents may be displaced (about 2% of the population).

Unincorporated County within Sandy Watershed Only: [31]
Crustal event (Mt Hood M6.9 Probabilistic): 81 buildings are expected to be damaged (0 critical facilities) for a total potential loss of $23.6 million (a loss ratio of about 3%). In addition, 77 residents may be displaced (about 2% of the population).

Government Camp[32]

Cascadia Subduction Zone event (M9.0 Deterministic): 5 buildings are expected to be damaged (0 critical facilities) for a total potential loss of $5.7 million (a loss ratio of about 2%). In addition, 4 residents may be displaced (less than 1% of the population).

Crustal event (Canby-Molalla M6.8 Deterministic): 0 buildings are expected to be damaged (0 critical facilities) for a total potential loss of $510,000 (a loss ratio of less than 1%). In addition, no residents are expected to be displaced.

Government Camp within Sandy Watershed Only: [33]
Crustal event (Mt Hood M6.9 Probabilistic): 348 buildings are expected to be damaged (1 critical facility) for a total potential loss of $121 million (a loss ratio of 82%). In addition, 100 residents may be displaced (about 39% of the population).

[30] DOGAMI, Multi-Hazard Risk Report for Clackamas County, Oregon (2024), Table A-1.
[31] DOGAMI, Lower Columbia-Sandy Watershed Natural Hazard Risk Report (2020), Table A-1.
[32] DOGAMI, Multi-Hazard Risk Report for Clackamas County, Oregon (2024), Table A-3.
[33] DOGAMI, Lower Columbia-Sandy Watershed Natural Hazard Risk Report (2020), Table A-5.

Molalla Prairie[34]

Cascadia Subduction Zone event (M9.0 Deterministic): 361 buildings are expected to be damaged (1 critical facility) for a total potential loss of $92.7 million (a loss ratio of about 7%). In addition, 27 residents may be displaced (less than 1% of the population).

Crustal event (Canby-Molalla M6.8 Deterministic): 1,275 buildings are expected to be damaged (3 critical facilities) for a total potential loss of $319.4 million (a loss ratio of about 24%). In addition, 217 residents may be displaced (about 5% of the population).

Mulino Hamlet[35]

Cascadia Subduction Zone event (M9.0 Deterministic): 253 buildings are expected to be damaged (2 critical facilities) for a total potential loss of $56.8 million (a loss ratio of about 10%). In addition, 39 residents may be displaced (about 1% of the population).

Crustal event (Canby-Molalla M6.8 Deterministic): 460 buildings are expected to be damaged (2 critical facilities) for a total potential loss of $103.5 million (a loss ratio of about 18%). In addition, 98 residents may be displaced (about 4% of the population).

Stafford Hamlet[36]

Cascadia Subduction Zone event (M9.0 Deterministic): 108 buildings are expected to be damaged (3 critical facilities) for a total potential loss of $46.6 million (a loss ratio of about 8%). In addition, 41 residents may be displaced (about 1% of the population).

Crustal event (Canby-Molalla M6.8 Deterministic): 262 buildings are expected to be damaged (3 critical facilities) for a total potential loss of $107.3 million (a loss ratio of about 19%). In addition, 151 residents may be displaced (about 5% of the population).

The Villages at Mt. Hood[37]

Cascadia Subduction Zone event (M9.0 Deterministic): 183 buildings are expected to be damaged (1 critical facility) for a total potential loss of $44.5 million (a loss ratio of about 3%). In addition, 74 residents may be displaced (about 1% of the population).

Crustal event (Canby-Molalla M6.8 Deterministic): 12 buildings are expected to be damaged (0 critical facilities) for a total potential loss of $4.8 million (a loss ratio of less than 1%). In addition, 4 residents may be displaced (less than 1% of the population).

Sandy Watershed Only:[38]
Crustal event (Mt Hood M6.9 Probabilistic): 923 buildings are expected to be damaged (2 critical facilities) for a total potential loss of $255.2 million (a loss ratio of about 32%). In addition, 993 residents may be displaced (about 20% of the population).

Earthquake Regional Impact Analysis

In 2018 DOGAMI completed a regional impact analysis for earthquakes originating from the Cascadia Subduction Zone and Portland Hills faults (O-18-02). Their study focused on damage to buildings, and

[34] DOGAMI, Multi-Hazard Risk Report for Clackamas County, Oregon (2024), Table A-5.
[35] DOGAMI, Multi-Hazard Risk Report for Clackamas County, Oregon (2024), Table A-7.
[36] DOGAMI, Multi-Hazard Risk Report for Clackamas County, Oregon (2024), Table A-9.
[37] DOGAMI, Multi-Hazard Risk Report for Clackamas County, Oregon (2024), Table A-11.
[38] DOGAMI, Lower Columbia-Sandy Watershed Natural Hazard Risk Report (2020), Table A-7

the people that occupy them, and to two key infrastructure sectors: electric power transmission and emergency transportation routes. Each earthquake was studied with wet and dry soil conditions and for events that occur during the daytime (2 PM) and night time (2 AM). Impacts to buildings and people were tabulated at the county, jurisdictional, and neighborhood unit level. Estimated damaged varied widely across the study area depending on local geology, soil moisture conditions, type of building, and distance from the studied faults. In general, damage from the Cascadia Subduction Zone scenario was greater in the western portion of the study area, however, damage could still be significant in some areas east of the Willamette River. The report found that damage to high-value commercial and industrial buildings was high since many of these facilities are in areas of high to very high liquefaction hazard (Figure 2-5). Casualties were higher during the daytime scenario (generally double) since more people would be at work and occupying non-wood structures that fare worse in an earthquake. The Portland Hills fault scenario created greater damages than the Cascade Subduction Zone scenario due primarily to its placement relative to population centers and regional assets; however, at distances 15 or more miles from the Portland Hills fault the damages from the Cascadia Subduction Zone scenario generally were higher. In both the Cascadia Subduction Zone and Portland Hills Fault scenarios it is forecasted that emergency transportation routes will be fragmented, affecting the distribution of goods and services, conditions are worse under the Portland Hills Fault scenario. Portions of the electric distribution system are also expected to be impacted under both scenarios, however, the impact is considerably less than it is to the transportation routes. Additional, capacity or redundancy within the electric distribution network may be beneficial in select areas that are likely to have greater impacts.

Table 2-9 shows the buildings that are in regions that are susceptible to liquefaction and landslides, it does not predict that damage will occur in specific areas due to either liquefaction or landslide. The table shows that a small percentage of buildings are located within the area susceptible to liquefaction (4% high and very high) or landslides (2% high to very high).

Table 2-9 Building statistics by Hazus-based liquefaction susceptibility rating and earthquake-induced landslide susceptibility rating

	Number of Buildings	Building Percent	Building Value ($ Million)	Building Value Percent
Liquefaction Susceptibility				
None to Low	113,010	63%	36,392	58%
Moderate	58,905	33%	23,738	38%
High	746	0%	276	0%
Very High	6,503	4%	1,984	3%
Landslide Susceptibility				
None to Low	161,505	90%	56,485	91%
Moderate	14,582	8%	4,890	8%
High	3,077	2%	1,015	2%
Total	179,164	100%	62,390	100%

Source: DOGAMI, Earthquake regional impact analysis for Clackamas, Multnomah, and Washington Counties, Oregon (2018, O-18-02), Tables 10-5 and 10-6.

Table 2-10 shows building damage expected under the Cascadia Subduction Zone scenario, about 13% of all buildings are expected to be damaged in the “dry” scenario and 15% in the “wet” scenario. Of those, it is expected that 158 buildings will collapse in the “dry” scenario, while 313 are expected to

collapse in the "wet" scenario.[39] The unincorporated portions of Clackamas County are expected to have a 5% building loss ratio with a repair cost of $1.5 billion under the CSZ "dry" scenario, and a 7% building loss ratio with a repair cost of $2.18 billion under the CSZ "wet" scenario.[40]

Table 2-10 Number of buildings per damage state for CSZ earthquake and soil moisture scenario

Building Damage State	"Dry" Soil	Building Percent	"Wet" Saturated Soil	Building Percent
None	121,428	68%	119,150	67%
Slight	34,145	19%	33,133	18%
Moderate	15,936	9%	15,386	9%
Extensive	5,390	3%	5,228	3%
Complete	2,265	1%	6,267	3%
Total	179,164	100%	62,390	100%

Source: DOGAMI, Earthquake regional impact analysis for Clackamas, Multnomah, and Washington Counties, Oregon (2018, O-18-02), Tables 12-1.

Table 2-11 shows building damage expected under the Portland Hills Fault scenario, about 46% of all buildings are expected to be damaged in the "dry" scenario and 49% in the "wet" scenario. Of those, it is expected that 666 buildings will collapse in the "dry" scenario, while 1,066 are expected to collapse in the "wet" scenario.[41] The unincorporated portions of Clackamas County are expected to have a 20% building loss ratio with a repair cost of $5.9 billion under the CSZ "dry" scenario, and a 26% building loss ratio with a repair cost of $7.6 billion under the CSZ "wet" scenario.

Table 2-11 Number of buildings per damage state for Portland Hills Fault earthquake and soil moisture scenario

Building Damage State	"Dry" Soil	Building Percent	"Wet" Saturated Soil	Building Percent
None	50,466	28%	47,990	27%
Slight	46,152	26%	42,988	24%
Moderate	47,122	26%	43,417	24%
Extensive	22,526	13%	20,761	12%
Complete	12,898	7%	24,008	13%
Total	179,164	100%	179,164	100%

Source: DOGAMI, Earthquake regional impact analysis for Clackamas, Multnomah, and Washington Counties, Oregon (2018, O-18-02), Tables 12-1.

Table 2-12 shows the permanent resident population that lives within buildings that are exposed to different expected levels of building damage. More population is exposed to higher degrees of expected damage under the Portland Hills Fault "wet" scenario than in any other scenario. The unincorporated portions of Clackamas County are expected to have around 778 daytime or 216 nighttime casualties during the CSZ "dry" scenario and 1,058 daytime or 508 nighttime casualties during the CSZ "wet"

[39] DOGAMI, Earthquake regional impact analysis for Clackamas, Multnomah, and Washington Counties, Oregon (2018, O-18-02), Table 12-3.
[40] DOGAMI, Earthquake regional impact analysis for Clackamas, Multnomah, and Washington Counties, Oregon (2018, O-18-02), Table 12-9.
[41] Ibid, Tables 12-8 and 12-9

scenario. In addition, it is expected that there will be a long-term displaced population of around 1,006 for the CSZ "dry" scenario and 4,652 for the CSZ "wet" scenario.

The long-term displaced population and casualties are greatly increased for all the Portland Hills Fault scenarios. The unincorporated portions of Clackamas County are expected to have around 3,582 daytime or 1,500 nighttime casualties during the Portland Hills Fault "dry" scenario and 4,555 daytime or 2,462 nighttime casualties during the Portland Hills Fault "wet" scenario. In addition, it is expected that there will be a long-term displaced population of around 12,036 for the Portland Hills Fault "dry" scenario and 24,307 for the Portland Hills Fault "wet" scenario.

Table 2-12 Permanent residents displanced by building damage state and by earthquake and soil moisture conditions scenario

Cascadia Subduction Zone (M9.0)		Portland Hills Fault (M6.8)	
"Dry" Soil	"Wet" Saturated Soil	"Dry" Soil	"Wet" Saturated Soil
75,828	73,670	101,881	94,448
31,559	30,471	105,523	96,722
6,644	6,580	47,996	44,065
1,931	10,093	25,152	50,802

Source: DOGAMI, Earthquake regional impact analysis for Clackamas, Multnomah, and Washington Counties, Oregon (2018, O-18-02), Tables 12-3.
Note: Numbers for permanent residents occupying buildings in the "None" damage state are not included.

Recommendations from the report included topics within Planning, Recovery, Resiliency: Buildings, Resiliency: Infrastructure Improvements, Resiliency: Essential and Critical Facilities, Enhanced Emergency Management Tools, Database Improvements, Public Awareness, and Future Reports. The recommendations of this study are largely incorporated within this NHMPs mitigation strategies (Volume I, Section 3). For more detailed information on the report, the damage estimates, and the recommendations see: Earthquake regional impact analysis for Clackamas, Multnomah, and Washington Counties, Oregon (2018, O-18-02).

2007 Rapid Visual Survey

As noted in the community profile approximately 76% of residential buildings were built prior to 1990 (74% are either pre-code or low code according to DOGAMI[42]), which increases the county's vulnerability to the earthquake hazard.

In 2007, DOGAMI completed a rapid visual screening (RVS) of educational and emergency facilities in communities across Oregon, as directed by the Oregon Legislature in Senate Bill 2 (2005). RVS is a technique used by FEMA (FEMA P-154) to identify, inventory and rank buildings that are potentially vulnerable to seismic events. DOGAMI ranked each building surveyed with a 'low,' 'moderate,' 'high,' or 'very high' potential for collapse in the event of an earthquake. It is important to note that these rankings represent a probability of collapse based on limited observed and analytical data and are therefore approximate rankings. To fully assess a buildings potential for collapse, a more detailed engineering study completed by a qualified professional is required, but the RVS study can help to prioritize which buildings to survey.

[42] DOGAMI, Earthquake regional impact analysis for Clackamas, Multnomah, and Washington Counties, Oregon (2018, O-18-02), Tables 10-2 and 10-3.

DOGAMI's Rapid Visual Screening for Clackamas County listed 179 facilities in the unincorporated County and incorporated cities. Information on specific public buildings' (schools and public safety) estimated seismic resistance is available on DOGAMI's website: http://www.oregongeology.org/rvs/default.htm

Flood

Flood Summary		Significant Changes Since Previous Update	Applicable Action Items
Hazard Ranking:	7	Content updated per 44 CFR 201.6(c)(2). NFIP content updated A section on Future Projections added. Quantitative risk assessment added (DOGAMI Risk Report).	Priority: MH #1, MH #8, FL #1, FL #2, FL #3, FL #5, FL #6
Total Threat Score:	122		
Probability:	High		Other: MH #5, MH #7, FL #4, FL #7
Vulnerability:	Moderate		

Characteristics

Flooding results when rain and snowmelt create water flow that exceeds the carrying capacity of rivers, streams, channels, ditches and other watercourses. In Oregon, flooding is most common from October through April when storms from the Pacific Ocean bring intense rainfall. Most of Oregon's destructive natural disasters have been floods.[43]

The flood events in Clackamas County usually occur when storms move in from the Pacific, dropping heavy precipitation into the Willamette valley; flooding is most significant during rain-on-snow events. Flooding in the valley becomes a problem when human activities infringe on the natural floodplain.

Two types of flooding primarily affect Clackamas County: riverine flooding and urban flooding. Channel migration and bank erosion also occurs along the Sandy River. In addition, any low-lying area has the potential to flood. The flooding of developed areas may occur when the amount of water generated from rainfall and runoff exceeds a storm water system's (ditch or sewer) capability to remove it.

Riverine Flooding

Riverine flooding is the overbank flooding of rivers and streams. The natural processes of riverine flooding add sediment and nutrients to fertile floodplain areas. Flooding in large river systems typically results from large-scale weather systems that generate prolonged rainfall over a wide geographic area, causing flooding in hundreds of smaller streams, which then drain into the major rivers. Figure 2-8 shows the various river basins in Clackamas County.

Shallow area flooding is a special type of riverine flooding. FEMA defines shallow flood hazards as areas that are inundated by the 100-year flood with flood depths of only one to three feet. These areas are generally flooded by low velocity sheet flows of water.

Urban Flooding

As land is converted from fields or woodlands to roads and parking lots, it loses its ability to absorb rainfall. Urbanization of a watershed changes the hydrologic systems of the basin. Heavy rainfall collects and flows faster on impervious concrete and asphalt surfaces. The water moves from the clouds, to the

[43] Taylor, George H. and Chris Hannan. The Oregon Weather Book. Grants Pass, OR: Oregon State University Press. 1999

ground, and into streams at a much faster rate in urban areas. Adding these elements to the hydrological systems can result in floodwaters that rise very rapidly and peak with violent force.

Almost one-eighth of the area in Clackamas County is incorporated and has a high concentration of impermeable surfaces that either collect water or concentrate the flow of water in unnatural channels. During periods of urban flooding, streets can become swift moving rivers and basements can fill with water. Storm drains often back up with vegetative debris causing additional, localized flooding.

Channel Migration and Bank Erosion

Following the 2011 flood on the Sandy River, County staff began to emphasize the different nature of the flood hazard in the upper reaches of the river, as that of bank erosion due to channel migration. The upper Sandy may not have to reach flood stage to achieve a level of flow capable of mobilizing sediments and impounding gravel and woody debris in the channel. These impoundments can redirect the main channel into the bank and cause failures that exacerbate further erosion downstream. DOGAMI has extensively mapped the channel migration zone (see reports cited at the end of this section for more information).

Sandy River Channel Migration Damage
January 16, 2011
Source: Oregonian

Location and Extent

Because Clackamas County spans a wide range of climatic and geologic regions, there is considerable variation in precipitation, with elevation being the largest factor in precipitation totals. Moving east from Oregon City at 55 feet above sea level to Mt Hood at 11,235 feet above sea level, annual precipitation averages range from 47 inches to over 125 inches, respectively. This change in elevation causes a significant increase in precipitation, in the form of both rain and snow. Although the majority of the county enjoys a fairly mild winter, with less than 5-10 inches of snow per year, the higher elevations surrounding Mt. Hood are covered with snow for the majority of the winter months, as well as Mt. Hood's snowmelt provides a continuous water source throughout the year and can be a major contributor to high waters. These are primary concerns when dealing with potential flood events.

Flooding is most common from October through April, when storms from the Pacific Ocean, 60 miles away, bring intense rainfall to the area.[44] During the rainy season, monthly rainfall totals average far higher than other months of the year. This results in high water, particularly in December and January. The larger floods are the result of heavy rains of two-day to five-day durations augmented by snowmelt at a time when the soil is near saturation from previous rains. Frozen topsoil also contributes to the frequency of floods.[45]

A large portion of Clackamas County's area lies in the lower Willamette River basin. The broad floodplain of the valley can be easily inundated by floodwaters. The surface material includes poorly drained, unconsolidated, fine-grained deposits of Willamette silt, sand, and gravel. Torrential flood

[44] Interagency Hazard Mitigation Team, State Hazard Mitigation Plan (2000) Oregon Office of Emergency Management.
[45] Taylor, George H., Hannan, Chris, The Climate of Oregon (1999). Oregon State University Press. Corvallis, Oregon.

events can introduce large deposits of sand and gravel that assist in the drainage of the otherwise poorly drained soils.[46]

Sandy River Flooding – January 16, 2011
Source: Clackamas County Disaster Management

After the January 2009 flood event on South Creek Road along Abernethy Creek, Clackamas County sponsored an inquiry to FEMA into mapping errors for transitioning the 1978 FIRM into DFIRM and argued that the original FIRM Approximate A Zone polygon was incorrectly registered that at least two properties in the Approximate A Zone were now outside of the flood zone, even Abernethy Creek itself. Following the 2009 flood event, the County petitioned FEMA for reconsideration and eventually submitted an inquiry through Senator Wyden's office to the Mitigation Directorate at FEMA Headquarters, but the request was denied. FEMA determined the SFHA mapping error was the responsibility of the county to identify during the review period. Table 2-13 lists the locations of known chronic flooding problems in Clackamas County.

Table 2-13 Locations of Identified Chronic Flooding Problems

Location	River	Description
Tranquality Lane	Clackamas River	Road
Paradise Park	Clackamas River	Open Space
Welches	Salmon River	Unincorporated community
Lolo Pass	Sandy River	Road
Timerline Rim	Sandy River	Housing development
Dickie Prairie Road	Molalla River	Road
Feyrer Park/Shady Dell	Molalla River	Open space and housing development
Alder Creek Area	Alder Creek	Open space
Canby	Pudding River	City
Dogwood Drive/Rivergrove	Tualatin River	City
Oregon City	Confluence of Willamette River and Clackamas River	City
Johnson Creek Basin	Johnson Creek	Basin
Abernethy Creek Basis	Abernethy Creek	Basin

Source: Clackamas County Disaster Management

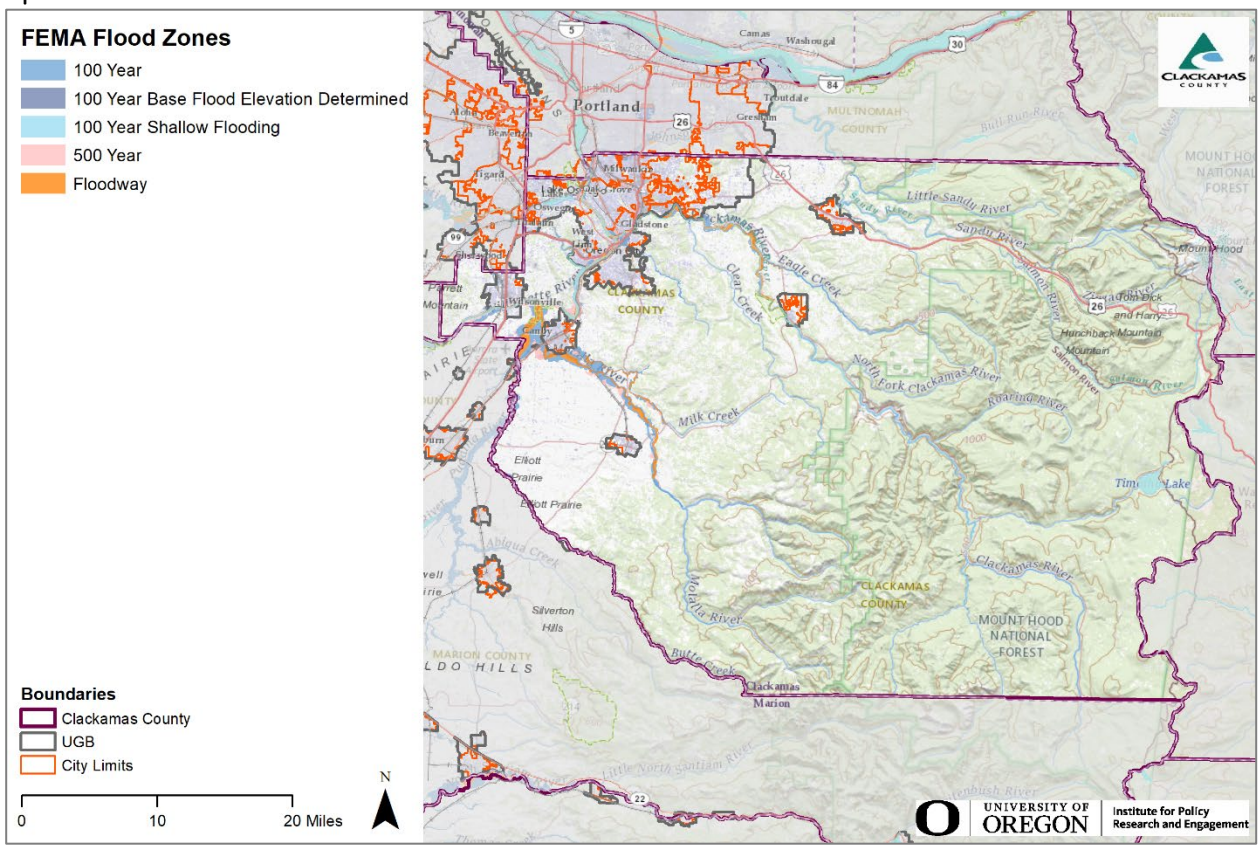
Additionally, floods are described in terms of their extent (including the horizontal area affected and the vertical depth of floodwaters) and the related probability of an occurrence. Flood studies often use historical records, such as streamflow gages, to determine the probability of occurrence for floods of

[46] Geologic Hazards of the Bull Run Watershed Multnomah and Clackamas Counties, Oregon. DOGAMI. Bulletin 82. 1974

different magnitudes. The probability of occurrence is expressed in percentages as the chance of a flood of a specific extent occurring in any given year.

The magnitude of flood used as the standard for floodplain management in the United States is a flood having a one percent probability of occurrence in any given year. This flood is also known as the 100-year flood or base flood. The most readily available source of information regarding the 100-year flood is the system of Flood Insurance Rate Maps (FIRMs) prepared by FEMA. These maps are used to support the National Flood Insurance Program (NFIP). The FIRMs show 100-year floodplain boundaries for identified flood hazards. These areas are also referred to as Special Flood Hazard Areas (SFHAs) and are the basis for flood insurance and floodplain management requirements. Map 2-4 provides an overview of the flood zones and extent in Clackamas County and Volume III, Appendix E includes maps showing average precipitation (Map E-2), FEMA floodplains (Map E-3), and river sub-basins (Map E-4).

Map 2-4 FEMA Flood Zones



Source: Oregon HazVu: Statewide Geohazards Viewer – To view map in more detail click hyperlink to left.

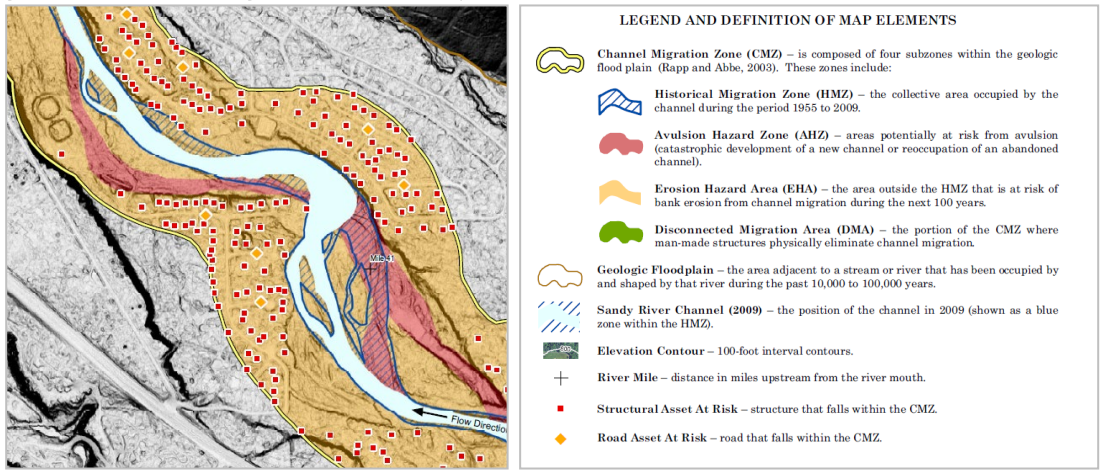
For detailed information, refer to the following Flood Insurance Study (FIS) and associated Flood Insurance Rate Maps (FIRMs):

- Clackamas County FIS (2019) - Volume 1 of 3
- Clackamas County FIS (2019) - Volume 2 of 3
- Clackamas County FIS (2019) - Volume 3 of 3

Conventional FIRMs (flood hazard maps) show existing floodplain information. However, in some areas bank erosion causes river channels to migrate, sometimes even in the absence of a flood event.

To address this concern DOGAMI has contributed a Channel Migration Zone mapping study for the Sandy River and generated LiDAR-based maps for the Sandy Basin and other flood-prone areas of the County. Figure 2-4 provides an example map and legend from the report. More information on the report is found below in the vulnerability section. The resulting channel migration zone and subzones represents the likely hazard area over the next 100 years. According to DOGAMI, "[t]he channel migration hazard map should be used as a guide for local governments, land owners, and infrastructure managers to identify assets potentially at risk and to develop effective mitigation measures".[47]

Figure 2-4 Channel Migration hazard map for Timberline Rim Area



Source: DOGAMI, Open-File Report O-11-13, Plate 10 (superseded by O-13-10).

To refine the data provided by DOGAMI Clackamas County contracted with Natural Systems Design to conduct a Flood Erosion Hazard Mitigation Evaluation for the Upper Sandy River (NSD evaluation). The NSD evaluation was completed in 2015 and was funded through the Hazard Mitigation Grant Program (HMGP) for DR-1956.[48] The NSD evaluation project area (Figure 2-5) is limited to a 10-mile reach of the Sandy River extending from River Mile 37.4 (just above the Salmon River confluence) to River Mile 47.5 (just above the Lost Creek confluence).

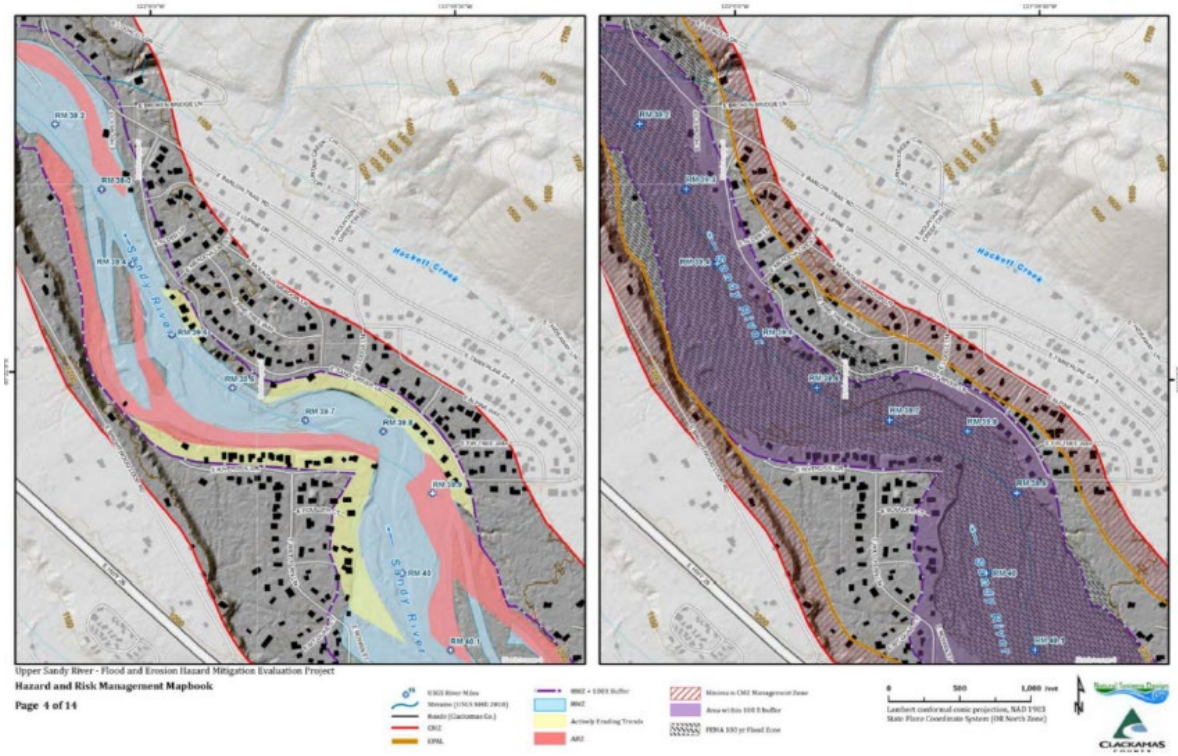
[47] DOGAMI, Open-File Report 0-13-10, Channel migration hazard data and maps for the Sandy River, Multnomah and Clackamas Counties, Oregon. John T. English, Daniel E. Coe, and Robert D. Chappell.
[48] Natural Systems Design, Flood Erosion Hazard Mitigation Evaluation: Upper Sandy River, March 25, 2015.

Figure 2-5 Upper Sandy River Project Area

Source: Natural Systems Design, Flood Erosion Hazard Mitigation Evaluation: Upper Sandy River, March 25, 2015.

The NSD evaluation's map update recommendations include: (1) expanding the historic migration zone (HMZ) to account for a broader corridor of channel occupancy over the historical record, (2) adding additional avulsion pathways to the avulsion hazard zone (AHZ), increasing the setback from the AHZ to limit future erosion hazards, and (4) removing some areas noted as disconnected migration areas (DMA) which may be at risk to erosion (e.g., areas blocked by roads). The NSD evaluation created an adjusted channel migration zone (CMZ) that averages 2,000 feet wide throughout the project area (Figure 2-6).

Figure 2-6 NSD Hazard and Risk Maps

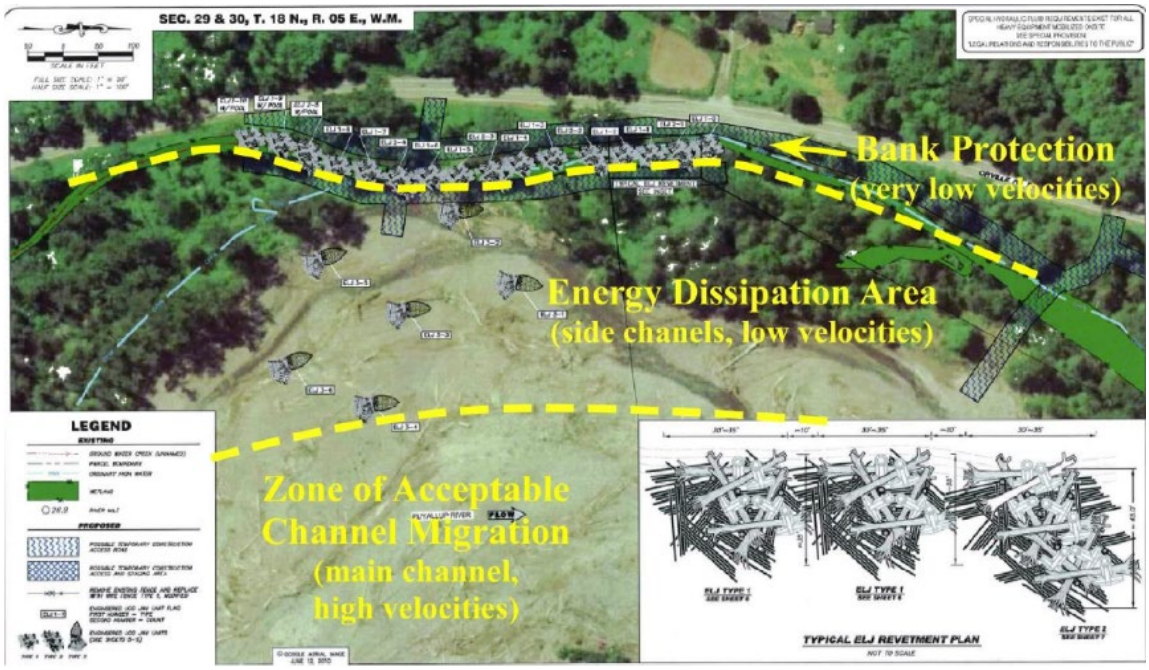


Source: Natural Systems Design, Flood Erosion Hazard Mitigation Evaluation: Upper Sandy River, March 25, 2015.

The NSD evaluation promotes the use of restorative erosion protection measures which take advantage of natural processes to decrease erosive forces while also benefitting fish and wildlife. Restorative measures must: (1) provide the river with sufficient space within an established River Management Corridor (RMC), (2) dissipate the river's energy as it approaches the margins of the RMC by splitting the main channel into smaller side channels, and (3) establish a line of defense at the RMC through the use of restorative bank protection measures (rough and complex) that dissipate energy, protect the bank, and enhance fish habitat.31 A list of high risk erosion hazard sites is provided in NSD evaluation Table 5 that may be used as a resource when evaluating which sites to prioritize in future mitigation efforts along the Sandy River. An example bank projection strategy is provided in Figure 2-7.

For more information review the NSD evaluation:
https://dochub.clackamas.us/documents/drupal/e5a6ebef-f7be-4bcd-8f0f-48d33d537afd

Figure 2-7 Example Bank Projectiona Strategy



Source: Natural Systems Design, Flood Erosion Hazard Mitigation Evaluation: Upper Sandy River, March 25, 2015.

More information on restorative flood protection measures can be found in the FEMA publication: Engineering with Nature: Alternative Techniques to Riprap Bank Stabilization.

Additional reports are available via FEMA's Flood Map Service Center website:

https://msc.fema.gov/portal

Refer to the following DOGAMI reports for additional information:

- Multi-Hazard Risk Report for the Clackamas County, Oregon: Including the cities of Barlow, Canby, Estacada, Gladstone, Happy Valley, Johnson City, Lake Oswego, Milwaukie, Molalla, Oregon City, Rivergrove, Sandy,West Linn, and Wilsonville and the unincorporated communities of Molalla Prairie, Mulino Hamlet, Stafford Hamlet, and The Villages at Mt Hood (2024).

- Multi-Hazard Risk Report for the Lower Columbia-Sandy Watershed, Oregon: Including the cities of Gresham, Sandy, and Troutdale and Unincorporated Communities of Government Camp and The Villages at Mt Hood (2020, O-20-06).
- Statewide subbasin-level channel migration screening (2017, IMS-56).
- Channel migration zone study of Sandy River (2013, O-13-10). Portions superseded by the Multi-Hazard Risk Report for the Lower Columbia-Sandy Watershed.
- Multi-Hazard and Risk Study for the Mount Hood Region (Earthquake, Flood and Channel Migration, Landslide, Volcano) (2011, O-11-16). Portions of the flood and channel migration section superseded by the Multi-Hazard Risk Report for the Lower Columbia-Sandy Watershed.
- Channel migration hazard maps for the Sandy River, Multnomah and Clackamas counties, Oregon (2011, O-11-12). Superseded by O-13-10.

Additional reports are available via DOGAMI's Publications Search website:

https://www.oregon.gov/dogami/pubs/Pages/pubsearch.aspx

Other agency/ consultant reports:

- Natural Systems Design, Flood Erosion Hazard Mitigation Evaluation: Upper Sandy River, March 25, 2015.
- Channel Migration Zone Hazard Maps (Risk Hazard Mapbook)
- Mathie, A.M., and Wood, N., 2013, Residential and service-population exposure to multiple natural hazards in the Mount Hood region of Clackamas County, Oregon: U.S. Geological Survey Open-File Report 2013–1073, available at http://pubs.usgs.gov/of/2013/1073/.

History

Clackamas County has many rivers and small tributaries in both unincorporated and incorporated areas that are susceptible to flooding. Major floods have affected the residents of the county since as early as 1861, when it was reported that the streets of Oregon City were inundated with about four feet of Willamette overbank flow. Although the 1996 floods were devastating to the entire region, the floods of 1861, 1890, and 1964 were larger. All four floods have been estimated to exceed the 100-year or base flood. Since the previous 2019 version of the NHMP there have no presidentially declared flood disaster events in Clackamas County, however, there have been seven significant flood events: 2012, 2014, 2015, 2016-2017, 2019, 2020, and 2021.

Probability Assessment

Based on the available data and research the HMAC determined the probability of experiencing a flood is "**high**", meaning one incident is likely within the next 10 to 35-year period *This rating has not changed since the previous NHMP.*

Flooding can occur every year depending on rainfall, snowmelt or how runoff from development impacts streams and rivers. FEMA has mapped the 100 and 500-year floodplains in portions of Clackamas County (see referenced 2008 FIS for more information; preliminary maps are available for the Sandy River, 2018). This corresponds to a 1% and 0.2% chance of a certain magnitude flood in any given year. The 100-year flood is the benchmark upon which the National Flood Insurance Program (NFIP) is based.

Future Projections [49][50]

According to the Oregon Climate Change Research Institute "Future Climate Projections, Clackamas County,"winter flood risk at mid- to low elevations in Clackamas County, where temperatures are near freezing during winter and precipitation is a mix of rain and snow, is projected to increase as winter temperatures increase. The temperature increase will lead to an increase in the percentage of precipitation falling as rain rather than snow. The projected increases in total precipitation, and in rain relative to snow, likely will increase flood magnitudes in the region. Vulnerable populations adjacent to floodways (including the unhoused, manufactured home communities, and campground occupants) will be more at risk as the winter flood risk increases.

Climate change will be an influencing factor for future flood probabilities. Long-term modeling suggests increases in annual average temperatures may translate in the Pacific Northwest to less total accumulated snow pack and faster storm runoff. This could mean flashier flood events for upper watersheds and the need for greater attention to storm water management in floodplains.

Additionally, while average monthly flows do not translate directly to flood risk because floods occur over shorter periods of time, the increases in monthly flow may result in increases in flood likelihood, particularly if increases are projected to occur during months in which flood occurrence historically has been high.

Clackamas County development regulations restrict, but do not prohibit, new development in areas identified as floodplain. This reduces the impact of flooding on future buildings. The County floodplain regulations in unincorporated areas are the same inside and outside of UGBs. Some areas that are mapped as Habitat Conservation Area by Metro include floodplain. In those locations, there is an additional hurdle for development that may result in diverting some development to areas outside a floodplain. The HCA standards apply inside the Metro service district boundary, which is not coterminous with the UGB.

As new land has been brought into the regional Urban Growth Boundary, the applicable development codes have been applied to prevent the siting of new structures in flood prone areas.s

For mitigation planning purposes, it is important to recognize that flood risk for a community is not limited only to areas of mapped floodplains. Other portions of the county outside of the mapped floodplains may also be at relatively high risk from over bank flooding from streams too small to be mapped by FEMA, from channel migration, or from local storm water drainage.

Vulnerability Assessment

The HMAC rated the county as having a "**moderate**" vulnerability to flood hazards, meaning that between 1-10% of the unincorporated County's population or assets would be affected by a major flood event. *This rating has not changed since the previous NHMP*.

A floodplain vulnerability assessment combines the floodplain boundary, generated through hazard identification, with an inventory of the property within the floodplain. Understanding the population and property exposed to natural hazards will assist in reducing risk and preventing loss from future events.

---

[49] Oregon Climate Change Research Institute (OCCRI), 6th Oregon Climate Assessment Report (2023). https://blogs.oregonstate.edu/occri/oregon-climate-assessments/

[50] Oregon Climate Change Research Institute, *Future Climate Projections, Clackamas County, Oregon*. February 2023.

The amount of property in the floodplain, as well as the type and value of structures on those properties, is calculated to provide a working estimate for potential flood losses.

Inter-Hazard Impact and Outcomes – Flood[51]

As the primary natural hazard, a.k.a "the cause", flood has both direct and indirect impacts on several other hazards, a.k.a. "the effect", and as a climate hazard, its impacts are further exacerbated by the effects of climate change.

- Landslide – Both: Flood can both indirectly and directly impact landslides. Directly, flooding can lead to landslides due to the presence of rapidly moving floodwater, which can lead to undercutting slopes and riverbanks. Indirectly, due to the excess water from flooding, rock and soil can become weakened by becoming over saturated from heavy rain, leading to greater risk of landslides to occur in the future. Flood conditions can elevate water tables and increase pressure on landslide slip planes.

Natural Hazard Risk Reports for Clackamas County

The **Risk Reports** (**DOGAMI, 2024 and 2020**) provide hazard analysis summary tables that identify populations and property within the Lower Columbia-Sandy River Watershed Study Area and countywide that are vulnerable to the flood and channel migration hazards. Volume III, Appendix D provides detailed Community Risk Profile tables for the unincorporated area of Clackamas County.

According to the Risk Reports the following population and property within the study area may be impacted by the profiled events (*where data is provided in both reports the newer data is presented below)*:

Unincorporated Clackamas County[52]

Flood: 713 buildings are located within the 1% Annual Flood Chance zone (0 critical facilities) for a total potential loss of $53.3 million (a loss ratio of less than 1%). In addition, 1,532 residents may be displaced (about 1% of the population).

Channel Migration: 99 buildings are exposed to channel migration (0 critical facilities) with a total buidling value of $35.8 million (an exposure ratio of less than 1%). In addition, 279 residents may be displaced (less than 1% of the population).

Government Camp[53]

Flood: 15 buildings are located within the 1% Annual Flood Chance zone (0 critical facilities) for a total potential loss of $177,000 (a loss ratio of less than 1%). In addition, 10 residents may be displaced (less than 1% of the population).

Channel Migration: There is no exposure to this hazard witih this community.

[51] Department of Natural Resources – Geological & Geophysical Surveys, *Flooding & Landslides*
[52] DOGAMI, Multi-Hazard Risk Report for Clackamas County, Oregon (2024), Table A-1.
[53] DOGAMI, Multi-Hazard Risk Report for Clackamas County, Oregon (2024), Table A-3.

Molalla Prairie[54]

Flood: 38 buildings are located within the 1% Annual Flood Chance zone (0 critical facilities) for a total potential loss of $471,000 (a loss ratio of less than 1%). In addition, 41 residents may be displaced (about 1% of the population).

Channel Migration: There is no exposure to this hazard witih this community.

Mulino Hamlet[55]

Flood: 167 buildings are located within the 1% Annual Flood Chance zone (0 critical facilities) for a total potential loss of $12.1 million (a loss ratio of about 2%). In addition, 194 residents may be displaced (about 7% of the population).

Channel Migration: There is no exposure to this hazard witih this community.

Stafford Hamlet[56]

Flood: 40 buildings are located within the 1% Annual Flood Chance zone (0 critical facilities) for a total potential loss of $3.5 million (a loss ratio of less than 1%). In addition, 106 residents may be displaced (about 3% of the population).

Channel Migration: There is no exposure to this hazard witih this community.

The Villages at Mt. Hood[57]

Flood: 117 buildings are located within the 1% Annual Flood Chance zone (0 critical facilities) for a total potential loss of $3.7 million (a loss ratio of less than 1%). In addition, 338 residents may be displaced (about 4% of the population).

Channel Migration: 1,117 buildings are exposed to channel migration (0 critical facilities) with a total buidling value of $384.8 million (exposure ratio of about 30%). In addition, 3,003 residents may be displaced (about 35% of the population).

Floodplain Management Plan (Activity 510)

The NHMP functions as, among other things, the County's Floodplain Management Plan so that the County receives credit for, and maintains compliance with, its membership within the National Flood Insurance Program (NFIP) Community Rating System (CRS), which recognizes jurisdictions for participating in floodplain management practices that exceed NFIP minimum requirements. The County was admitted into the CRS program in April 2004 and received a rating of Class 5, becoming the highest rated jurisdiction in Oregon and one of only 23 nationally. Currently, the County's participation in the CRS is rescinded and the County does not receive a discount in flood insurance premiums for residents of unincorporated Clackamas County in a special flood hazard zone.

Below are several CRS related activities that the 2018 NHMP documents for credit under the Activity 510 – Floodplain Management Plan:

[54] DOGAMI, Multi-Hazard Risk Report for Clackamas County, Oregon (2024), Table A-5.
[55] DOGAMI, Multi-Hazard Risk Report for Clackamas County, Oregon (2024), Table A-7.
[56] DOGAMI, Multi-Hazard Risk Report for Clackamas County, Oregon (2024), Table A-9.
[57] DOGAMI, Multi-Hazard Risk Report for Clackamas County, Oregon (2024), Table A-11.

National Flood Insurance Program (NFIP)

In 1968, Congress passed the National Flood Insurance Act in 1968, which was meant to provide subsidized insurance rates to people with homes that did not meet minimum standards but were built before FEMA's new flood mapping existed. The NFIP was established as it was identified there was a need for: "(1) a program of flood insurance [that] can promote the public interest by providing appropriate protection against the perils of flood losses and encouraging sound land use by minimizing exposure of property to flood losses; and (2) [establishing] objectives of a flood insurance program [that] should be integrally related to a unified national program for floodplain management." The Flood Insurance Act is administered and managed through the National Flood Insurance Program, (NFIP). The NFIP is a voluntary program that is based upon cooperative agreements between the federal government and local participating communities. The NFIP enables eligible property owners to purchase flood insurance and helps to provide an insurance alternative to the rising costs of federal flood disaster relief.

Table 2-14 shows the initial and current FIRM effective dates for Clackamas County communities. However, after years of massive storms such as Hurricanes Katrina and Sandy, NFIP is out of money and deeply in debt. In order to help the program become solvent and build a reserve fund, federal legislation approved in 2012 requires that flood insurance rates reflect the flood risk of the property. FEMA implemented the Flood Insurance Study (FIS) and Flood Insurance Rate Maps (FIRMs) in 2008 (effective June 17, 2008). In turn, while some people with flood insurance saw an increase because their rates already reflect their flood risk, others had to pay significantly more based on their actual flood risk. Triggers for rate changes include policy lapses, map changes and property purchases.

Table 2-14 Community Flood Map History

Community	Intial FIRM	Current FIRM
Clackamas County	March 1, 1978	January 18, 2019
Barlow	May 5, 1981	June 17, 2008
Canby	June 15, 1981	June 17, 2008
Damascus	March 1, 1978	June 17, 2008
Estacada	June 17, 2008	June 17, 2008
Gladstone	March 15, 1977	June 17, 2008
Happy Valley	December 4, 1979	June 17, 2008
Lake Oswego	August 4, 1987	June 17, 2008
Milwaukie	June 18, 1980	June 17, 2008
Molalla	June 17, 2008	June 17, 2008
Oregon City	December 15, 1980	June 17, 2008
Rivergrove	August 4, 1987	June 17, 2008
Sandy	December 11, 1979	January 18, 2019
West Linn	March 15, 1977	June 17, 2008
Wilsonville	January 6, 1982	June 17, 2008

Source: Federal Emergency Management Agency, Community Status Book Report (2019)

As a NFIP member, Clackamas County regulates the development in its floodplains based on Federal Emergency Management Agency (FEMA) standards. In turn, property owners must buy flood insurance

for residences in the floodplain. By law, lending institutions require flood insurance for structures in a floodplain and have the option to require it for other areas.

For Clackamas County, effective maps for portions of the County within the Lower Columbia-Sandy River Watershed were released January 18, 2019. Clackamas County has an open Community Assistance Visit (CAV) that was initiated January 11, 2017 and closed out on January 13, 2021.

Risk Analysis – NFIP Repetitive Loss Properties:

Clackamas County works to mitigate problems regarding flood issues when they arise, with particular focus on areas in the county that more susceptible to flooding issues and have incurred repetitive losses.

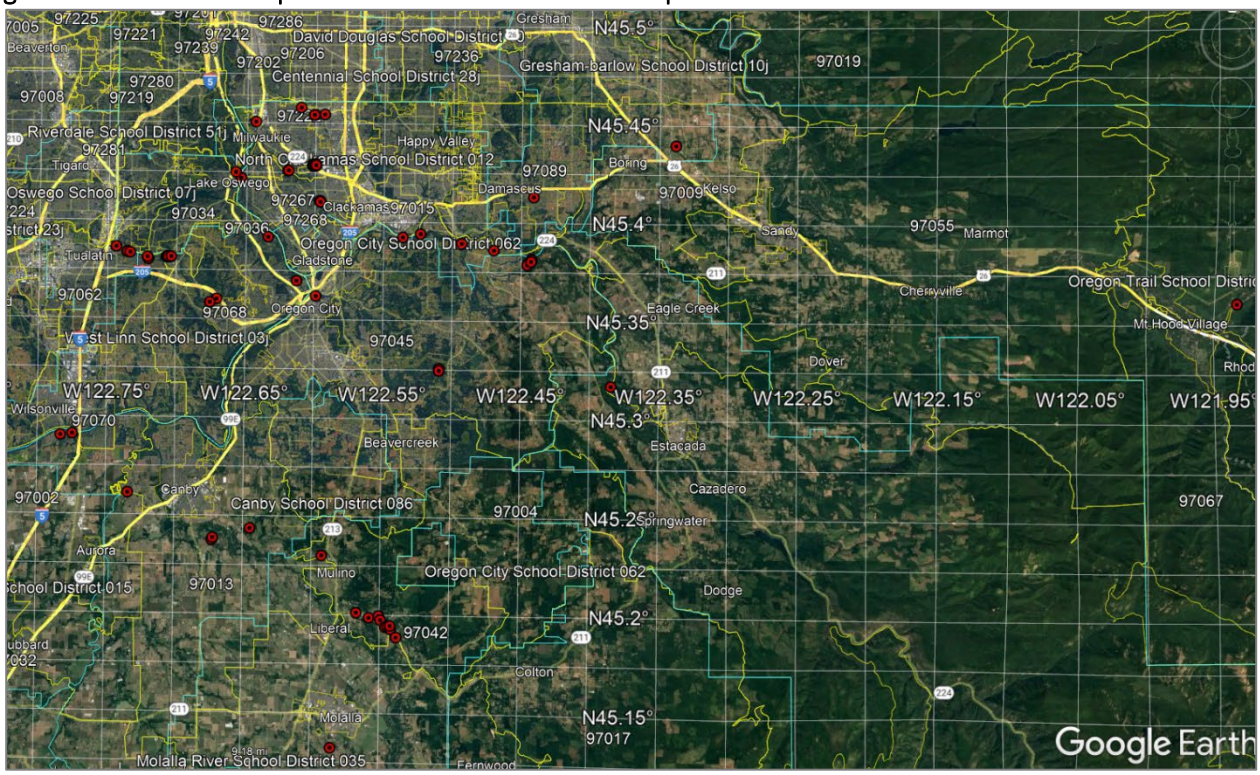
As per the NFIP, a Repetitive Loss Property is defined as any insurable building with two or more paid flood insurance claims exceeding $1,000 within a ten-year period. A RL property may or may not be currently insured by the NFIP.

A Severe Repetitive Loss property (SRL) is defined as having at least four (4) paid flood insurance claims each exceeding $5,000, or when there are two (2) or more losses where the building payments exceed the property value. Loss history is determined by counting all flood claims paid on an insured property, regardless of any change(s) of ownership, since the building's construction or back to 1978. States or communities may sponsor projects to mitigate flood losses to these properties or may be able to provide technical assistance on mitigation options.

RL and SRL properties are troublesome because they continue to expose lives and valuable property to the flooding hazard. Additionally, continued repetitive loss claims from flood events lead to an increased amount of damage caused by floods, higher insurance rates, and contribute to the rising cost of taxpayer funded disaster relief for flood victims. Local governments as well as federal agencies such as FEMA attempt to address losses through various methods, including structure elevation above base flood elevation, structure relocation, vulnerable structure acquisition and demolishment, specifically for those located in the Special Flood Hazard Area (SFHA), as well as flood insurance and drainage improvement projects.

Table 2-15 provide information on the identified RL and SRL properties located in unincorporated Clackamas County. As of February 2023, NFIP record identifies 45 RL properties in unincorporated Clackamas County, with five (5) of those properties considered SRL. There have been 107 paid RL claims totaling $2,894,970, with a total of $233,780 total paid loses for SRL properties. Seventeen (17) of the RL/SRL properties are not insured as of February 2023. Only nine (9) of the properties are considered mitigated. Figure 2-8 provides the general location of these properties.

Figure 2-8 Location of Repetitive Loss and Severe Loss Properties



Source: FEMA Region X, Regional Flood Insurance Liaison, email February 23, 2023..

Table 2-15 Repetitive Loss and Severe Repetitve Loss Properties Detail

RL #	RL or SRL Property	Occupancy	Mitigated?	Currently NFIP Insured?	Rated Flood Zone	Post FIRM	Paid Claims	Total Paid Amount
66560	RL	Single Family	NO	SDF	A	NO	2	$6,801
73713	RL	Single Family	YES	YES	A07	NO	3	$132,435
77503	RL	Single Family	NO	NO	X	NO	3	$63,439
80940	SRL	Single Family	NO	SDF	B	YES	2	$39,933
80944	RL	Single Family	NO	NO	C	NO	2	$16,732
81719	SRL	Single Family	NO	YES	AE	NO	2	$11,501
81787	SRL	Single Family	YES	YES	AE	NO	4	$39,975
82319	RL	Single Family	NO	YES	A04	NO	2	$17,494
82361	RL	Single Family	NO	SDF	A	NO	2	$41,201
82362	RL	Single Family	NO	SDF	A	NO	2	$44,728
82375	RL	Single Family	NO	YES	A04	NO	2	$8,058
82403	RL	Single Family	YES	NO	C	YES	2	$75,028
82407	RL	Single Family	YES	YES	A04	NO	2	$19,704
82561	RL	Single Family	NO	NO	X	YES	2	$84,976
83268	RL	Single Family	NO	NO	A19	YES	2	$125,288
83275	RL	Single Family	YES	NO	A04	NO	3	$57,635
83280	RL	Single Family	YES	YES	A	YES	3	$275,768
83282	RL	Single Family	NO	NO	B	YES	3	$52,708
83289	RL	Single Family	YES	NO	A	NO	2	$27,038
83291	RL	Single Family	NO	YES	A	NO	2	$43,196
83295	RL	Single Family	NO	YES	A19	NO	2	$28,933
83633	RL	Single Family	YES	YES	A	NO	2	$95,093
83762	RL	Single Family	NO	NO	AE	NO	2	$7,072
84096	RL	Single Family	NO	YES	AE	NO	2	$8,949
85839	RL	Single Family	NO	YES	B	YES	2	$80,721
85979	RL	Single Family	NO	YES	C	NO	2	$84,648
87930	RL	Single Family	NO	YES	A	NO	2	$74,014
87945	RL	Single Family	YES	YES	X	YES	2	$90,040
88843	RL	Single Family	NO	NO	AE	NO	3	$77,410
88856	SRL	Single Family	NO	NO	X	NO	2	$18,418
100596	RL	Single Family	NO	YES	A07	NO	2	$14,220
100609	RL	Single Family	NO	NO	X	NO	2	$30,066
122625	RL	Single Family	NO	NO	AE	NO	3	$60,122
161989	RL	Single Family	NO	YES	A	NO	2	$11,961
174193	SRL	Single Family	NO	SDF	X	NO	6	$123,952
184826	RL	Single Family	NO	YES	X	NO	3	$46,901
197989	RL	Single Family	NO	NO	A05	NO	2	$123,375
212414	RL	Single Family	NO	YES	AE	NO	3	$37,585
245219	RL	Single Family	NO	YES	AE	NO	2	$29,624
245220	RL	Single Family	NO	YES	AE	NO	2	$11,832
245528	RL	Single Family	NO	NO	AE	NO	2	$117,381
245645	RL	Single Family	NO	NO	X	NO	2	$15,123
245816	RL	Single Family	NO	NO	X	YES	2	$17,338
245819	RL	2-4 Family	NO	YES	AE	NO	3	$234,197
246401	RL	Other Non-Residential	NO	YES	AE	NO	3	$272,355
Total							***107***	**$2,894,970**

Source: FEMA Region X, Regional Flood Insurance Liaison, email February 23, 2023.
SDF: Special Direct Facility.

Implementing Flood Hazard Mitigation

Clackamas County works closely with OEM and FEMA to reduce flood losses and seeks to best utilize federal mitigation grant funds to minimize future flood risk. With that said, Clackamas County has demonstrated in the two most recent disaster their investment in flood mitigation actions through prioritizing substantially damaged properties and repetitive loss properties when applying for flood acquisition projects. The County considers these buyouts of flood prone properties to be the most cost effective approach to reduce future flood losses for property owners, minimize future disaster-related expenses to the community and provide savings to federal tax payers on a permenant reduction in flood

One of the best investments for implementing hazard mitigation is not only through projects but to affect policy, such as land use planning and even long-term recovery planning. Following the 2011 flood disaster, Clackamas County convened a standing group to address sustainable flood recovery on the upper Sandy River. This group has begun addressing the interdepartmental roles and responsibilities in transitioning from response activities to recovery phase.

The mitigation successes record indicates that 11 properties in unincorporated Clackamas County have received some form of flood mitigation (buy out, elevation, relocation, etc.). See Mitigation Success in the Plan Summary for more information on these properties.

DOGAMI completed a Channel Migration Study in 2013 (Open-File Report O-13-10). County staff is working with the Sandy River Basin Watershed Council's "restorative flood response" outreach to homeowners and associations on providing education about benefits from combining multiple goals of enriching habitat, cost-effectiveness, elevated bank protection and equitable performance towards neighboring properties.

The County reviewed the level of flood insured properties in the upper Sandy Basin and invested in public outreach to encourage more Preferred Risk policies for residences outside of the Special Flood Hazard Zone and that by having flood insurance, homeowners can also take advantage of the Flood Mitigation Assistance Program for projects like acquisitions that do not require a disaster declaration.

Public outreach was employed several times since the January 2011 flood event to address public concerns, present flood response and recovery operations status, discuss flood threat issues to property owners and promote the purchase of flood insurance.

Urban Area Flood Mitigation

50th Anniversary recognition of the 1964 Christmas flood – Clackamas Willamette Rivers Confluence

In anticipation of the 2014 holiday season, Clackamas County began collecting images and interviews from residents who directly experienced the 1964 Christmas flood. By focusing on personal photos and accounts, the County used stories rather than agency reports to document how this flood event affected people, neighborhoods and Clackamas history.

Post Flood Actions – December 2015

Clackamas County held a September 2016 community meeting for owners and tenants of flooded homes to review the nature of the flood event, mitigation options with

HMGP funds and information resources from federal, state and county agencies and the North Clackamas Urban Watersheds Council.

An NFIP Repetitive Loss residential property along SE Rusk Road that flooded in 1996, 2009, and 2015 is participating in the 2016 Flood Mitigation Assistance (FMA) program. The property was elevated in 2020 (FMA-PJ-10-OR-2016-003).

In October 2015 and November 2016, the County organized two "Flood of Information" community education events for urban flood hazards and winter weather safety. Participants included the North Clackamas Urban Watersheds Council, the Greater Oregon City Watershed Council, the Oregon NFIP Coordinator, the US Geological Survey's Portland

Water Resources Office, the Cascades Region of the American Red Cross and staff from multiple County departments.

Surface Water Management – Water Environment Services (WES)

WES administers sanitary sewer, surface water management, and erosion control programs in urban areas of Clackamas County.

Since 2012, WES has completed several in-stream restoration projects, repaired many drainage issues, rehabilitated some stormwater ponds, conducted monitoring, and other storm system-related maintenance. These restoration projects have been done to improve physical habitat and water quality, as well as to correct drainage/flow issues.

- Mt Scott Creek in North Clackamas Park: In-stream restoration and invasive control/native vegetation enhancement, construction of an overlook deck. Completed in partnership w/NCPRD, partial funding from Metro Nature in Neighborhoods Capital Grant program and WES ratepayer fees.
- Happy Valley Park stream stabilization: Replaced a culvert with a bridge, repaired a headcut, improved in-stream habitat in partnership w/City of Happy Valley. Funding by and WES ratepayer fees.
- Cedar Way stream stabilization: Repaired a headcut and stabilized a stream along a walking path in partnership w/City of Happy Valley. Funding from and WES ratepayer fees.
- Rock Creek Confluence project: in-stream restoration, invasive control/native vegetation enhancement, construction of a shelter for use by environmental education program. Partnered with Clackamas River Basin Council, partial funding from Metro Nature in Neighborhoods Capital Grant program, The Nature Conservancy, OWEB, and WES ratepayer fees.
- Carli Creek constructed wetland and stream restoration: construction completed, including in-stream restoration and constructed wetland that treats stormwater runoff from industrial properties and gradually releases treated water back to Carli Creek. Partial funding from PGE's Clackamas Habitat Fund and WES ratepayer fees.

Kellogg Creek Stream Gauge Installation – Water Environment Services (WES)

WES installed satellite communications at its lower Kellogg Creek flow monitoring station near Milwaukie and partnered with NOAA to host the real-time data on its Advanced Hydrologic Prediction Service website. This will not only serve for flood monitoring, but also provide needed stream flow data for watershed planning. https://water.weather.gov/ahps2/hydrograph.php?wfo=PQR&gage=kcmo3

RiverHealth Stewardship Program – Water Environment Services (WES)

The RiverHealth Stewardship Program grants support a variety of watershed activities with the purpose of enhancing water quality, restoring fish habitat, managing invasive species, organizing volunteer events, and removing trash from waterways.

Since 2013, their RiverHealth Stewardship Program grants have funded over $1.3 million dollars to support community groups, businesses, and property owners who want to improve the health of watersheds within the surface water areas served by WES. The most recent funding cycle (FY 2022-2023) supported 12 orgnizations with a combined total of $300,000 in grant funds.

Benefiting watersheds include Rock Creek, Kellogg Creek, Mt Scott Creek, Phillips Creek, Johnson Creek, and the Clackamas River. The grants will also support the continued stewardship of previously restored project sites, protecting District investments made in recent years.

Rural Area Flood Mitigation

Channel Migration Zone Hazards – Upper Sandy River

In January of 2011, Clackamas County experience a 25-year flood on the upper Sandy River with destruction to three houses, severe damage to roads and bridges, and multiple properties that lost tens of feet of streamside land – all to bank erosion. Since 2011, the County has worked to address an emerging understanding of the basis for the hazard and risk as primarily channel migration on a steep mountain river system and not traditional over-bank flooding. No hydrologic studies had been conducted in the Upper Sandy basin and there was no scientifically based research to use for managing erosion and property losses. Bank armoring using rip rap (rock armoring), permitted and unpermitted, was the normal approach for property by property protection. This historical treatment demonstrated clear evidence of many examples of unintended consequences of erosion along exposed neighboring and downstream properties, often creating escalated armoring and negative impacts to habitat and stream function.

US Army Corps of Engineers (USACE) Public Involvement Pilot Project

In 2013-14 the County was included in a dozen selected communities across the nation as pilot projects for Public Involvement and conflict resolution around flood risk management. The County convened a workgroup of representatives from upper Sandy River communities to consider options for short-term flood recovery and future mitigation.

50th Anniversary recognition of the 1964 Christmas flood – Upper Sandy River Basin

During the 1964 Christmas floods, Clackamas County was the hardest hit area in Oregon and the upper Sandy River communities were the hardest hit on the County, mostly from channel migration damage. 155 homes were destroyed with miles of washed out roads and the loss of numerous bridges. The County used this historic anniversary to emphasize that 50 years later channel migration hazard is still a threat and must be addressed in future policy decisions in planning for flood recovery and community development (Figure 2-11).

Three flood acquisitions due to CMZ damage

Clackamas County acquired three flood erosion-damaged residential properties following the 2011 upper Sandy River disaster declaration using HMGP funds (DR-1956-OR). Channel migration during the high-water event eroded approximately 40 feet of property at each location and undermined the foundations making the residences uninhabitable. All three properties were acquired and transferred to County ownership as open space.

Other flood mitigation assistance

Two repetitive loss properties along South Creek Road have received mitigation assistance against future flood losses. Following the flood of January 2009 along Abernethy Creek, one used HMGP funds to elevate at least eight feet above grade and three feet above the flood of record. The second property was an HMGP flood acquisition along Abernethy Creek that is returning the property to permanent open space in the floodplain. Clackamas County completed an additional two flood elevations: one along the upper Sandy River in February 2008 using a Flood Mitigation Assistance Grant, and the other along Abernethy Creek in March 2010 using the Hazard Mitigation Grant Program (HMGP).

Mitigation Success - Abernethy Creek elevation completed in March 2010 and successfully tested on January 19, 2012.
Source: Clackamas County

HMGP 5% Flood Warning System installation, but continuing technical problems.

Following the 2011 flood event, the County sought a means to monitor the stream flows of the three rivers in the upper Sandy Basin to better help provide status and warnings for communities at risk. Improving on the existing three NWS staff gauges, we used HMGP 5% funds to install five new sonar-based, solar powered sensors with radio communication on County-owned bridges (2 on the Sandy, 2 on the Salmon, and 1 on the Zig Zag Rivers). Unfortunately, due to mountainous terrain, extensive tree

cover, and harsh winter weather conditions, these five stations have never performed to their expected design capabilities. The County is pursuing upgrades to provide direct PGE power and fiber optic communications using an HMGP 5327 grant (HMGP-FM5327-13, *Upper Sandy River Flood Warning System Improvements*).

OPDR Channel Migration Zone hazard and risk public opinion survey

During the summer of 2016, the Oregon Partnership for Disaster Resilience (OPDR) used RiskMap outreach funds from the FIRM update of the Sandy River Basin to design and conduct and a public option survey to capture valuable data on community attitudes towards flood risk tolerance and avoidance, preferences on flood mitigation, and the role of government on flood risk management. Out of 3,000 surveys sent, we received approximately 300 responses, with mixed opinions on flood risk management. Generally, the community has more support for maintaining existing levels of exposure but is willing to have government place more restrictions on future development.

RiskMap Resilience Meeting for the Upper Sandy River Basin

As a concluding activity for the FIRM update in the Upper Sandy River basin, the County sponsored FEMA's Resilience Meeting in October 2017 to review mitigation opportunities. This meeting was attended by federal, state and local government officials as well as a panel of five community representatives to highlight CMZ issues and express concerns related to homeowners, community planning, or realtors. The County reviewed policy issues that emerged following the 2011 flood and emphasized the strategies of the two following actions underway in 2018:

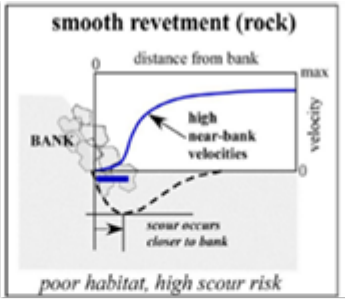
- US Army Corps Silver Jackets Project – Upper Sandy River Flood Risk Management Plan: The County worked with the Corps' Silver Jackets group to receive a two-year (FFY 2018-19) project for flood risk management planning and community engagement. His effort building on the 2013-14 Public Involvement Pilot and the recommendations from the 2015 Natural Systems Design erosion study.
- Oregon Solutions assistance with State policy for CMZ regulation: The County has been working with Oregon Solutions since 2015 on a project assessment around CMZ polices and is currently supporting Oregon Solutions and the Governor's Resilience Policy Advisor on a statewide examination of the need for CMZ polices and regulations for both property and habitat.

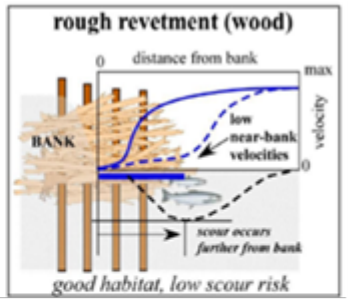
Clackamas County CRS Program Review

In 2009-10 the County requested the University of Oregon's Partnership for Disaster Resilience to lead a project to assess the feasibility and benefits of a more efficient, streamlined and integrated approach to flood mitigation and flood plain management in the county. A 2011 report found that programmatic improvements are expected to reduce the risk of damage to property and life resulting from flood; establish better coordination of mitigation actions and activities across public, private and not-for-profit entities; enhance and restore natural and constructed flood control functionality; and maximize the use of limited resources.[58] The County does not currently participate in CRS.

[58] OPDR, 2011, Clackamas County Community Rating System Program Review.

Sandy River Basin Watershed Council (SRBWC) – Restorative Flood Response Community Handbook





SRBWC Community Handbook – This 2016 handbook is based on the County's 2015 CMZ study and is co-authored by the SRBWC and NSD. The SRBWC is very effective in engaging the public on reach-based stream restoration projects through their non-regulatory role and hands-on volunteer opportunities.

The SRBWC has become a vital partner in flood mitigation in the upper Sandy River Basin, due to their work on what they call, "Restorative Flood Response." This approach leverages bank stabilization, with advanced bio engineering practices tailored for the Sandy River, to improve habitat, stream function, and reduces flood risk.

Floodplain Reconnection Project – Columbia Land Trust and SRBWC

Engineered Log Jam (ELJ) – Construction of 3 ELJs, removal of 300 feet of post-1964 flood levees and reconnection of 2,900 feet of side channel to provide refuge for salmonids, absorb flood velocities, and redistribute storm flows across a broader floodplain. Photo: SRBWC.

Landslide

Landslide Summary		Significant Changes Since Previous Update	Applicable Action Items
Hazard Ranking:	9	Content updated per 44 CFR 201.6(c)(2). A section on Future Projections added. Quantitative risk assessment added (DOGAMI Risk Report).	Priority: MH #1
Total Threat Score:	112		
Probability:	High		Other: MH #5, LS #1, LS #2, LS #3, LS #4
Vulnerability:	Low		

Characteristics

A landslide is any detached mass of soil, rock, or debris that falls, slides or flows down a slope or a stream channel. Landslides are classified according to the type and rate of movement and the type of materials that are transported. In a landslide, two forces are at work: 1) the driving forces that cause the material to move down slope, and 2) the friction forces and strength of materials that act to retard the movement and stabilize the slope. When the driving forces exceed the resisting forces, a landslide occurs.

Clackamas County is subject to landslides or debris flows (mudslides), especially in the Cascade Range in the eastern portion of the county, which may affect buildings, roads and utilities.

Additionally, landslides often occur together with other natural hazards, thereby exacerbating conditions, as described in Table 2-16.

Table 2-16 Natural Hazard Interacting with Landslide

Natural Hazard	Possible Resulting Impacts
Earthquake	Shaking due to earthquakes can trigger events ranging from minor rock falls and topples to massive slides.
Heavy Precipitation	Intense or prolonged precipitation can heavily saturate slopes, which can lead to landslides
Volcano	Volcanoes commonly have landslides because they are tall, steep, and weakened by the rise and eruption of molten rock, and can be triggered by earthquakes beneath or nearby the volcano or stem from explosive eruptions.
Wildfire	Wildfires can remove vegetation from hillsides, creating what is known as "burn scars", which can significantly increase runoff and landslide potential.
Additional: Dam Failure	Landslides into a reservoir can indirectly compromise dam safety and the integrity of the dam.

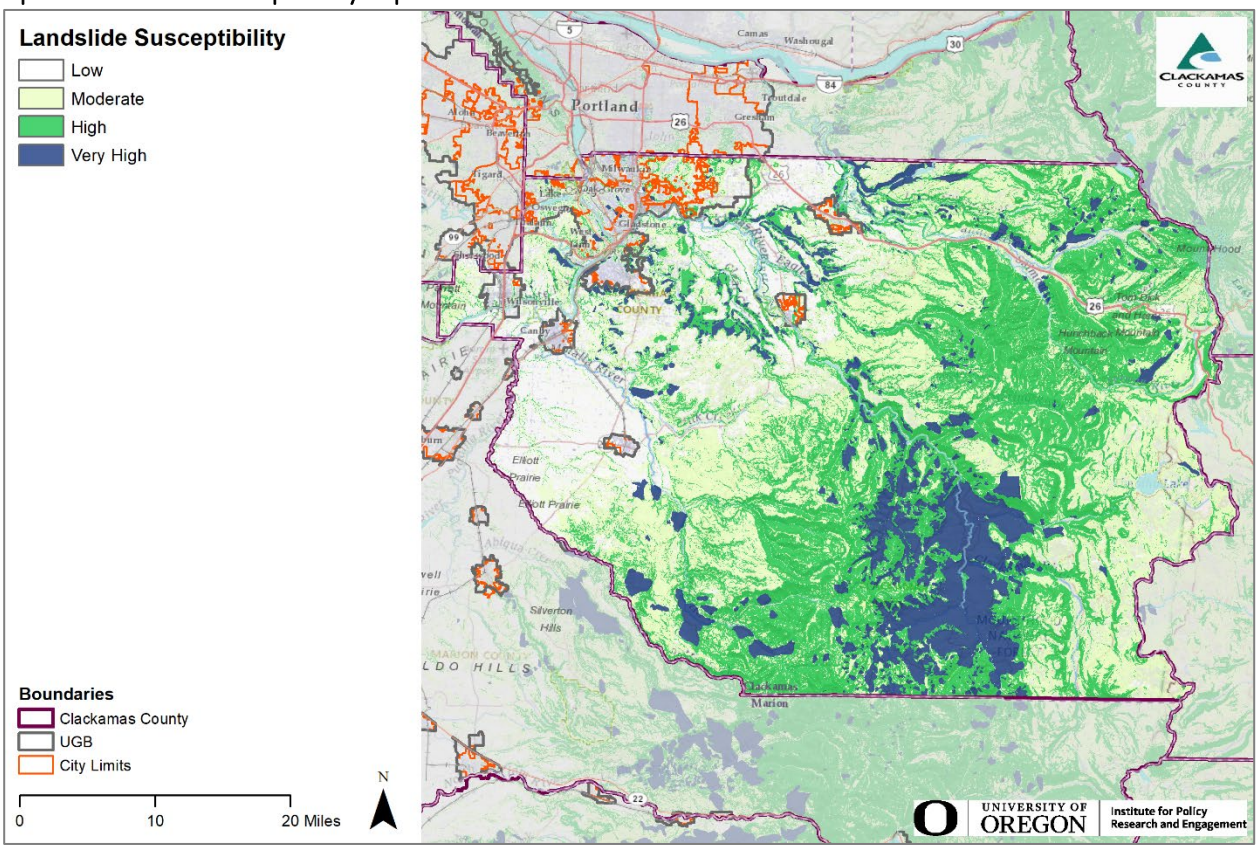
Source: Centers for Disease and Prevention, "Landslides and Mudslides", Retrieved May 1, 2023

Location and Extent

In many parts of Clackamas County, weathering and the decomposition of geologic materials produces conditions conducive to landslides. Human activity has further exacerbated the landslide problem in many parts of the county. A study conducted by Dr. Scott Burns at Portland State University found that changes to the slope through cutting or filling increased the risk of landslides in 76% of the 701 inventoried landslides in the Metro region. The study documented 48 landslides that occurred in Oregon City in February 1996 and found that only about half the slides were considered natural.[59]

For Clackamas County, many high landslide potential areas are in hilly-forested areas (Map 2-5). Landslides in these areas may damage or destroy some timber and impact logging roads. Many of the major highways in Clackamas County are at risk for landslides at one or more locations with a high potential for road closures and damage to utility lines. Especially in the central-eastern portions of the County, with a limited redundancy of road network, such road closures may isolate communities. Additional maps can be found in Volume III, Appendix E: slop stability (Map E-5), historic landslides (Map E-6), and debris flows (Map E-7).

Map 2-5 Landslide Susceptibility Exposure



Source: Oregon Partnership for Disaster Resilience. Oregon Department of Geology and Mineral Industries.
Note: To view detail click this link to access Oregon HazVu

More detailed landslide hazard assessment at specific locations requires a site-specific analysis of the slope, soil/rock and groundwater characteristics at a specific site. Such assessments are often

[59] Burns, Burns, James, and Hinchke. Landslides in Portland, Oregon Metropolitan Area (resulting from Storm of 1996: Inventory, Map Data, and Evaluation.)

conducted prior to major development projects in areas with moderate to high landslide potential, to evaluate the specific hazard at the development site.

Table 2-17 shows landslide susceptibility exposure for Clackamas County and the incorporated cities. Approximately 45% of the county has high or very high landslide susceptibility exposure. These are concentrated in areas of high slopes, and close to river valleys (Map 2-5). In general cities within the County have a lower landslide susceptibility exposure than does the unincorporated area of the County (see Volume II for more information on each city's exposure). Note that even if a County or city has a high percentage of area in a high or very high landslide exposure susceptibility zone, this does not mean there is a high risk, because risk is the intersection of hazard and assets.

The severity or extent of landslides is typically a function of geology and the landslide triggering mechanism. Rainfall initiated landslides tend to be smaller and earthquake induced landslides may be very large. Even small slides can cause property damage, result in injuries or take lives.

Table 2-17 Landslide Susceptibility Exposure

Jurisdiction	Area, ft^2	Low	Moderate	High	Very High
Clackamas County	52,482,820,515	23.5%	31.1%	34.5%	10.9%
Canby	121,922,939	89.2%	9.0%	1.8%	0.0%
Estacada	62,896,341	59.8%	14.6%	22.9%	2.6%
Gladstone	69,974,152	70.8%	22.2%	4.6%	2.4%
Happy Valley	255,471,143	36.0%	48.6%	15.3%	0.2%
Johnson City	1,896,509	73.9%	23.2%	2.9%	0.0%
Lake Oswego	317,377,635	42.0%	43.6%	12.9%	1.5%
Milwaukie	137,561,959	64.5%	31.2%	4.3%	0.0%
Molalla	65,771,550	95.7%	4.2%	0.1%	0.0%
Oregon City	278,148,504	1.9%	16.1%	8.2%	3.7%
Sandy	93,736,907	52.2%	29.5%	15.0%	3.2%
West Linn	223,398,149	35.3%	44.0%	15.7%	5.0%
Wilsonville	207,231,898	74.0%	20.5%	5.5%	0.1%

Source: DOGAMI Open-File Report, O-16-02, Landslide Susceptibility Overview Map of Oregon (2016).

For more information, refer to the following report and maps provided by DOGAMI:

- Multi-Hazard Risk Report for the Clackamas County, Oregon: Including the cities of Barlow, Canby, Estacada, Gladstone, Happy Valley, Johnson City, Lake Oswego, Milwaukie, Molalla, Oregon City, Rivergrove, Sandy,West Linn, and Wilsonville and the unincorporated communities of Molalla Prairie, Mulino Hamlet, Stafford Hamlet, and The Villages at Mt Hood (2024).
- Multi-Hazard Risk Report for the Lower Columbia-Sandy Watershed, Oregon: Including the cities of Gresham, Sandy, and Troutdale and Unincorporated Communities of Government Camp and The Villages at Mt Hood (2020, O-20-06).
- Statewide Landslide Susceptibility (2016, O-16-02).
- Landslide inventory and susceptibility for northwest Clackamas County (2013, O-13-08).
- Surficial geology for greater Portland area (2012, O-12-02).

- Multi-Hazard and Risk Study for the Mount Hood Region (2011, O-11-16). *Portions of the landslide section superseded by the Multi-Hazard Risk Report for the Lower Columbia-Sandy Watershed*.
- Landslide Inventory Maps for the Canby (2009, IMS-32), Damascus (2012, IMS-49), Estacada (2012, IMS-52), Gladstone (2012, IMS-48), Lake Oswego (2010, IMS-32), Oregon City (2010, IMS-30), Redland (2012, IMS-51), Sandy (2012, IMS-38), Sherwood (2012, IMS-50) quadrangles.
- Slope failures in Oregon: GIS inventory for three 1996/97 storm events (2000, Special Paper 34).

Additional reports are available via DOGAMI's Publications Search website:

https://www.oregon.gov/dogami/pubs/Pages/pubsearch.aspx

History

Landslides may happen at any time of the year. In addition to landslides triggered by a combination of slope stability and water content, earthquakes may also trigger landslides. Areas prone to seismically triggered landslides are generally the same as those prone to ordinary (i.e., non-seismic) landslides. As with ordinary landslides, seismically triggered landslides are more likely for earthquakes that occur when soils are saturated with water.

Debris flows and landslides are a very common occurrence in hilly areas of Oregon, including portions of Clackamas County. Many landslides occur in undeveloped areas and thus may go unnoticed or unreported. For example, DOGAMI conducted a statewide survey of landslides from four winter storms in 1996 and 1997 and found 9,582 documented landslides, with the actual number of landslides estimated to be many times the documented number. For the most part, landslides become a problem only when they impact developed areas and have the potential to damage buildings, roads or utilities. Map 2-5 shows the landslide inventory (Very High category) for Clackamas County, for additional information see the historic landslides map in Volume III, Appendix E (Map E-6) and the Statewide Landslide Information Database for Oregon.

Landslides in Clackamas County are not a localized problem. For example, sediment generated by the slides can affect regional water quality. During the winter of 1972, a relatively small landslide on the north fork of the Bull Run River in the western Cascades introduced a large volume of silt and clay into Portland's main water supply reservoir. Consequently, the city's water supply was discolored for several weeks.[60]

Many landslides are difficult to mitigate, particularly in areas of large historic movement with weak underlying geologic materials. As communities continue to modify the terrain and influence natural processes, it is important to be aware of the physical properties of the underlying bedrock as it, along with climate, dictates hazardous terrain. Without proper planning, landslides will continue to threaten the safety of people, property, and infrastructure.

Development coupled with natural processes such as heavy rainfall or rapid snowmelt can cause landslides or re-activate historical landslide sites. The County has received three Presidential Disaster Declarations since 2002, three of which included major landslide damage to county roads and infrastructure. Although not included within the disaster declaration the County also experienced landslides associated with storm events in 2012, 2014, 2015, 2016-2017.

[60] Schlicker, Ht., and Finlayson Ct. (1979) Geologic and Geohazards of NW Clackamas County. Bulletin 99. DOGAMI, OR.)

Probability Assessment

Based on the available data and research the HMAC determined the probability of experiencing a landslide or debris flow is "high", meaning at least one incident is likely within the next 10 to 35-year period. *This rating has not changed since the previous NHMP.*

Landslides are a common hazard in and around Oregon. In fact, a prominent theme of the 1996 flood disaster was that a significant amount of building damage affected structures outside of identified flood hazard areas. Many of the 5,000 Clackamas County applicants eligible for FEMA housing assistance grants were not floodplain cases but were landslide and erosion losses.[61]

The probability of rapidly moving landslide occurring depends on a number of factors, including steepness of slope, slope materials, local geology, vegetative cover, human activity and water. There is a strong correlation between intensive winter rainstorms and the occurrence of rapidly moving landslides (debris flows). Consequently, the National Weather Service tracks storms during the rainy season, monitors rain gauges and snow melt and issues warnings as conditions warrant. Given the correlation between precipitation, snowmelt and rapidly moving landslides, it would be feasible to construct a probability curve. The installation of slope indicators or the use of more advanced measuring techniques could provide information on slower moving slides.

Geo-engineers with DOGAMI estimate widespread landslides about every 20 years; landslides at a local level can be expected every two or three years.[62]

Future Projections [6364]

Landslides are often triggered by rainfall when the soil becomes saturated. As a surrogate measure of landslide risk, the Oregon Climate Change Research Institute "Future Climate Projections, Clackamas County," presents a threshold based on recent precipitation (cumulative precipitation over the previous 3 days) and antecedent precipitation (cumulative precipitation on the 15 days prior to the previous 3 days). By the 2050s under the higher emissions scenario, the average number of days per year in Clackamas County on which the landslide risk threshold is exceeded is not projected to change substantially. However, landslide risk depends on multiple factors, and this metric, which is based on precipitation, does not reflect all aspects of the hazard. Additional triggers, such as earthquakes, wildfires, or development, can increase risks of landslides. Future development along slopes or adjacent to riverbanks will be a greater risk of impact from this hazard.

Vulnerability Assessment

The HMAC rated the County as having a "low" vulnerability to landslide hazards, meaning that less than 1% of the unincorporated County's population or assets would be affected by a major disaster. *This rating has not changed since the previous NHMP*.

To a large degree, landslides are very difficult to predict. Vulnerability assessments assist in predicting how different types of property and population groups will be affected by a hazard.[65] The optimum method for doing this analysis at the city or county level is to use parcel-specific assessment data on

[61] Interagency Hazard Mitigation Team, State Hazard Mitigation Plan (2000) Oregon Office of Emergency Management.
[62] Mills, K. 2002. Oregon's Debris Flow Warning System. Cordilleran Section–98th Annual Meeting. Corvallis.
[63] Oregon Climate Change Research Institute (OCCRI), 6th Oregon Climate Assessment Report (2023). https://blogs.oregonstate.edu/occri/oregon-climate-assessments/
[64] Oregon Climate Change Research Institute, *Future Climate Projections, Clackamas County, Oregon*. February 2023.
[65] Burby, R., ed. 1998. Cooperating with Nature. Washington D.C.: Joseph Henry Press.

land use and structures.[66] Data that includes specific landslide-prone and debris flow locations in the county can be used to assess the population and total value of property at risk from future landslide occurrences.

Landslides can impact major transportation arteries, blocking residents from essential services and businesses. Many aspects of the county are vulnerable to landslides. This includes land use and development patterns, the economy, population segments, ecosystem services and cultural assets.

A quantitative landslide hazard assessment requires overlay of landslide hazards (frequency and severity of landslides) with the inventory exposed to the hazard (value and vulnerability) by considering:

- Extent of landslide susceptible areas;
- Inventory of buildings and infrastructure in landslide susceptible areas;
- Severity of earthquakes or winter storm event (inches of rainfall in 24 hours);
- Percentage of landslide susceptible areas that will move and the range of movements (displacements) likely; and
- Vulnerability (amount of damage for various ranges of movement).

Roads and Bridges

Large losses incurred from landslide hazards in Clackamas County have been associated with roads. The Clackamas County Roads Division is responsible for responding to slides that inhibit the flow of traffic or are damaging a road or a bridge. The roads department does its best to communicate with residents impacted by landslides, but can usually only repair the road itself, as well as the areas adjacent to the slide where the county has the right of way.

It is not cost effective to mitigate all slides because of limited funds and the fact that some historical slides are likely to become active again even with mitigation measures. The County Roads Division alleviates problem areas by grading slides, and by installing new drainage systems on the slopes to divert water from the landslides. This type of response activity is often the most cost-effective in the short-term but is only temporary. Unfortunately, many property owners are unaware of slides and the dangers associated with them.

Inter-Hazard Impact and Outcomes – Landslide[67]

As the primary natural hazard, a.k.a "the cause", landslide has both direct and indirect impacts on several other hazards, a.k.a. "the effect", and as a climate hazard, its impacts are further exacerbated by the effects of climate change.

- Flood – Both: Landslides can both indirectly and directly impact floods. Landslides can cause flooding by blocking valleys and stream channels, which can force large amounts of water to backup. This causes backwater flooding in the upstream area and if the blockage gives away, quick downstream flooding too. Or if the valley or river are along a dam, a landslide can lead to flooding that could a subsequent dam burst.

Natural Hazard Risk Reports for Clackamas County

The **Risk Reports** (DOGAMI, 2024 and 2020) provide hazard analysis summary tables that identify populations and property within the Lower Columbia-Sandy River Watershed Study Area and

[66] Burby, R., ed. 1998. Cooperating with Nature. Washington D.C.: Joseph Henry Press.
[67] Department of Natural Resources – Geological & Geophysical Surveys, *Flooding & Landslides*

countywide that are vulnerable to the landslide hazard. Volume III, Appendix D provides detailed Community Risk Profile tables for the unincorporated area of Clackamas County.

According to the Risk Reports the following population and property within the study area may be impacted by the profiled events (*where data is provided in both reports the newer data is presented below)*:

Unincorporated Clackamas County[68]

Landslide: 5,956 buildings are exposed to the High and Very High Landslide Susceptibility hazard (7 critical facilities) with a total buidling value of $2.14 billion (an exposure ratio of about 6%). In addition, 12,965 residents may be displaced (about 7% of the population).

Government Camp[69]

Landslide: 28 buildings are exposed to the High and Very High Landslide Susceptibility hazard (0 critical facilities) with a total buidling value of $3.63 million (an exposure ratio of about 1%). In addition, 225 residents may be displaced (about 17% of the population).

Molalla Prairie[70]

Landslide: 86 buildings are exposed to the High and Very High Landslide Susceptibility hazard (0 critical facilities) with a total buidling value of $22.23 million (an exposure ratio of about 2%). In addition, 89 residents may be displaced (about 2% of the population).

Mulino Hamlet[71]

Landslide: 236 buildings are exposed to the High and Very High Landslide Susceptibility hazard (0 critical facilities) with a total buidling value of $62.54 million (an exposure ratio of about 11%). In addition, 307 residents may be displaced (about 11% of the population).

Stafford Hamlet[72]

Landslide: 102 buildings are exposed to the High and Very High Landslide Susceptibility hazard (0 critical facilities) with a total buidling value of $46.73 million (an exposure ratio of about 8%). In addition, 298 residents may be displaced (about 10% of the population).

The Villages at Mt. Hood[73]

Landslide: 420 buildings are exposed to the High and Very High Landslide Susceptibility hazard (0 critical facilities) with a total buidling value of $144.82 million (an exposure ratio of about 11%). In addition, 1,047residents may be displaced (about 12% of the population).

[68] DOGAMI, Multi-Hazard Risk Report for Clackamas County, Oregon (2024), Table A-1.
[69] DOGAMI, Multi-Hazard Risk Report for Clackamas County, Oregon (2024), Table A-3.
[70] DOGAMI, Multi-Hazard Risk Report for Clackamas County, Oregon (2024), Table A-5.
[71] DOGAMI, Multi-Hazard Risk Report for Clackamas County, Oregon (2024), Table A-7.
[72] DOGAMI, Multi-Hazard Risk Report for Clackamas County, Oregon (2024), Table A-9.
[73] DOGAMI, Multi-Hazard Risk Report for Clackamas County, Oregon (2024), Table A-11.

Severe Weather

Clackamas County experiences a range of weather-related hazards on an annual basis, such as severe heat, winter storms and wind storms. This section combines the above hazard sections from the previous NHMP into a single Severe Weather section.

Severe weather events may occur throughout Oregon during all seasons. Often originating in the Pacific Ocean, westerly winds pummel the coast, slowing as they cross the Coastal mountain range and head into the inland valleys.[74] Similarly, severe winter storms consisting of rain, freezing rain, ice, snow, cold temperatures, and wind originate from troughs of low pressure offshore in the Gulf of Alaska or in the central Pacific Ocean that ride along the jet stream during fall, winter, and early spring months.[75] In summer, the most common wind directions are from the west or northwest; in winter, they are from the south and east. Local topography, however, plays a major role in affecting wind direction. For example, the north-south orientation of the Willamette Valley channels the wind most of the time, causing predominately north and south winds.

Characteristics

Incidents of extreme weather (such as floods, droughts, severe storms, heat waves and fires) can directly impact human health as well as cause serious environmental and economic impacts. Indirect impacts can occur when climate change alters or disrupts natural systems, potentially leading to effects that impact lives, property, and the envirnoment at a later time.[7677] Oregon and the Pacific Northwest experience a variety of extreme weather incidents ranging from severe winter storms and floods to drought and dust storms, often resulting in morbidity and mortality among people living in the impacted regions.

Deaths directly attributed to extreme weather events include falls from ice, storms, extreme cold, and extreme heat. Extreme weather can cause death when hazards occur suddenly, when safe shelter is unavailable, or in the presence of existing chronic conditions, such as diabetes or cardiovascular disease. Between 2014 and 2022, 236 people died due to extreme weather. Most (61%) or 144 people died of extreme heat (hyperthermia), (36%) or 84 people died of extreme cold (hypothermia), 6 falls from ice (3%), and 2 storms (1%).[78]

Some groups and communities experience greater impacts from severe weather based on their ability to prepare for, whithstand, and recover from events. According to the Climate and Helath Monitoring Report, the following groups face higher risks:

- Older adults, children, people who use mobility devices, and people with disabilities who are unable to find protection from a storm or have limited access to transportation.
- People who have less capacity or fewer resources to gather supplies for extreme weather events, as well as to cover costs related to post-storm recovery.
- Communities who are isolated culturally, linguistically, or by technology barriers, like limited internet, may not have access to appropriate emergency communications.

[74] US Department of Agriculture. http://www.fsa.usda.gov/or/Notice/Flp104.pdf
[75] Interagency Hazard Mitigation Team. 2000. State Hazard Mitigation Plan. Salem, OR: Oregon Office of Emergency Management
[76] Ibid.
[77] OCCRI, "Future Climate Projections Clackamas County, Oregon"(2023)
[78] Multnomah County Health Department, Washington County Health Department, and Clackamas County health Department, "2012-2022 Regional Climate and Health Monitoring Report", 2023, P.18

- People experiencing houselessness and do not have means to shelter.
- Communities of color that have experienced historic redlining, structural exclusion, or lived in areas that have not been prioritized for public works enhancements.
- Communities that are geographically isolated or do not have backup systems for essential services like water, power, or travel routes damaged by extreme weather.[79]

Climate change has and is expected to continue to increase severe weather events and, therefore, increased exposure to potential injuries, illnesses, and deaths from both direct and indirect effects of these severe weather events. According to the Oregon Climate Change Research Institute, climate change is expected to increase the frequency and intensity of some weather incidents, such as extreme heat, winter storms, and windstorms.[80]

[79] Multnomah County Health Department, Washington County Health Department, and Clackamas County health Department, "2012-2022 Regional Climate and Health Monitoring Report", 2023, p.17
[80] Oregon Climate Change Research Institute (OCCRI), 6th Oregon Climate Assessment Report (2023). https://blogs.oregonstate.edu/occri/oregon-climate-assessments/

Extreme Heat

Extreme Heat Summary		Significant Changes Since Previous Update	Applicable Action Items
Hazard Ranking:	5	Content updated per 44 CFR 201.6(c)(2). A section on Future Projections added. Impact of extreme heat events on vulnerable populations included.	Priority: MH #1, MH #6, SW #1, SW #2
Total Threat Score:	150		
Probability:	Moderate		Other: MH #5
Vulnerability:	Moderate		

Characteristics

Extreme heat describes either a singular instance of dangerously high temperatures occurring on a given day or a prolonged period of high temperatures lasting over several days. Heat waves generally describe consecutive days of higher temperatures and most often occurring during summer. One approach to categorizing hazardous heat is when local temperatures exceed a heat index of 90 degrees Fahrenheit. This threshold is when the human body begins to suffer adverse effects of prolonged exposure to heat.

Extreme heat events are hazardous due to their impact on people and systems, both manmade and natural, and poses risks to human health and potential impacts on infrastructure operability and reliability. Prolonged exposure to heat can increase the likelihood of exhaustion, dehydration, heat cramps, heat stroke, and even death. Between 1999 and and 2020, there occurred a total of 15,707 heat-related deaths in the US, according to the Centers for Disease Control and Prevention[81]. That's more than hurricanes, lightning, tornadoes, floods and earthquakes combined[82].

As a result of these public health risks, hospitals see a spike in heat-related illnesses, especially from people working outdoors, who are at are at increased risk due to prolonged exposure, as well as impacts economic activities that be disrupted due to hazardous working conditions. In addition, extremely hot and consecutive days of high heat contribute to increased wildfire risk due to such reasons at the presence of dryer fuel load. Experiencing multiple heat waves in a season, and over several years, can also drive drought conditions and put stress wildlife such as trees and riverine species, such as salmon.

Location and Extent

A 2023 heat assessment conducted by Clackamas, Washington and Multnomah County Health Departments revealed that urban and suburban areas, particularly land uses with large concrete single story buildings and large parking areas experience the highest temperatures across the metro area.[83] Additionally, urban and suburban areas are where more people are concentrated and there tends to be less vegetation present to permit evaporation, as well as greater presence of cars and factories that give off heat, and the proximity of asphalt roads and buildings store and radiate heat can create heat island effects across the County. A heat island effect occurs when an areas become "islands" of higher

[81] CDC, "QuickStats: Death Involving Exposure to Excessive Heat, by Sex", https://www.cdc.gov/mmwr/volumes/71/wr/mm7134a5.htm
[82] National Weather Survey, "Weather Related Fatality and Injury Statistic", https://www.weather.gov/hazstat/
[83] CAPA Strategies, "Portland Metro Heat Watch Report", December 2023.

temperatures relative to outlying areas. On a hot summer day, urban areas can be 5°F to 18°F hotter than surrounding rural areas which is enough to turn a heat wave into a serious health crisis.[84] Additionallly, dense urban areas around city and neighborhood centers with low canopy cover (fewer trees) and majority impervious surfaces saw the highest temperatures. Land use classification areas of Multi-Family Residential, Mixed-Use Residential, Commercial and Industrial in particular were the hottest. The data generally shows that areas with lower tree canopy, more impervious surfaces, and lower population density had higher temperatures. The hottest areas were mainly in suburban cities that are located along major transportation corridors in the outskirts of the counties.

History

A severe heat episode or "heat wave" occurs about every two to three years and typically lasting two to three days but can last as many as five days. A severe heat episode can be defined as consecutive days of upper 90s to around 100. Severe heat hazard in the Portland metro region can be described as the average number of days we have temperatures greater than or equal to 90F and 100F. On average the region experiences 12.5days with temperatures above 90-degrees Fahrenheit, based on new 30-year climate averages (1951-2020), with an average of 17.3 days in the 2010s. Furthermore, in the Portland region, there were 24 days above 90 degrees Fahrenheit in 2021 and 29 days in 2022.[85]

As the number of days above 90 degrees Fahrenheit continues to increase in the county, so does the number of heat wave, including severe heat events that surpass 100 degrees Fahrenheit. Such an event occurred during the Oregon 2021 Heat Dome, in which between June 24-29, temperatures in the Portland region reached more than 112 degrees Fahrenheit, and other regions thrgouhout Clackamas County reaching upwards of 117 degrees Fahrenheit.[86] During this record-setting heat dome event, 94 people across Clackamas, Washington and Multnomah Counties died, compared to a typical year where the region would expect one heat-related death.[87]

Following this event, in July of 2022, the Portland region experienced seven consecutive days at or above 95 degrees Fahrenheit.[88] Each of these events triggered the opening of cooling centers throughout the County, many of which housed indivuals for days at time, due to their inability to reside safely and comfortably in their homes. As such events become more common, the necessity for cooling shelters will grow.

Prior to these extreme heat events, other severe heat episodes occuring in 2016 when cooling centers were opened in the County. Before that a five-day event in July 2009 delivered three consecutive days in excess of 100F and two days over 90F; high temperatures on July 28-29 of 2009 were recorded at 106F each day. Another event occurred in July 2006.

---

[84] Resources for the Future, “Urban Heath Islands 101”, https://www.rff.org/publications/explainers/urban-heat-islands-101/
[85] OCCRI, “Sixth Oregon Climate Assessment”,
[86] Smithsonian, “Heat Dome Scorches Pacific Northwest With Record-Breaking High Temperatures”, https://www.smithsonianmag.com/smart-news/heat-dome-scorches-pacific-northwest-180978085/
[87] Multnomah County Health Department, Washington County Health Department, and Clackamas County health Department, “2012-2022 Regional Climate and Health Monitoring Report”, 2023, p.3.
[88] OPB, “Pacific Northwest heat wave was a freak, 10,000-year event, study finds”, https://www.opb.org/article/2022/09/28/pacific-northwest-heat-wave-2021-oregon-summer-weather-heat-dome-climate-change/

Probability Assessment

Based on the available data and research the HMAC determined the probability of experiencing a long lasting extreme heat event is "**moderate**", meaning one incident is likely within the next 75 to 100-year period. *This rating has increased changed since the previous NHMP.*

Extreme heat events occur every few years within the region, and while they are generally not long lasting, they are growing in length, intensity, and occurance. Predicted average increases in summer temperatures will make heat waves a greater likelihood.

Future Projections [89] [90]

According to the Oregon Climate Change Research Institute "Future Climate Projections, Clackamas County," the number, duration, and intensity of extreme heat events will increase as temperatures continue to warm. In Clackamas County, the number of extremely hot days (days on which the temperature is 90°F or higher) and the temperature on the hottest day of the year are projected to increase by the 2020s and 2050s under both the lower (RCP 4.5) and higher (RCP 8.5) emissions scenarios. The number of days per year with temperatures 90°F or higher is projected to increase by an average of 12 (range 3–21) by the 2050s, relative to the 1971–2000 historical baselines, under the higher emissions scenario. The temperature on the hottest day of the year is projected to increase by an average of about 7°F (range 2–11°F) by the 2050s. Higher temperatures and longer/more extreme heat events will have negative impacts upon vulnerable populations such as those over 65+, children, those living in older or temporary housing, and field workers.

Vulnerability Assessment

The HMAC rated the county as having a "**moderate**" vulnerability to extreme heat, meaning that more than 10% of the unincorporated County's population or assets would be affected by an extreme heat event. *This rating has increased since the previous NHMP*.

Very high temperatures can create serious health problems. Heath problems related to high heat can include headache, dizziness and weakness. In extreme cases heat-related illness can cause convulsions and sudden loss of consciousness and can be fatal. Those at greatest risk for heat-related illness include infants and children up to 4 years of age, people 65 and older, people who are overweight, and people who are ill or on certain medications, as well as those who work outdoors.

Reducing risk and exposure to high heat is vital, and public health officials have shared information regardings best practices for personal safety and protection against high heat."Prevention is the best defense," said Mel Kohn, M.D., M.P.H., director of Oregon Public Health. "Drinking plenty of water, staying out of the sun during the hottest part of the day, knowing the warning signs of heat-related illness and taking precautions when swimming are a few important steps people can take." Kohn added: "We have had hot weather in the past, but with the climate change we are likely to have more high temperature days in Oregon."[91]

Without mitigation, increased numbers of extreme heat events will likely result in additional heat-related morbidity and mortality, especially among vulnerable populations. As the length and intensity of

[89] Oregon Climate Change Research Institute (OCCRI), 6th Oregon Climate Assessment Report (2023). https://blogs.oregonstate.edu/occri/oregon-climate-assessments/
[90] OCCRI, "Future Climate Projections Clackamas County, Oregon"
[91] Oregon Health Authority http://cms.oregon.gov/DHS/news/2010news/2010-0813.pdf

extreme heat events grow, so does the need for air conditioning, which poses an inequitably high cost burden on those who are financially insecure.

Inter-Hazard Impact and Outcomes – Extreme Heat[92]

As the primary natural hazard, a.k.a "the cause", extreme heat has both direct and indirect impacts on several other hazards, a.k.a. "the effect", and as a climate hazard, its impacts are further exacerbated by the effects of climate change.

- Drought – Direct: An extreme heat event occurring in an area already experiencing drought could further exacerbate the extent of it, as well as increasing the severity of the drought.
- Flood – Indirect: Warmer temperatures can increase evaporation, leading to more moisture being put into the atmosphere that then leads to heavier rain, which can then lead to more flash floods. Also, as warmer temperatures increase moisture evaporation (i.e., drought), this can further exacerbate the occurrence of a barer and arid landscapes, and as water is unable to adequately be saturated into the ground, this leads to higher chances of flash floods during times of rain.

[92] Nature Climate Change, "*Precipitation trends determine future occurrences of compound hot-dry events*", 2022

Windstorm

Windstorm Summary		Significant Changes Since Previous Update	Applicable Action Items
Hazard Ranking:	8	Content updated per 44 CFR 201.6(c)(2). A section on Future Projections added.	Priority: MH #1, MH #6, SW #1, SW #2
Total Threat Score:	121		
Probability:	Moderate		Other: MH #5
Vulnerability:	Low		

Characteristics

A windstorm is generally a short duration event involving straight-line winds and/or gusts in excess of 50 mph. Although windstorms can affect the entirety of Clackamas County, they are especially dangerous near developed areas with large trees or tree stands. The extent of any particular windstorm is determined by its track, intensity and local terrain.[93] In the northwest Oregon, wind speed is typically 60 mph for 25-year storm events, 70 mph for 50-year storm events and 80 mph for 100-year storm events. Clackamas County has experienced multiple 25-, 50- and 100-year windstorm events over the past century with impacts often occurring countywide. A windstorm will frequently knock down trees and power lines, damage homes, businesses, public facilities and create tons of storm related debris. Windstorms are a common, chronic hazard in Clackamas County.

Location and Extent

The most common type of wind pattern affecting Clackamas County is straight-line winds, which originate as a downdraft of rain-cooled air and reach the ground and spread out rapidly. Straight- line winds can produce gusts of 100 mph or greater. Records of major Pacific windstorms are documented by state agencies and weather stations throughout Oregon, including several official weather stations in Clackamas County's lower valleys. Table 2-19 shows the expected wind speeds from windstorm events in Clackamas County.

Typically, mountainous terrain slows down wind movement, which is why Oregon's sheltered valley areas have the slowest wind speed in the state. However, in the foothills, the wind speeds may increase due to down-sloping winds from the mountains. Although windstorms can affect the entirety of the county, they are especially dangerous in developed areas with significant tree stands and major infrastructure, especially above ground utility lines. A windstorm will frequently knock down trees and power lines, damage homes, businesses, public facilities and create tons of storm related debris.

History

The most destructive windstorm ever recorded in Oregon, in terms of loss of life and property damage, was the Columbus Day storm of 1962. Damage was most severe in the Willamette Valley. The storm killed thirty-eight people and did upwards of $200 million in damage (over $1.7 billion in today's dollars). Hundreds of thousands of homes were without power for short periods of time, while others were without power for two to three weeks. More than 50,000 homes were seriously damaged, and nearly 100 were completely destroyed. The storm destroyed fruit and nut orchards and killed scores of

[93] State of Oregon Natural Hazard Mitigation Plan (2020)

livestock. Intense wind speeds were recorded in the metropolitan areas with gusts of 116 mph on Portland's Morrison Bridge.

Clackamas County has experienced several high wind events. Other events include an event December 12, 1995 that has been described as the most significant event since the Columbus Day storm. A regional storm in early December 2007 that required a federal disaster declaration along the Oregon Coast brought high winds and heavy rain to the County

On March 13, 2011, 50 mph winds with 70 mph gusts brought trees down in numerous areas of the County and left power out for tens of thousands of residents. Damages were concentrated in the eastern half of the County along in communities like Molalla and Estacada in the Cascade foothills.

Windstorm damage – March 13, 2011

Source: Clackamas County Disaster Management

Since 2007 the National Weather Service reports three tornadoes that have touched down in or near Clackamas County: On January 10, 2008 an EF1 tornado touched down in Vancouver, Washington causing considerable damage; October 26, 2009 an EF0 tornado touched down near Oregon City causing damage to many houses; and on December 14, 2010 a damaging EF2 tornado struck in the City of Aumsville in Marion County not far from the southern border of Clackamas County. On October 12, 2017 another EF0 tornado touched down near Canby at the Aurora State Airport impacting airplanes and buildings.

Windstorms often occur with winter storms. Several additional, small windstorm events have occurred since the previous NHMP, see the Storm Events Database provided by the National Oceanic and Atmospheric Administration for more information. According to historical records, there have been an estimated six major windstorm events in the past 100 years, which is about one every 16-17 years.

Additionally, in Fall 2020, multiple days of high (average sustained winds of 20-30 mph with 50-60 mph gusts) fueled mutiple wildfires, causing them to rapidly spread, as well as requiring local power companies to enact controlled power outages along the Mount Hood corridor.[94] These wind during this event were identified as east, straight-line winds, that due to their directionality, are much more hot and arid in nature, thus further exacerbating wildfires.[95]

[94] OEM, "2020 Oregon Wildfire Spotlight", https://storymaps.arcgis.com/stories/6e1e42989d1b4beb809223d5430a3750
[95] Statesman Journal, "'A dangerous week': East winds, storms in Oregon could spread wildfires", https://www.statesmanjournal.com/story/news/2022/09/06/oregon-wildfires-could-spread-rapidly-with-dreaded-east-winds-forecast-oakridge-grants-pass-joseph/65612595007/

Probability Assessment

Based on the available data and research the HMAC determined the probability of experiencing a windstorm is "**moderate**", meaning one severe incident is likely within the next 35 to 75-year period. *This rating has not changed since the previous NHMP.*

Windstorms in the county usually occur in the winter from October to March and their extent is determined by their track, intensity (the air pressure gradient they generate) and local terrain. Summer thunderstorms may also bring high winds along with heavy rain and/ or hail. The National Weather Service uses weather forecast models to predict oncoming windstorms, while monitoring storms with weather stations in protected valley locations throughout Oregon.

Table 2-18 shows the wind speed probability intervals that structures 33 feet above the ground would expect to be exposed to within a 25, 50 and 100-year period. The table shows that structures in Region 2, which includes Clackamas County, can expect to be exposed to 65 mph winds in a 25-year recurrence interval (4% annual probability).

Table 2-18 Probability of Severe Wind Events Region 2 – Oregon NHMP

	25-Year Event (4% annual probability)	50-Year Event (2% annual probability	100-Event (1% annual probability)
Region 2: North Willamette Valley	65 mph	72 mph	80 mph

Source: Oregon State Natural Hazard Mitigation Plan, 2020

Future Projections [96][97]

Limited research suggests little if any change in the frequency and intensity of windstorms in the Northwest as a result of climate change. Those impacted by windstorms at present, including older residential or commercial developments with above-ground utilities, poor insulation or older construction, heavy tree canopies, or poor storm drainage, will continue to be impacted by windstorms in the future.

Vulnerability Assessment

The HMAC rated the county as having a "**low**" vulnerability to windstorm hazards, meaning that less than 1% of the unincorporated County's population or assets would be affected by a major disaster. *This rating has not changed since the previous NHMP.*

Some groups and communities experience greater impacts based on their ability to prepare for, whithstand, and recover from events. According to the Climate and Helath Monitoring Report, the following groups face higher risks:

- Older adults, children, people who use mobility devices, and people with disabilities who are unable to find protection from a storm or have limited access to transportation.
- People who have less capacity or fewer resources to gather supplies for extreme weather events, as well as to cover costs related to post-storm recovery.

[96] Oregon Climate Change Research Institute (OCCRI), 6th Oregon Climate Assessment Report (2023). https://blogs.oregonstate.edu/occri/oregon-climate-assessments/
[97] OCCRI, "Future Climate Projections Clackamas County, Oregon"

- Communities who are isolated culturally, linguistically, or by technology barriers, like limited internet, may not have access to appropriate emergency communications.
- People experiencing houselessness and do not have means to shelter.
- Communities of color that have experienced historic redlining, structural exclusion, or lived in areas that have not been prioritized for public works enhancements.
- Communities that are geographically isolated or do not have backup systems for essential services like water, power, or travel routes damaged by extreme weather.[98]

Many buildings, utilities and transportation systems within Clackamas County are vulnerable to wind damage. This is especially true in open areas, such as natural grasslands or farmlands. It is also true in forested areas, along tree-lined roads and electrical transmission lines and on residential parcels where trees have been planted or left for aesthetic purposes. Structures most vulnerable to high winds include insufficiently anchored manufactured homes and older buildings in need of roof repair.

Fallen trees are especially troublesome, posing as potential dangers to the surrounding structures, infrastructure, and lives. They can block roads and rails for long periods of time, impacting emergency operations. In addition, up-rooted or shattered trees can down power and/or utility lines and effectively bring local economic activity and other critical facilities to a standstill. Much of the problem may be attributed to a shallow or weakened root system in saturated ground. In Clackamas County, trees are more likely to blow over during the winter (wet season).

More information on this hazard can be found in the Risk Assessment for Region 2, Northern Willamette Valley/Portland Metro, of the Oregon NHMP (2020).

Inter-Hazard Impact and Outcomes – Windstorm[99]

As the primary natural hazard, a.k.a "the cause", windstorm has direct impacts on several other hazards, a.k.a. "the effect", and as a climate hazard, its impacts are further exacerbated by the effects of climate change.

- Wildfire – Direct: Wind can directly impact wildfire in a number of ways. First, wind aids combustion by increasing its oxygen supply, which can further exacerbate a wildfire that is already started. Also, wind can carry heat and burning embers beyond it ignition site, spreading the wildfire and increasing it extent and impact.
- Winter Storm – Direct: Windstorms can directly impact winter storms as strong wind can pick up and carry available snow from the ground, or blow falling snow, thus leading to low visibility and potentially significant snow drifts.

[98] Multnomah County Health Department, Washington County Health Department, and Clackamas County health Department, "2012-2022 Regional Climate and Health Monitoring Report", 2023, p.17
[99]National Oceanic and Atmospheric Administration, Ask the scientist: How can the weather spark and spread wildfires?, 2018

Winter Storm

Winter Storm Summary		Significant Changes Since Previous Update	Applicable Action Items
Hazard Ranking:	4	Content updated per 44 CFR 201.6(c)(2). A section on Future Projections added.	Priority: MH #1, MH #6, SW #1, SW #2
Total Threat Score:	161		
Probability:	Moderate		Other: MH #5
Vulnerability:	Moderate		

Characteristics

Winter storms affecting Clackamas County are generally characterized by a combination of heavy rains and high winds throughout the county, sometimes with snowfall, especially at higher elevations in the eastern portion of the County. Heavy rains can result in localized or widespread flooding, as well as debris slides and landslides. High winds commonly result in tree falls which primarily affect the electric power system, but which may also affect roads, buildings and vehicles.

This chapter deals primarily with the snow and ice effects of winter storms, as well as extreme cold:

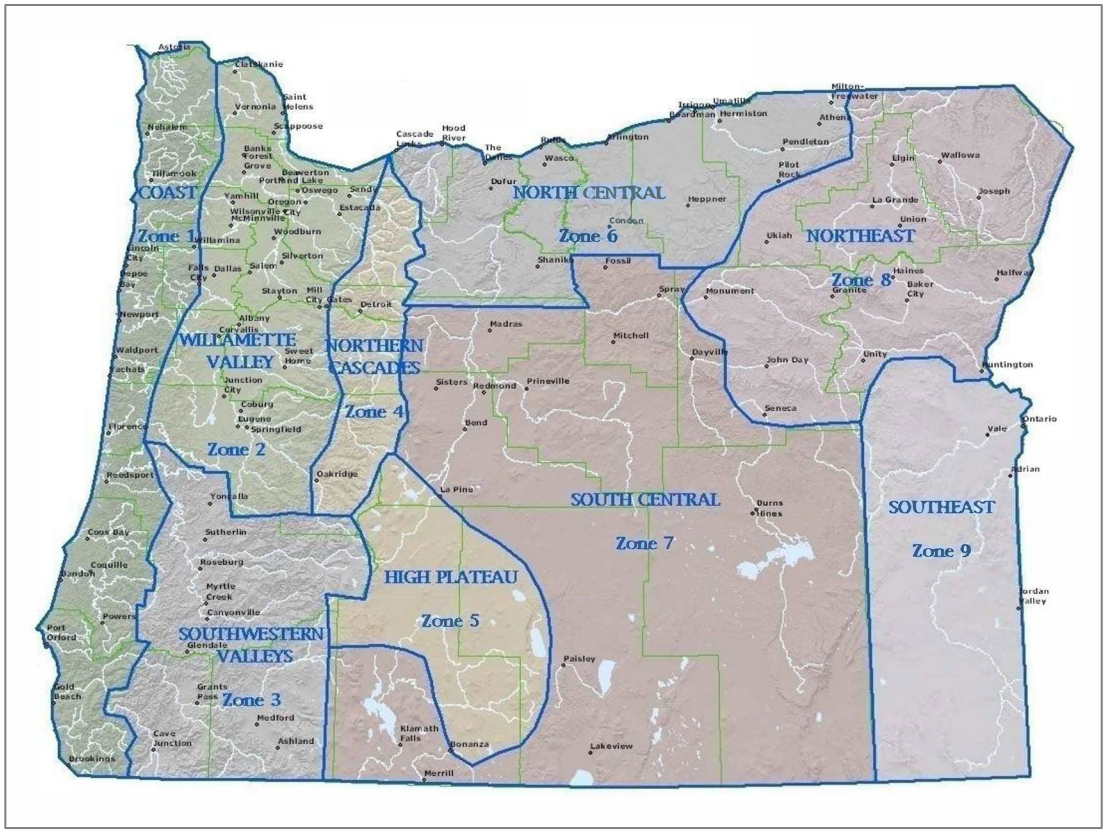
- Snowstorms: require three ingredients: cold air, moisture, and air disturbance. The result is snow, small ice particles that fall from the sky. In Oregon, the further inland and north one moves, the more snowfall can be expected. Blizzards are included in this category.
- Ice storms: are a type of winter storm that forms when a layer of warm air is sandwiched by two layers of cold air. Frozen precipitation melts when it hits the warm layer and refreezes when hitting the cold layer below the inversion. Ice storms can include sleet (when the rain refreezes before hitting the ground) or freezing rain (when the rain freezes once hitting the ground).
- Extreme Cold: Dangerously low temperatures accompany many winter storms. This is particularly dangerous because snow and ice storms can cause power outages, leaving many people without adequate heating.

Outside of mountainous areas, significant snow accumulations are much less likely in western Oregon than on the east side of the Cascades. However, if a cold air mass moves northwest through the Columbia Gorge and collides with a wet Pacific storm, then a larger than average snow fall may result.

Location and Extent

The National Climatic Data Center has established climate zones in the United States for areas that have similar temperature and precipitation characteristics. Oregon's latitude, topography and proximity to the Pacific Ocean give the state diversified climates. Map 2-6 shows that Clackamas County is located within Zone 2: Willamette Valley and Zone 4: Northern Cascades. Winter storm events have relatively predictable and longer speeds of onset and the effects of winter storms are often long lasting. The area of Clackamas County within Zone 4 generally has longer lasting winter storms that include colder temperatures and greater snow depth.

Map 2-6 Oregon Climate Divisions – Oregon Climate Service



Source: Oregon Climate Service.

The winter storms that affect Clackamas County typically are not local events affecting only small geographic areas. Rather, winter storms are usually large cyclonic low-pressure systems that move in from the Pacific Ocean and affect large areas of Oregon and/or the whole Pacific Northwest. These storms are most common from October through March.

Ice storms are comprised of cold temperatures and moisture, but subtle changes can result in varying types of ice formation which may include freezing rain, sleet and hail. Of these, freezing rain can be the most damaging of ice formations.

History

Winter storms occur yearly; more destructive storms occur once or twice per decade, most recently in 2023. Other winter storm events occurred in 1996, 2004, 2008, 2011, 2012, 2014, 2015, 2016, 2017, 2021, and 2023. The 2008 (DR-1824), 2011 (DR-1956), 2012 (DR-4055), 2016 (DR-4258), 2017 (DR-4296), and 2021 (DR-4599) events included disaster declarations.

Car covered in ice, 2004

Source: Clackamas County Disaster Management

The County has recevied multiple FEMA Disaster Declarations for extended severe winter weather events. Once during an event taking place between December 22 through December 28, 2008, and again during an event taking place between February 11 through February 15, 2021. During both event, Clackamas County (and throughout Oregon) experienced heavy snow accumulations, ice, and sustained freezing temperatures that caused extensive property damage. Transportation networks were significantly affected, as major freeways railways, and the Portland International Airport were periodically closed.

Downed trees disrupted power to several portions of the county, leaving many residents without heat or water for several days. Residential care facilities, home-bound ill personnel requiring daily treatment, hospital patients, and anyone requiring emergency assistance was affected by this winter storm because obstructed roadways prevented emergency vehicle movement. The damage to fire stations, equipment, roads, and other infrastructure affected the ability to effectively respond, as well as reducing the operating budgets of these facilities.

Probability Assessment

Based on the available data and research the HMAC determined the probability of experiencing a winter storm is "**moderate**", meaning one incident is likely within the next 35 to 75-year period. *This rating has not changed since the previous NHMP*.

The recurrence interval for a moderate to severe winter storm is about once every year; however, there can be many localized storms between these periods. Severe winter storms occur in western Oregon regularly from November through February. Clackamas County experiences moderate winter storms every year to every other year, more damaging winter storms happen less often. According to historical records, there have been an estimated 16 severe winter storm events in the past 100 years, which is about one every six years.

Future Projections [100] [101]

According to the Oregon Climate Change Research Institute "Future Climate Projections, Clackamas County," cold extremes will become less frequent and intense as the climate warms. In Clackamas County, the number of cold days (maximum temperature 32°F or lower) per year is projected to decrease by an average of 6 (range -3– -8) by the 2050s, relative to the 1971–2000 historical baselines, under the higher emissions scenario. The temperature on the coldest night of the year is projected to increase by an average of 6°F (range 0– 11°F) by the 2050s.

[100] Oregon Climate Change Research Institute (OCCRI), 6th Oregon Climate Assessment Report (2023). https://blogs.oregonstate.edu/occri/oregon-climate-assessments/
[101] OCCRI, "Future Climate Projections Clackamas County, Oregon"

The intensity of extreme precipitation is expected to increase as the atmosphere warms and holds more water vapor. In Clackamas County, the number of days per year with at least 0.75 inches of precipitation is not projected to change substantially. However, by the 2050s, the amount of precipitation on the wettest day and wettest consecutive five days per year is projected to increase by an average of 15% (range 0–31%) and 10% (range -1–26%), respectively, relative to the 1971–2000 historical baselines, under the higher emissions scenario.

Vulnerable populations will be more likely to experience the negative impacts of winter storms in the future, particularly the unhoused and the elderly.

Vulnerability Assessment

The HMAC rated the County as having a "**moderate**" vulnerability to winter storm hazards, meaning that between 1 and 10% of the unincorporated County's population or assets would be affected by a major disaster. *This rating has not changed since the previous NHMP*.

Given current available data, no quantitative assessment of the risk of winter storm was possible at the time of this NHMP update. However, assessing the risk to the County from winter storms should remain an ongoing process determined by community characteristics and physical vulnerabilities. Weather forecasting can give County resources (emergency vehicles, warming shelters) time to prepare for an impending storm, but the changing character of the County population and resources will determine the impact of winter storms on life and property in Clackamas County.

The most likely impact of snow and ice events on Clackamas County are road closures limiting access/egress to/from some areas, especially roads to higher elevations. Winter storms with heavy wet snow or high winds and ice storms may also result in power outages from downed transmission lines and/or poles.

Winter storms which bring snow, ice and high winds can cause significant impacts on life and property. Many severe winter storm deaths occur as a result of traffic accidents on icy roads, heart attacks may occur from exertion while shoveling snow and hypothermia from prolonged exposure to the cold. The temporary loss of home heating can be particularly hard on the elderly, young children and other vulnerable individuals.

Similar to other extreme weather hazards, some groups and communities experience greater impacts based on their ability to prepare for, whithstand, and recover from events. According to the Climate and Helath Monitoring Report, the following groups face higher risks:

- Older adults, children, people who use mobility devices, and people with disabilities who are unable to find protection from a storm or have limited access to transportation.
- People who have less capacity or fewer resources to gather supplies for extreme weather events, as well as to cover costs related to post-storm recovery.
- Communities who are isolated culturally, linguistically, or by technology barriers, like limited internet, may not have access to appropriate emergency communications.
- People experiencing houselessness and do not have means to shelter.
- Communities of color that have experienced historic redlining, structural exclusion, or lived in areas that have not been prioritized for public works enhancements.

- Communities that are geographically isolated or do not have backup systems for essential services like water, power, or travel routes damaged by extreme weather.[102]

Property is at risk due to flooding and landslides that may result if there is a heavy snowmelt. Additionally, ice, wind and snow can affect the stability of trees, power and telephone lines and TV and radio antennas. Downed trees and limbs can become major hazards for houses, cars, utilities and other property. Such damage in turn can become major obstacles to providing critical emergency response, police, fire and other disaster recovery services.

Severe winter weather also can cause the temporary closure of key roads and highways, air and train operations, businesses, schools, government offices and other important community services. Below freezing temperatures can also lead to breaks in un-insulated water lines serving schools, businesses, industries and individual homes. All of these effects, if lasting more than several days, can create significant economic impacts for the affected communities and the surrounding region. In the rural areas of the county severe winter storms can isolate small communities, farms, and ranches.

At the time of this update, sufficient data was not available to determine winter storm vulnerability in terms of explicit types and numbers of existing and future buildings, infrastructure or critical infrastructure.

More information on this hazard can be found in the Risk Assessment for Region 2, Northern Willamette Valley/Portland Metro, of the Oregon NHMP (2020).

Inter-Hazard Impact and Outcomes – Winter Storm[103] [104]

As the primary natural hazard, a.k.a "the cause", winter storm has both direct and indirect impacts on several other hazards, a.k.a. "the effect", and as a climate hazard, its impacts are further exacerbated by the effects of climate change.

- Flood – Both: Winter storms can have direct and indirect impacts on floods. Directly, during winter storms, an area can be inundated with snow, which when temperatures rise, the snow melts quickly. As such, the melted snow lacks places to be absorbed, which increases the risk of flooding. Indirectly, when snow thaws too rapidly to be adequately absorbed back into the soil, surrounding bodies of water or drainage systems will be filled with the melted snow, leading to potential flooding.
- Landslide – Both: Winter storms can have direct and indirect impacts on landslides. Directly, the excess weight from the accumulation of snow and rain can put stress on weak and steep slopes. Indirectly, due to the excess water from melting snow (potentially leading to flooding), rock and soil can become weakened by becoming over saturated from heavy rain, leading to greater risk of landslides to occur in the future.

[102] Multnomah County Health Department, Washington County Health Department, and Clackamas County health Department, "2012-2022 Regional Climate and Health Monitoring Report", 2023, p.17
[103] Washington Emergency Management Division, *Landslide*
[104] Seattle Pi – Education, Do Blizzards Affect the Environment

Volcanic Event

Volcanic Event Summary		Significant Changes Since Previous Update	Applicable Action Items
Hazard Ranking:	10	Content updated per 44 CFR 201.6(c)(2). A section on Future Projections added.	Priority: MH #1
Total Threat Score:	84		
Probability:	Low		Other: MH #5, VE #1, VE #2
Vulnerability:	Moderate		

Characteristics

The Pacific Northwest, lies within the "ring of fire," an area of very active volcanic activity surrounding the Pacific Basin. Volcanic eruptions occur regularly along the ring of fire, in part because of the movement of the Earth's tectonic plates. The Earth's outermost shell, the lithosphere, is broken into a series of slabs known as tectonic plates. These plates are rigid, but they float on a hotter, softer layer in the Earth's mantle. As the plates move about on the layer beneath them, they spread apart, collide, or slide past each other. Volcanoes occur most frequently at the boundaries of these plates and volcanic eruptions occur when molten material, or magma, rises to the surface.

Location and Extent

Proximity has a direct relationship to volcanic impacts, though additional factors do also effect impact, including climatic and circumstantial factors, such as wind direction, snowpack, season of occurrence, etc. These factors will impacts lava flows, pyroclastic flows, lahars, as well as ashfall. Lahars could travel many miles down upper river valleys, dependent on snow/ice volume melted by the eruption. Ashfall is also expected to occur within 20 miles of the vent, through climatic factors could increase this, such as wind conditions altering ash plume drift.

These factors can have significant impact on how an event will impact the overall area. Table 2-19 lists the threat potential for volcanoes in Oregon, including distance from the volcano to urban Clackamas County (distance from Oregon City).

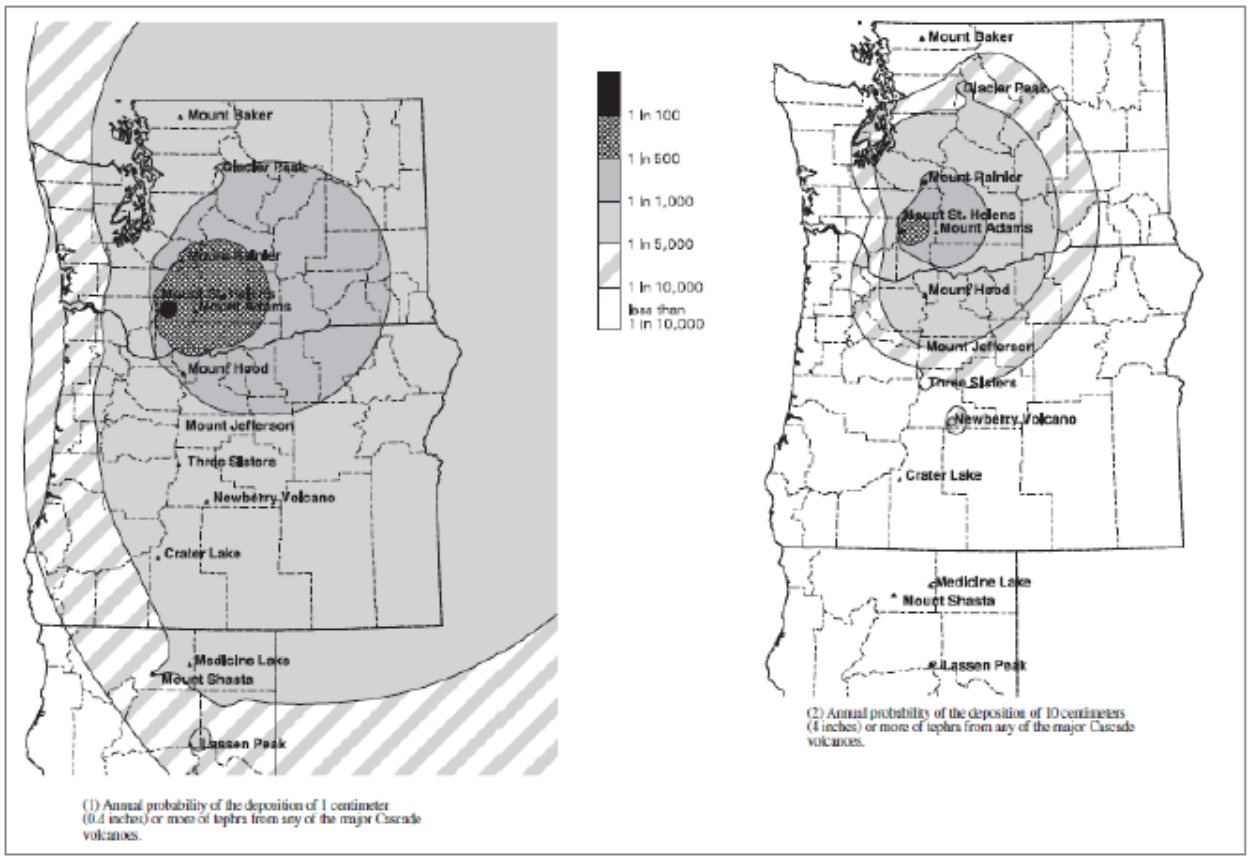
Table 2-19 Threat Potential for Volcanoes in Oregon and Distance from Clackams County

Mountain / Volcano	Threat Potential	Distance in miles to Clackamas County (*Oregon City)
Mount Hood	High to Very High	60
Three Sisters	High to Very High	175
Mount Bachelor	High to Very High	180
Newberry	High to Very High	200
Crater Lake	High to Very High	270
Belknap	Moderate	150
Mount Jefferson	Low to Very Low	110
Black Butte Crater Lava Field	Low to Very Low	235
Davis Lake Volcanic Field	Low to Very Low	200

Source: USGS Volcano Hazards Program
*Distance from Volcano is measured from Oregon City, a central urban center of Clackamas County and the County Seat.

Scientists use wind direction to predict areas that might be affected by volcanic ash; during an eruption that emits ash, the ash fall deposition is controlled by the prevailing wind direction. The predominant wind pattern over the Cascades originates from the west and previous eruptions seen in the geologic record have resulted in most ash fall drifting to the east of the volcanoes. Map 2-7 shows the annual probability of ten centimeters or more of ash accumulation from Pacific Northwest volcanoes. depicts the potential and geographical extent of volcanic ash fall in excess of ten centimeters from a large eruption of Mt. St. Helens.

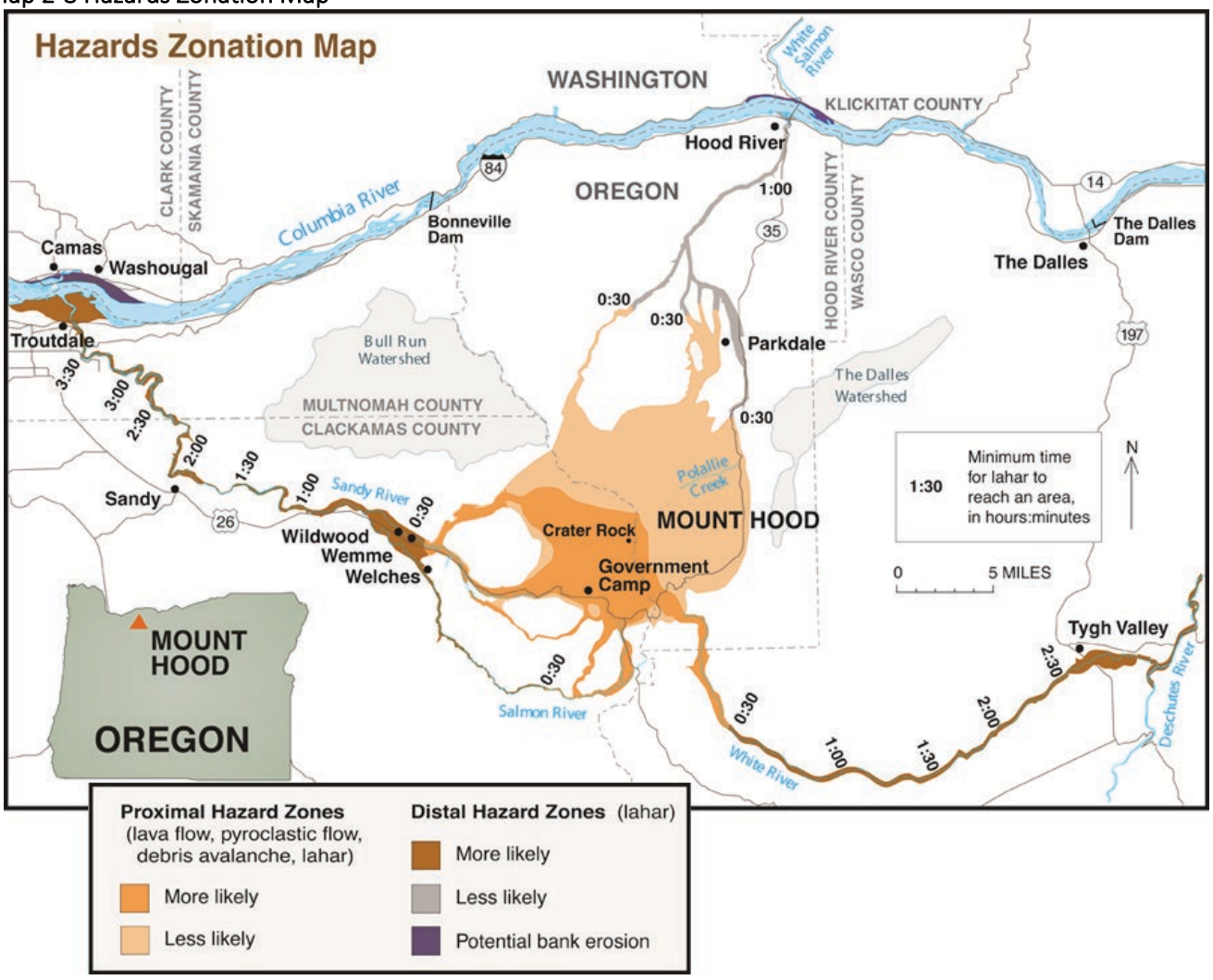
Map 2-7 Regional Tephra-fall Maps – USGS



Source: USGS "Volcano Hazards in the Mount Jefferson Region, Oregon"

The USGS/Cascades Volcano Observatory (CVO) produced a volcanic hazard zonation report for Mount Hood in 1997 and 2000. The report includes a description of potential hazards that may occur to immediate communities. The hazard zones illustrated on Map (USGS 060-00) were determined based on the distance from the volcano, vent location, and type of hazardous events (Map 2-8). The two proximal zones show two potential eruptive scenarios. The zone shown in peach indicates failure of the vents on the north, east, or western flanks. The proximal hazard zone shown in orange is the more likely scenario, which is a failure of the lava dome, Crater Rock, and primarily would affect the drainages in the Sandy River basin in Clackamas County.

Map 2-8 Hazards Zonation Map



Source:USGS, Cascades Volcano Observatory, Volcano Hazards Program

Geologic hazard maps have been created for most of the volcanoes in the Cascade Range (including Mt. St Helens, Mt. Adams, Mt. Hood, and Mt. Jefferson) by the USGS Volcano Program at the Cascade Volcano Observatory in Vancouver, WA and are available at http://vulcan.wr.usgs.gov/Publications/hazards_reports.html. Volcanic activity from more distant volcanoes will have less impact upon the County.

Refer to the following DOGAMI reports for additional information:

- Multi-Hazard Risk Report for the Clackamas County, Oregon: Including the cities of Barlow, Canby, Estacada, Gladstone, Happy Valley, Johnson City, Lake Oswego, Milwaukie, Molalla, Oregon City, Rivergrove, Sandy,West Linn, and Wilsonville and the unincorporated communities of Molalla Prairie, Mulino Hamlet, Stafford Hamlet, and The Villages at Mt Hood (2024).
- Multi-Hazard Risk Report for the Lower Columbia-Sandy Watershed, Oregon: Including the cities of Gresham, Sandy, and Troutdale and Unincorporated Communities of Government Camp and The Villages at Mt Hood (2020, O-20-06).

- Multi-Hazard and Risk Study for the Mount Hood Region (2011, O-11-16). *Portions of the volcano section superseded by the Multi-Hazard Risk Report for the Lower Columbia-Sandy Watershed*. See also, Mount Hood Hazards and Assets Viewer.

Additional reports are available via DOGAMI's Publications Search website:

https://www.oregon.gov/dogami/pubs/Pages/pubsearch.aspx

Other agency/ consultant reports:

- Mathie, A.M., and Wood, N., 2013, Residential and service-population exposure to multiple natural hazards in the Mount Hood region of Clackamas County, Oregon: U.S. Geological Survey Open-File Report 2013–1073, available at http://pubs.usgs.gov/of/2013/1073/.
- Ewert, J.W., Diefenbach, A.K., and Ramsey, D.W., 2018, 2018 update to the U.S. Geological Survey national volcanic threat assessment: U.S. Geological Survey Scientific Investigations Report 2018–5140, 40 p., https://doi.org/10.3133/sir20185140.

History

Mount Hood and Mount St. Helens are two active volcanoes near Clackamas County. Mount Hood is several hundred miles north of the county and is more than 500,000 years old. It has had two significant eruptive periods, one about 1,500 years ago and another about 200 years ago. Mount St. Helens is in southern Washington State and has been active throughout its 50,000-year lifetime. In the past 200 years, seven of the Cascade volcanoes have erupted, including (from north to south): Mt. Baker, Glacier Peak, Mt. Rainier, Mount St. Helens (Washington), Mt. Hood (Oregon), Mt. Shasta and Mt. Lassen (California).

There has been no recent volcanic activity near the county associated with Mount Hood. The 1980 explosion of Mount St. Helens in southern Washington State is the latest on record; both Mount St. Helens and Mount Hood remain listed as active volcanoes.

Probability Assessment

Based on the available data and research the HMAC determined the probability of experiencing volcanic activity is "low", meaning one incident is likely within the next 75 to 100-year period. *This rating has not changed since the previous NHMP.*

The Sandy River drainage is within proximal hazard Zone PA and has a return period of 5000 to 1,000 years (0.1% to 0.2% annual chance of occurrence).[105]

The United States Geological Survey-Cascades Volcano Observatory (CVO) produced volcanic hazard zonation reports for Mount St. Helens and Mount Hood in 1995 and 1997. The reports include a description of potential hazards that may occur to immediate communities. The CVO created an updated annual probability of tephra (ash) fall map for the Cascade region in 2001, which could be a rough guide for Clackamas County in forecasting potential tephra hazard problems (Figure 2-17). The map identifies the location and extent of the hazard.

The CVO Volcanic tephra fall map is based on the combined likelihood of tephra-producing eruptions occurring at Cascade volcanoes. Probability zones extend farther east of the range because winds blow

[105] DOGAMI, 2011. Multi-Hazard and Risk Study for the Mount Hood Region, Multnomah, Clackamas, and Hood River Counties, Oregon, Open File Report O-11-13.

from westerly directions most of the time. The map shows annual probabilities for a fall of one centimeter (about 0.4 inch). The patterns on the map show the dominating influence of Mount St. Helens as a tephra producer. Because small eruptions are more numerous than large eruptions, the probability of a thick tephra fall at a given locality is lower than that of a thin tephra fall. The annual probability of a fall of one centimeter or more of tephra is about 1 in 10,000 for Clackamas County. This is small when compared to other risks faced by the County.

Future Projections

Although the science of volcano predictions is improving, it remains challenging to predict a potential volcanic event. Ash fall, which will be the greatest impact, will impact the entire County. Impacts will be felt hardest by property managers (ranches, farmers, etc.) and by those relying upon clean surface water (for drinking water production and irrigation).

Vulnerability Assessment

The HMAC rated the county as having a "**moderate**" vulnerability to volcanic activity, meaning that between 1-10% of the unincorporated County's population or assets would be affected by a major disaster (volcanic ash/lahar). *This rating has not changed since the previous NHMP.*

The U.S. Geological Survey (USGS) lists the threat potential of volcanoes. According to the USGS there are nine volcanoes with Very High or High threat potentials in Oregon and Washington (listed here in order of threat potential): Mount St. Helens, Mount Rainier, Mount Hood, Three Sisters, Newberry, Mount Baker, Glacier Peak, Crater Lake, and Mount Adams (High).[106]

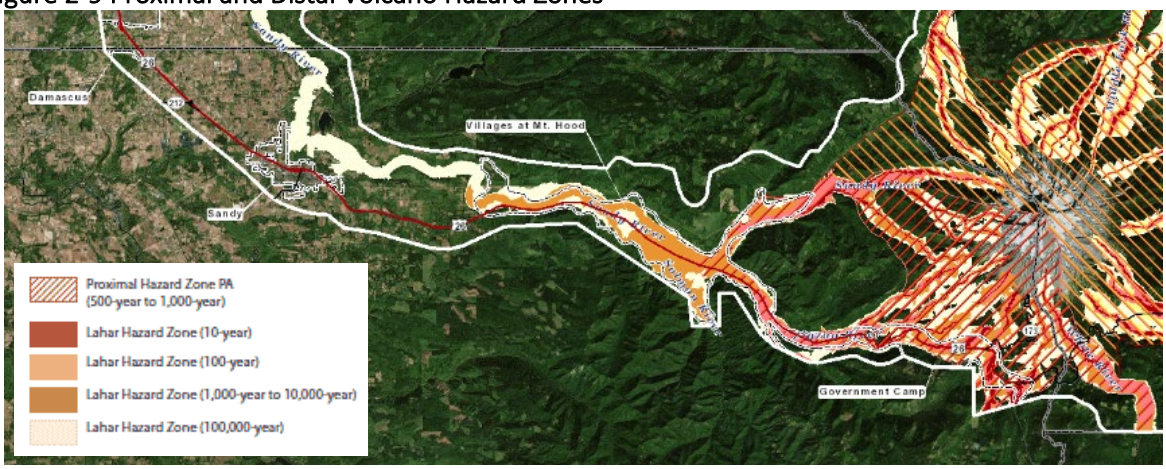
The primary threat to lives and property from active volcanoes is from violent eruptions that unleash tremendous blast forces, generate mud and debris flows (lahars), or produce flying debris and ash clouds. Volcano hazards are divided into proximal (near the volcano) and distal (far from the volcano). Mount Hood poses the greatest threat to the population of Clackamas County. Proximal hazard zones for Mount Hood are about 15 miles from the summit and are subject to several hazards including rapidly moving landslides, pyroclastic surges, and debris avalanches. The Sandy Watershed is located within proximal hazard Zone PA (Figure 2-9).

The most severed, widespread, and hazardous consequence of a Mount Hood eruption would include lahars sweeping down the length of the Sandy River valley impacting Government Camp, The Villages at Mount Hood, and the City of Sandy. A Mount Hood eruption could impact up to 68 percent of homes, 60 percent of residents, 73 percent of businesses and 87 percent of employees in the Hoodland Area (including parts of Clackamas and Hood River counties). A mega-eruption scenario would increase population exposure, but the increase is not substantial—typically 10 percent or less of an increase in population exposed.

Population exposure to volcano hazards is largest in the proximal hazard zone, including 65 percent of the local workforce, 80 percent of educational facilities, 82 to 100 percent of daytime visitors to recreation sites (summer and winter month averages, respectively), and approximately two thirds of overnight visitors.

[106] Ewert, J.W., Diefenbach, A.K., and Ramsey, D.W., 2018, 2018 update to the U.S. Geological Survey national volcanic threat assessment: U.S. Geological Survey Scientific Investigations Report 2018–5140, 40 p., https://doi.org/10.3133/sir20185140.

Figure 2-9 Proximal and Distal Volcano Hazard Zones



Source: DOGAMI, Mount Hood Hazards and Assets Viewer

According to County GIS about 8% of total county acres are exposed to volcano hazards. These areas are centralized around potential failure areas in the proximal zone, as well as the Sandy River valley in the distal zones. Only 5% of total county parcels are exposed, as the volcanic landscape generally does not lend itself well to development (Table 2-20).

Volcanic activity from ash clouds that drift downwind to the county from near or distant eruptions is possible from Mount Saint Helens, Three Sisters, Mount Bachelor and the Newberry Crater areas. Because the distance to these potentially active volcanic areas is so great, the only adverse effect that would impact areas of Clackamas County is ash fallout, with perhaps some impact on water supplies. The area affected by ash fallout depends upon the height attained by the eruption column and the atmospheric conditions at the time of the eruption. Volcanic ash can contaminate water supplies, cause electrical storms, create health problems and collapse roofs.

The amount of property exposed to the volcanic eruption hazard area, as well as the type and value of structures on those properties, is calculated to provide a working estimate for potential volcanic eruption losses.

Risk to Life & Property: High

Proximal Hazard Zones 1 and 2 are areas subject to rapidly moving debris avalanches, pyroclastic flows, and lahars that can reach the hazard boundary in less than 30 minutes, as well as slow-moving lava flows. Areas within proximal hazard zones should be evacuated before an eruption begins because there is little time to get people out of harm's way once an eruption starts. Most pyroclastic flows, lava flows, and debris avalanches will stop within the proximal hazard zone, but lahars can travel much farther. Evacuation may prove problematic, as volcanoes are difficult to predict, and there is only one primary route (Hwy 26 off the mountain. In addition, Mount Hood is a prime destination for visitors during all seasons. For these reasons, the threat to life is quite high.

Risk to Critical Facilities and Infrastructure: High

Distal Hazard Zone 3 includes areas adjacent to rivers that are pathways for lahars. Estimated travel time for lahars to reach these zones is more than 30 minutes, which may allow individuals time to move to higher ground and greater safety if given notice. Lahars could affect transportation corridors by damaging or destroying roads and can damage Bull Run pipelines that cross the Sandy River. Although

only one critical facility is exposed to the volcano hazard, the effect of lahars and pyroclastic flows and ashfall on equipment and infrastructure will be devastating.

Inter-Hazard Impact and Outcomes – Volcanic Event[107] [108]

As the primary natural hazard, a.k.a "the cause", a volcanic event has both direct and indirect impacts on several other hazards, a.k.a. "the effect".

- Earthquake – Both: Volcanic events can cause two different types of earthquakes. The first is volcanic-tectonic earthquakes, in which the movement of magma beneath the surface of the earth, and this movement causes pressure changes, and this stress causes underlying rocks to move and break leading to an earthquake. The second is volcanic long-period earthquakes, where vibrations are generated by the movement of magma and other volcanic fluids, which leads to pressure building and surrounding rocks to fall, leading to small earthquakes.
- Landslide – Both: Volcanic events can create lahars, which are mudflow and debris flows that originate on the slope of a volcano and are caused by rapid melting of snow and ice during eruptions. Also, landslides can occur when hydrothermal processes and activity weaken the slopes of volcanoes, which can cause rock formations to break and fall, causing landslides.

Natural Hazard Risk Reports for Clackamas County

The **Risk Reports** (**DOGAMI, 2024 and 2020**) provide hazard analysis summary tables that identify populations and property within the Lower Columbia-Sandy River Watershed Study Area and countywide that are vulnerable to the volcanic event (lahar) hazard. Volume III, Appendix D provides detailed Community Risk Profile tables for the unincorporated area of Clackamas County.

According to the Risk Reports the following population and property within the study area may be impacted by the profiled events (*where data is provided in both reports the newer data is presented below)*:

Unincorporated Clackamas County[109]

Volcanic Event (lahar): Exposure was not modeled in this area. Exposure exists within the Sandy River Watershed from Mt Hood to the Columbia River (Map 2-8 and Figure 2-9).

Government Camp[110]

Volcanic Event (lahar): 412 buildings are exposed to the volcanic lahar hazard (0 critical facilities) with a total buidling value of $140.34 million (an exposure ratio of about 49%). In addition, 958 residents may be displaced (about 71% of the population).

Molalla Prairie[111]

Volcanic Event (lahar): There is no exposure to this hazard witih this community.

[107] Pacific Northwest Seismic Network, *Volcanic Earthquakes*
[108] USGS, Landslides are common on tall, steep, and week volcanic cones
[109] DOGAMI, Multi-Hazard Risk Report for Clackamas County, Oregon (2024), Table A-1.
[110] DOGAMI, Multi-Hazard Risk Report for Clackamas County, Oregon (2024), Table A-3.
[111] DOGAMI, Multi-Hazard Risk Report for Clackamas County, Oregon (2024), Table A-5.

Mulino Hamlet[112]

Volcanic Event (lahar): There is no exposure to this hazard witih this community.

Stafford Hamlet[113]

Volcanic Event (lahar): There is no exposure to this hazard witih this community.

The Villages at Mt. Hood[114]

Volcanic Event (lahar): 255 buildings are exposed to the volcanic lahar hazard (0 critical facilities) with a total buidling value of $79.46 million (an exposure ratio of about 6%). In addition, 622 residents may be displaced (about 7% of the population).

[112] DOGAMI, Multi-Hazard Risk Report for Clackamas County, Oregon (2024), Table A-7.
[113] DOGAMI, Multi-Hazard Risk Report for Clackamas County, Oregon (2024), Table A-9.
[114] DOGAMI, Multi-Hazard Risk Report for Clackamas County, Oregon (2024), Table A-11.

Wildfire

Wildfire Summary		Significant Changes Since Previous Update	Applicable Action Items
Hazard Ranking:	1	Content updated per 44 CFR 201.6(c)(2). A section on Future Projections added. Quantitative risk assessment added (DOGAMI Risk Report).	Priority: MH #1, MH #6, WF #1, WF #2, WF #3
Total Threat Score:	189		
Probability:	High		Other: MH #5, MH #7
Vulnerability:	Moderate		

Recent fires in Oregon and across the western United States have increased public awareness of the potential losses to life, property, and natural and cultural resources. In June of 2004, the Board of Clackamas County Commissioners (BCC) directed the County Departments to work with state and federal agencies, fire protection districts, and community organizations throughout the County to develop an integrated wildfire plan. The BCC initiated this effort to reduce wildfire risk to residents, the environment, and quality of life within Clackamas County.

The Clackamas County Community Wildfire Protection Plan (CWPP) was adopted in 2024. The updated CWPP includes risk mapping consistent with Senate Bills 762 and 80. The CWPP is hereby incorporated into this NHMP by reference and it will serve as the wildfire chapter. The following presents a brief summary of key information; refer to the full CWPP for a complete description and evaluation of the wildfire hazard.

Characteristics

Wildfires occur in areas with large amounts of flammable vegetation that require a suppression response due to uncontrolled burning. Fire is an essential part of Oregon's ecosystem, but can also pose a serious threat to life, health, and property particularly in the state's growing rural communities. The increase in residential development in the wildland-urban interface (WUI) areas has resulted in greater wildfire risk. Fire has historically been a natural wildland element and can sweep through vegetation that is adjacent to a combustible home. New residents in remote locations are often surprised to learn that in moving away from built-up urban areas, they have also left behind readily available fire services providing structural protection. Recent fires in Oregon and across the western United States have increased public awareness over the potential losses to life, property and natural and cultural resources that fire can pose.

The following three factors contribute significantly to wildfire behavior and can be used to identify wildfire hazard areas.

- **Topography**: As slope increases, the rate of wildfire spread increases. South-facing slopes are also subject to more solar radiation, making them drier and thereby intensifying wildfire behavior. However, ridgetops may mark the end of wildfire spread, since fire spreads more slowly or may even be unable to spread downhill.
- **Fuel**: The type and condition of vegetation plays a significant role in the occurrence and spread of wildfires. Certain types of plants are more susceptible to burning or will burn with greater intensity. Dense or overgrown vegetation increases the amount of combustible material available to fuel the fire (referred to as the "fuel load"). The ratio of living to dead plant matter is also

important. The risk of fire is increased significantly during periods of prolonged drought as the moisture content of both living and dead plant matter decreases. The fuel's continuity, both horizontally and vertically, is also an important factor.

- Weather: The most variable factor affecting wildfire behavior is weather. Temperature, humidity, wind, and lightning can affect chances for ignition and spread of fire. Extreme weather, such as high temperatures and low humidity, can lead to extreme wildfire activity. By contrast, cooling and higher humidity often signals reduced Wildfire occurrence and easier containment.

The frequency and severity of wildfires is also dependent upon other hazards, such as lightning, drought, equipment use, railroads, recreation use, arson and infestations. If not promptly controlled, wildfires may grow into an emergency or disaster. Even small fires can threaten lives and resources and destroy improved properties. In addition to affecting people, wildfires may severely affect livestock and pets. Such events may require emergency watering/feeding, evacuation and shelter.

Additionally, the indirect effects of wildfires can be catastrophic. In addition to stripping the land of vegetation and destroying forest resources, large and intense wildfires can harm the land itself, including soil, vegetation, and waterways. Soil exposed to intense heat may lose its capability to absorb moisture and support life, which can lead to the soil being able to erode more quickly. This can enhance siltation of rivers and streams, thereby both increasing flood potential, posing harm to aquatic life, and degrading water quality. Also, lands stripped of vegetation are subject to increased debris flow hazards, as described above.

Location and Extent

Wildfire hazard areas are commonly identified in regions as the Wildland Urban Interface (WUI). The interface is the urban-rural fringe where homes and other structures are built into a densely forested or natural landscape. If left unchecked, it is likely that fires in these areas will threaten lives and property. One challenge Clackamas County faces is from the increasing number of houses being built in the urban/rural fringe. The "interface" between urban or suburban areas and the resource lands has significantly increased the threat to life and property from fires. Responding to fires in the expanding Wildland Urban Interface area may tax existing fire protection systems beyond original design or current capability.

The ease of fire ignition further determines ranges of the wildfire hazard due to natural or human conditions and the difficulty of fire suppression. The wildfire hazard is also magnified by several factors related to fire suppression/control, such as the surrounding fuel load, weather, topography and property characteristics.

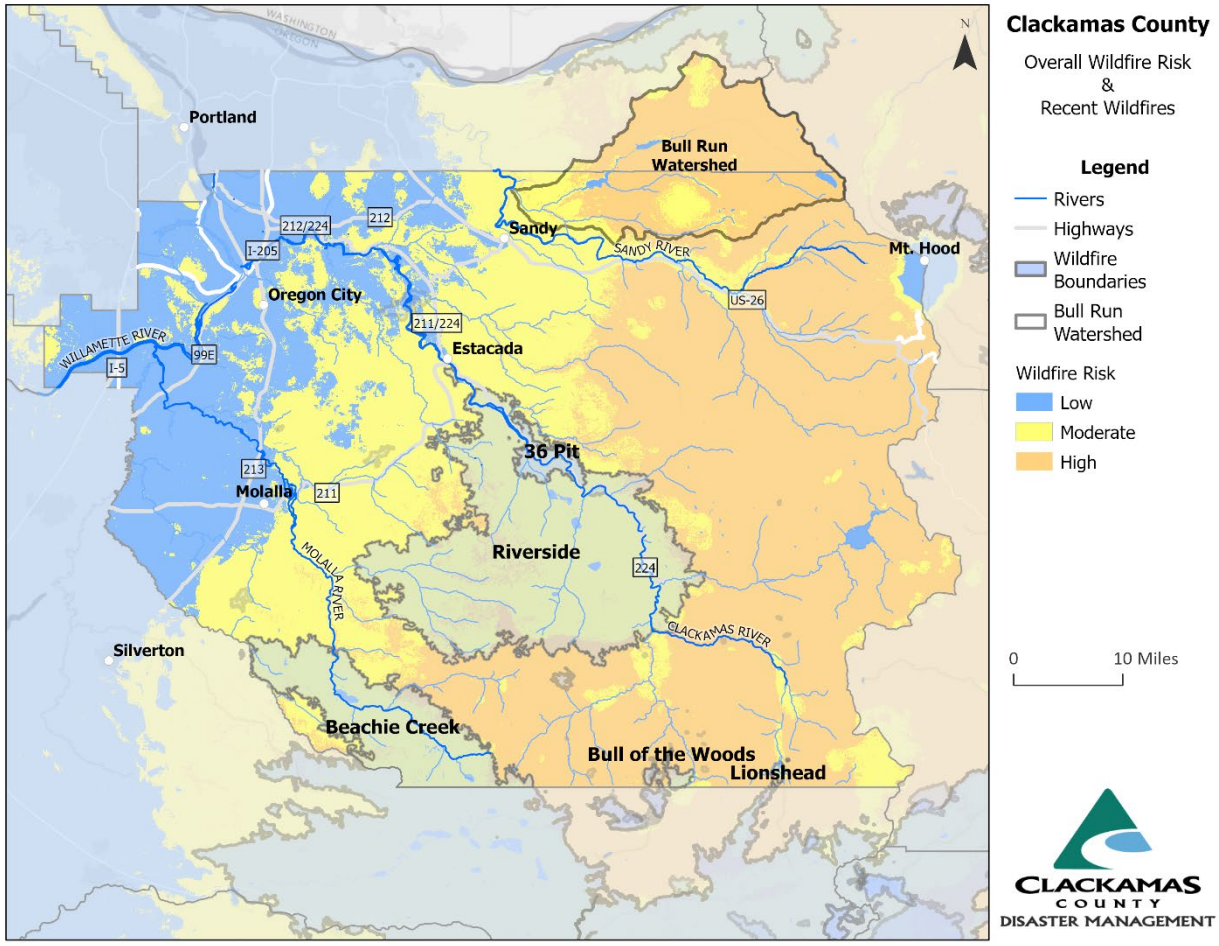
Fire susceptibility throughout the county dramatically increases in late summer and early autumn as summer thunderstorms with lightning strikes increases and vegetation dries out, decreasing plant moisture content and increasing the ratio of dead fuel to living fuel. However, various other factors, including humidity, wind speed and direction, fuel load and fuel type and topography can contribute to the intensity and spread of wildland. In addition, common causes of wildfires include arson and negligence from industrial and recreational activities.

The 2024 CWPP addresses wildfires countywide and defined each local fire district or department as individual Community at Risk.

Wildfire risk is greatest along the counties mountainous eastern and southern boundaries (Map 2-9). In these areas, there is high burn probability with expected flame lengths greater than 8-feet under

normal weather conditions. Most of the developed portion of the county (about 55%) has less severe (low to moderate) wildfire burn probability that include expected flame lengths less than 8-feet under normal weather conditions. However, conditions vary widely and with local topography, fuels, and local weather (including wind) conditions. Under warm, dry, windy, and drought conditions expect higher likelihood of fire starts, higher intensity, more ember activity, and a more difficult to control wildfire that will include more fire effects and impacts.

Map 2-9 Wildfire Risk and Recent Large Wildfires



Source: Map created by Oregon Partnership for Disaster Resilience.
Data: Oregon statewide wildfire risk map created by Oregon State University (unpublished)
Note: To view additional wildfire risk information click this link to access Oregon Explorer's CWPP Planning Tool

Clackamas County CWPP Risk Assessment and Maps

The 2024 CWPP continues to take a more localized approach to wildfire planning by creating individual CWPP's for each fire agency. Chapter 9: Clackamas County Fire Agencies has been expanded to include a brief description of wildfire hazards, emergency operations, structural ignitability, community outreach and education and fuels reduction priorities for each local fire agency. Local Communities at Risk were also identified (except for Tualatin Valley Fire and Rescue which opted to not identify local CARs). Each Fire Agency CWPP is complete with action plans to address wildfire issues specific to the local area.

The risk assessment section contains two components. The first is a quantitative risk assessment, produced by Oregon State University, updating the Oregon Wildfire Risk Explorer Map, which examines physical risk factors such as topography, groundcover, and fuel load.

The 2024 update also includes a second component, a social vulnerability assessment map, which examines the risk of wildfire to socially vulnerable populations throughout Clackamas County. The definition of socially vulnerable populations comes from the Oregon Senate Bill 762, which describes socially vulnerable as including low income and significant non-English speaking populations.

Additional maps are included in the CWPP (link, Appendix E: Maps) to provide additional detail. Conditional net value change maps show the estimated change in a resource's value if a wildfire were to occur. Thus, conditional net value change can show high loss even if the actual risk of a wildfire igniting is low. Both negative and positive effects are mapped. Expected net value change shows estimated change in the resource's value if a wildfire were to occur weighted by the probability of a fire occurring (the burn probability). Thus even if the conditional net value change is high, expected net value change can be low, if the probability of wildfire occurring is low.

Refer to the following DOGAMI reports for additional information:

- Multi-Hazard Risk Report for the Clackamas County, Oregon: Including the cities of Barlow, Canby, Estacada, Gladstone, Happy Valley, Johnson City, Lake Oswego, Milwaukie, Molalla, Oregon City, Rivergrove, Sandy,West Linn, and Wilsonville and the unincorporated communities of Molalla Prairie, Mulino Hamlet, Stafford Hamlet, and The Villages at Mt Hood (2024).
- Multi-Hazard Risk Report for the Lower Columbia-Sandy Watershed, Oregon: Including the cities of Gresham, Sandy, and Troutdale and Unincorporated Communities of Government Camp and The Villages at Mt Hood (2020, O-20-06).
- Multi-Hazard and Risk Study for the Mount Hood Region (2011, O-11-16). *Portions of the volcano section superseded by the Multi-Hazard Risk Report for the Lower Columbia-Sandy Watershed*. See also, Mount Hood Hazards and Assets Viewer.

Additional reports are available via DOGAMI's Publications Search website:

https://www.oregon.gov/dogami/pubs/Pages/pubsearch.aspx

Other agency/ consultant reports:

- Mathie, A.M., and Wood, N., 2013, Residential and service-population exposure to multiple natural hazards in the Mount Hood region of Clackamas County, Oregon: U.S. Geological Survey Open-File Report 2013–1073, available at http://pubs.usgs.gov/of/2013/1073/.
- Oregon Wildfire Response Protocol for Severe Smoke Episodes (Oregon Health Authority, updated August 15, 2023), provides guidance for the local, state, tribal, and federal agencies in Oregon who respond to severe smoke episodes caused by large or long-duration wildfires and to ensure a coordinated response to mitigate impacts on public health.

History

Between 2002 and 2023, a total of 32 named fires burned 578,805 acres in or near Clackamas County (Table 2-20).[115]

Between 2010 and 2019, 84% of ignitions were caused by humans and the remaining 16% of ignitions were from lightning.[116] Until the Riverside Fire in 2020, Clackamas County had largely escaped large fires. The Riverside Fire burned approximately 138,151 acres driven by strong and erratic, easterly winds with very low humidity.[117] The Riverside Fire was first detected on September 8, 2020 and grew to 112,000 acres by September 9, 2020. During the fire, crews reported extreme fire behavior including running crown fire, torching, and long-range spotting. In many ways, the 2020 Labor Day fires showed the influence that a warming climate, fuel buildup, and fire suppression activities can have on wildfire activity.

In addition to the Riverside Fire, four other fires started on the same day in 2020 in Clackamas County, including the Dowty fire, the Unger fire, the Graves Creek fire, and the Wilhoit fire.

Map 2-10 shows fire starts from 1992-2019, fires ignited by humans are shown in red, lightning caused fires are shown in yellow. In the past 10 years 16% of all fires were caused by lightning and 84% of fires were caused by human activity (ranging from arson and debris burning to equipment use and fires caused along powerlines). In general, the human caused wildfires are in populated areas and within river and stream corridors near transportation routes, while lightning caused wildfires are often in more remote locations.

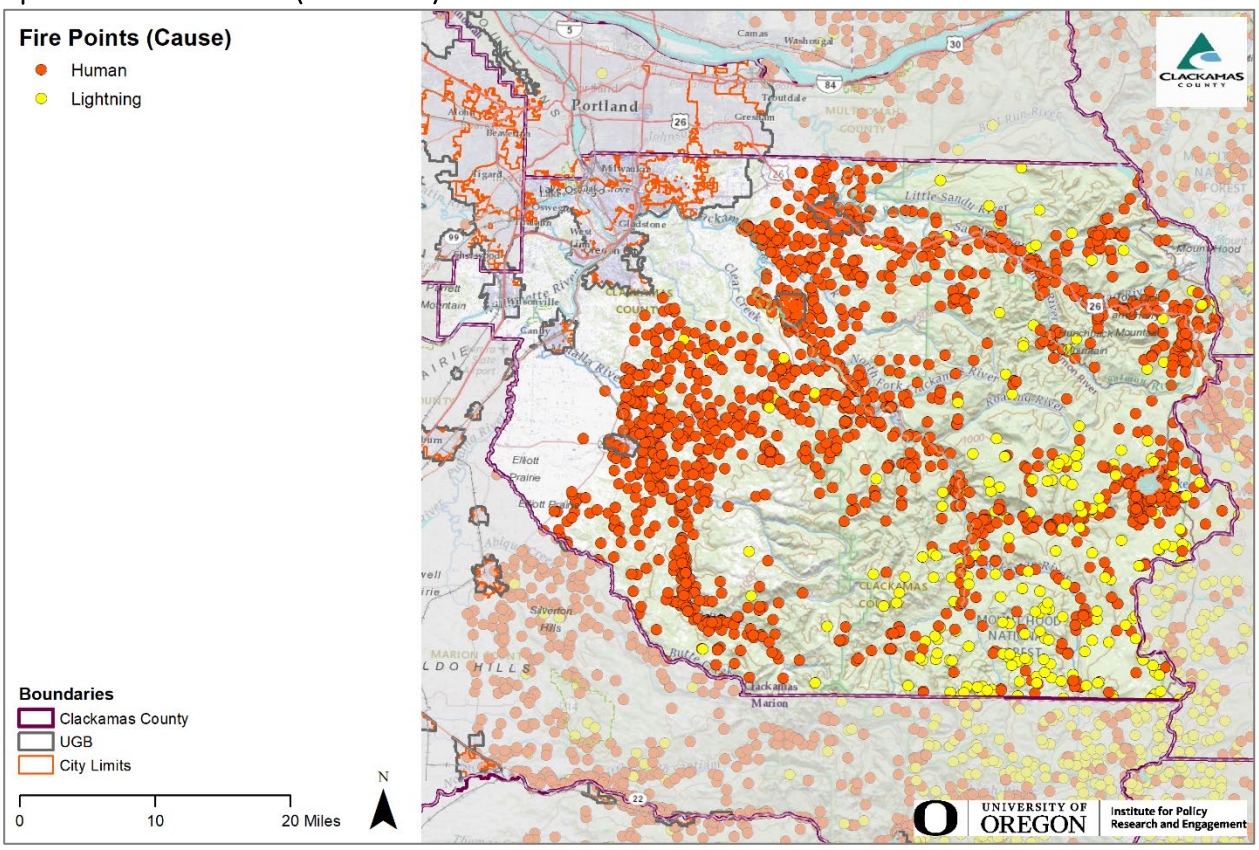
Table 2-20 Summary of Named Fires, Clackamas County 2002-2023

Year	Name	Acres
2002	Bowl	264
2006	Blister	501
2008	Lake Lenore	406
2010	Battle Creek 2	1,225
2010	Bull of the Woods	2,811
2010	Fly Lake	1,211
2010	Lemiti	40
2010	Spot	454
2011	Bagby	8
2011	Granite	31
2012	Devils Ridge	33
2014	488	11
2014	36 Pit	5,530
2014	Ester Creek	98
2014	High Rock	13
2014	Skyline Road	116
2017	Jazz	58
2017	Spring Creek	19
2018	Collawash	22
2018	Drum	26
2020	Beachie Creek	193,565
2020	Dowty Road	1,509
2020	Graves Creek	46
2020	Lionshead	204,588
2020	Riverside	138,151
2020	Unger Road	497
2020	Whilhoit Road	532
2021	Janus	24,894
2022	McIver	30
2023	Forest Park	30
2023	224	31
2023	Camp Creek	2,055
Total		**578,805**

Source: Oregon Wildfire Risk Explorer, 2020, Oregon Wildfire Risk Map

[115] Clackamas County Community Wildfire Protection Plan (2023)
[116] Oregon Wildfire Risk Explorer, 2020, County Summary Report, tools.oregonexplorer.info/OE_HtmlViewer/index.html?viewer=wildfir.e, Primary data Source: USDA Forest Service Pacific Northwest Qualitative Wildfire Risk Assessment (2018)
[117]FEMA, 2020, Riverside Fire: Erosion Threat Assessment/Reduction Team (ETART) Extended Report, https://gscdn.govshare.site/1aa8ace4addf06592a8d7dcb775413bf10fd1ec6/ETARTReport-RiversideFire.pdf

Map 2-10 Local Fire Starts (1992-2019)



Source: Oregon Partnership for Disaster Resilience. Data obtained from Oregon CWPP Planning Tool.
Note: To view additional wildfire risk information click this link to access Oregon Explorer's CWPP Planning Tool

While the majority of fire ignitions occurred along travel corridors and the edges of major urban areas, the fires that escape initial suppression efforts tend to be in more remote areas and are more likely to occur in some portions of the landscape than others (Map 2-10). The figure includes the 36 Pit Fire (2014) in the center Blister Fire (2006) just to the south. On the southern edge of the county are the View Lake Fire Complex (2010) and the Bull of the Woods Fire (2010). Several other wildfire have threatened the county as shown just outside the southeast boundary of the county: Logging Unit Complex (2014) and High Cascades Complex (2011) and around Mt. Hood in the northeast: Dollar Lake Fire (2011), Gnarl Ridge Fire (2008), and Mt. Hood Complex (2006). The Eagle Creek Fire (2017) and the Camp Creek Fire (2023), just outside the figure to the north, threatened the Bull Run Watershed that provides water to 950,000 customers in the Portland metropolitan region.

Probability Assessment

Based on the available data and research the HMAC determined the probability of experiencing a Wildfire is "**high**", meaning one incident is likely within the next 10 to 35-year period. *This rating has not changed since the previous NHMP.*

Certain conditions must be present for significant interface fires to occur. The most common are hot, dry and windy weather; the inability of fire protection forces to contain or suppress the fire; the occurrence of multiple fires that overwhelm committed resources; and a large fuel load (dense and/or overgrown vegetation). Once a fire has started, several conditions influence its behavior, including fuel,

topography, weather, drought, and development. Many of these conditions are demonstrated across large areas within Clackamas County, creating a significant collective risk.

Future Projections [118] [119]

According to the Oregon Climate Change Research Institute "Future Climate Projections, Clackamas County," wildfire frequency, intensity, and area burned are projected to continue increasing in the Northwest. Wildfire risk, expressed as the average number of days per year on which fire danger is very high, is projected to increase in Clackamas County by 14 (range -6– 34) by the 2050s, relative to the historical baseline (1971–2000), under the higher emissions scenario. Similarly, the average number of days per year on which vapor pressure deficit is extreme is projected to increase by 29 (range 10–44) by the 2050s. Communities at risk to wildfire include those within the urban wildfire interface or along river or creek corridors, where fire can travel quickly. Communities will need to address growing wildfire risks if populations are not restricted from expanding further into higher risk areas.

Vulnerability Assessment

The HMAC rated the county as having a "**moderate**" vulnerability to wildfire hazards, meaning that between 1-10% of the County's population or assets would be affected by a major disaster. *This rating has not changed since the previous NHMP.*

Impact to people and property from wildfire is shown in Map 2-11 darker areas have higher expected losses.

Table 2-21 provides a list of the Communities at Risk (CARs) in Clackamas County. CARs are defined as geographic areas "within and surrounding permanent dwellings with basic infrastructure and services, under a common fire protection jurisdiction, government, or tribal trust or allotment, for which there is a significant threat due to wildfire." Risk is rated along a three-point scale: Low (L), Moderate (M), and High (H) risk.

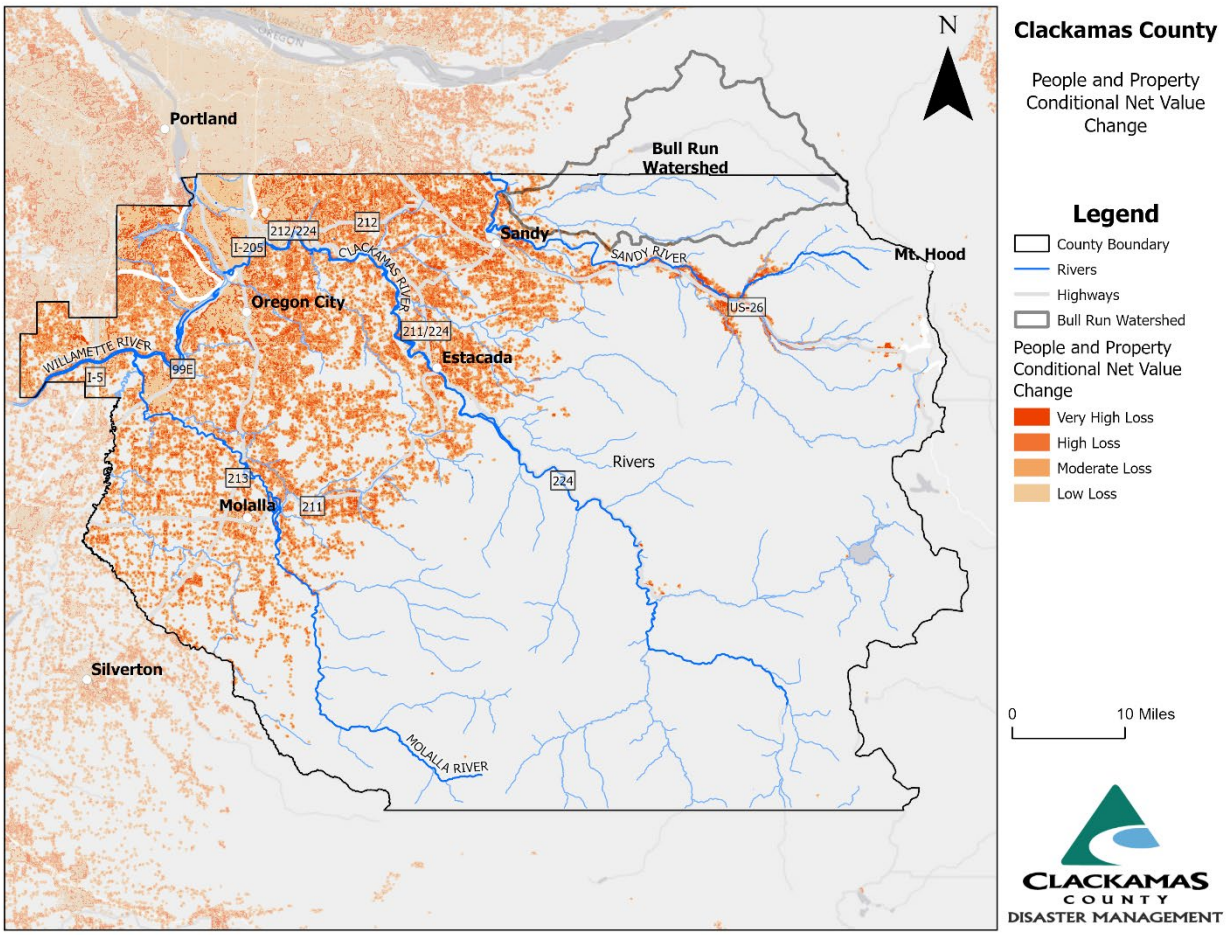
The amount of property exposed to the wildfire risk hazard area, as well as the type and value of structures on those properties, is calculated to provide a working estimate for potential wildfire losses.

Additionally, wildfires create smoke. Wildfire smoke is a mix of gases and fine particles from burning trees and plants, buildings, and other material.[120] When smoke arrives, people's health is immediately impacted and impacts can continue even after the air quality improves. For example, following the Eagle Creek wildfire in 2017, air quality-related emergency room visits increased a few days after the fire began and continued to remain higher than expected for approximately one week after the event.[121] Wildfire smoke can make anyone sick; however, according to the Centers for Disease Control and Prevention, groups most vulnerable to wildfire smoke are people with asthma, Chronic Obstructive Pulmonary Disease (COPD), or heart disease, or who are pregnant, children, and responders.[122] Groups who face higher risk of health impacts from poor air quality include outdoor workers, older adults and

[118] Oregon Climate Change Research Institute (OCCRI), 6th Oregon Climate Assessment Report (2023). https://blogs.oregonstate.edu/occri/oregon-climate-assessments/
[119] OCCRI, "Future Climate Projections Clackamas County, Oregon"
[120] Centers for Disease Control and Prevention, "Protect Yourself from Wildfire Smoke", https://www.cdc.gov/air/wildfire-smoke/default.htm
[121] Multnomah County Health Department, Washington County Health Department, and Clackamas County health Department, "2012-2022 Regional Climate and Health Monitoring Report", 2023 p.24
[122] Centers for Disease Control and Prevention, "Protect Yourself from Wildfire Smoke", https://www.cdc.gov/air/wildfire-smoke/default.htm

immigrants and communities that are culturally or linguistically isolated and may not have access to emergency communications warning of poor air quality.[123]

Map 2-11 People and Property Conditional Net Value Change



Source: Oregon Partnership for Disaster Resilience. Data obtained from Oregon CWPP Planning Tool.
Note: To view additional wildfire risk information click this link to access Oregon Explorer's CWPP Planning Tool

[123] Multnomah County Health Department, Washington County Health Department, and Clackamas County health Department, "2012-2022 Regional Climate and Health Monitoring Report", 2023 p.20

Inter-Hazard Impact and Outcomes – Wildfire[124] [125]

As the primary natural hazard, a.k.a "the cause", wildfire has indirect impacts on several other hazards, a.k.a. "the effect", and as a climate hazard, its impacts are further exacerbated by the effects of climate change.

- Flood – Indirect: Wildfire can result in leaving massive burn scarring and leaves areas arid and lacking vegetation, as well as an accumulation of debris and ash left from the fire. Such conditions can eventually lead to significant flooding and/or landslides to occur during times of high precipitation.
- Landslide – Indirect: Wildfire causes massive burn scarring and leaves areas arid and lacking vegetation, as well as an accumulation of debris and ash left from the fire. Such conditions can eventually lead to significant flooding and/or landslides to occur during times of high precipitation.

Table 2-21 Communities at Risk (CAR) Identified in Clackamas County

Community	Risk Rating
Beaver Creek	High
Eagle Creek	High
Government Camp	Moderate
Sandy	Moderate
Canby	Low
Clackamas	Low
Colton	Low
Damascus	Low
Estacada	Low
Gladstone	Low
Happy Valley	Low
Lake Oswego	Low
Molalla	Low
Oregon City	Low
West Linn	Low
Wilsonville	Low

Source: Oregon Department Forestry, 2020, "Communities at Risk Report."

Natural Hazard Risk Reports for Clackamas County

The Risk Reports (DOGAMI, 2024 and 2020) provide hazard analysis summary tables that identify populations and property within the Lower Columbia-Sandy River Watershed Study Area and countywide that are vulnerable to the wildfire hazard. Volume III, Appendix D provides detailed Community Risk Profile tables for the unincorporated area of Clackamas County.

According to the Risk Reports the following population and property within the study area may be impacted by the profiled events (*where data is provided in both reports the newer data is presented below)*:

Unincorporated Clackamas County[126]

Wildfire: 9,833 buildings are exposed to the High or Moderate Risk Wildfire hazard (10 critical facilities) with a total buidling value of $2.91 billion (an exposure ratio of about 8%). In addition, 16,526 residents may be displaced (about 9% of the population).

[124] National Flood Insurance Program, "*Flood After Fire Fact Sheet*", 2012
[125] USGS, What should I know about wildfires and debris flows
[126] DOGAMI, Multi-Hazard Risk Report for Clackamas County, Oregon (2024), Table A-1.

Government Camp[127]

Wildfire: 675 buildings are exposed to the High or Moderate Risk Wildfire hazard (0 critical facilities) with a total buidling value of $192.25 million (an exposure ratio of about 66%). In addition, 1,046 residents may be displaced (about 77% of the population).

Molalla Prairie[128]

Wildfire: 161 buildings are exposed to the High or Moderate Risk Wildfire hazard (0 critical facilities) with a total buidling value of $30.03 million (an exposure ratio of about 2%). In addition, 219 residents may be displaced (about 5% of the population).

Mulino Hamlet[129]

Wildfire: 59 buildings are exposed to the High or Moderate Risk Wildfire hazard (0 critical facilities) with a total buidling value of $17.08 million (an exposure ratio of about 3%). In addition, 100 residents may be displaced (about 4% of the population).

Stafford Hamlet[130]

Wildfire: 37 buildings are exposed to the High or Moderate Risk Wildfire hazard (0 critical facilities) with a total buidling value of $17.87 million (an exposure ratio of about 3%). In addition, 134 residents may be displaced (about 4% of the population).

The Villages at Mt. Hood[131]

Wildfire: 3,197 buildings are exposed to the High or Moderate Risk Wildfire hazard (2 critical facilities) with a total buidling value of $1.08 billion (an exposure ratio of about 83%). In addition, 7,460 residents may be displaced (about 87% of the population).

[127] DOGAMI, Multi-Hazard Risk Report for Clackamas County, Oregon (2024), Table A-3.
[128] DOGAMI, Multi-Hazard Risk Report for Clackamas County, Oregon (2024), Table A-5.
[129] DOGAMI, Multi-Hazard Risk Report for Clackamas County, Oregon (2024), Table A-7.
[130] DOGAMI, Multi-Hazard Risk Report for Clackamas County, Oregon (2024), Table A-9.
[131] DOGAMI, Multi-Hazard Risk Report for Clackamas County, Oregon (2024), Table A-11.

Section 3: Mitigation Strategy

This section outlines Clackamas County's strategy to reduce or avoid long-term vulnerabilities to the identified hazards. Specifically, this section presents a mission and specific goals and actions thereby addressing the mitigation strategy requirements contained in 44 CFR 201.6(c). The NHMP Hazard Mitigation Advisory Committee (HMAC) viewed and updated the mission, goals, and action items documented in this NHMP. Additional planning process documentation is in Volume III, Appendix B.

This section outlines Clackamas County's strategy to reduce or avoid long-term vulnerabilities to the identified hazards. Specifically, this section presents a mission and specific goals and actions thereby addressing the mitigation strategy requirements contained in 44 CFR 201.6(c). The NHMP Hazard Mitigation Advisory Committee (HMAC) viewed and updated the mission, goals, and action items documented in this NHMP. Additional planning process documentation is in Volume III, Appendix B.

Mitigation Plan Mission

The NHMP mission states the purpose and defines the primary functions of Clackamas County's NHMP. It is intended to be adaptable to any future changes made to the NHMP and need not change unless the community's environment or priorities change.

The mission of the Clackamas County NHMP is to:

Enhance county resiliency and capacity to address natural hazards by promoting sound public policy and effective mitigation strategies designed to equitably reduce risk and impacts on community members, community lifelines, historic and cultural resources property, and ecological systems.

This can be achieved by increasing public awareness, documenting the resources for risk reduction and loss-prevention, and identifying activities to guide the county towards building a safer, more sustainable community.

Note: The 2024 NHMP HMAC reviewed the previous NHMP's mission statement and agreed to make updates to the Mission and Goals.

Mitigation Plan Goals

Mitigation plan goals are more specific statements of direction that Clackamas County residents and public and private partners can take while working to reduce the County's risk from natural hazards. These statements of direction form a bridge between the broad mission statement and action items. The goals listed here serve as checkpoints as agencies and organizations begin implementing mitigation action items.

Meetings with the HMAC, previous hazard event reports, and the previous county NHMPs served as methods to obtain input and identify priorities in developing goals for reducing risk and preventing loss from natural hazards in Clackamas County.

The 2024 Clackamas County NHMP HMAC reviewed the previous NHMP goals in comparison to the State NHMP (2019) goals and determined necessary and agreed upon updates to the Mission and Goals. This included adding references to community lifelines and prioritizing equity in mitigation planning.

NHMP goals are all important and listed below in no particular order of priority. Establishing community priorities within action items neither negates nor eliminates any goals, but it establishes which action items to consider implementing first, should funding become available.

Goal 1: Protect Life and Property

- Develop and implement mitigation and climate adaptation projects and policies that aid in protecting lives by making homes, businesses, community lifelines, and other property more resilient to natural hazards and impacts from climate change.
- Establish mitigation projects and policies that minimize losses and repetitive damages from recurring disasters while promoting insurance coverage for severe hazards
- Improve hazard identification and risk assessment information to inform and provide recommendations for enhanced resilience in new development decisions, and promote preventative measures for existing development in areas vulnerable to natural hazards.

Goal 2: Enhance Natural Systems

- Incorporate natural hazard mitigation planning and activities into watershed planning, natural resource management, natural systems enhancement, and land use planning to protect life, property, and ecological system.

Goal 3: Augment Emergency Services

- Strengthen emergency operations by enhancing communication, collaboration, and coordination of natural hazard mitigation activities and policies across agencies at all levels and regions of government, sovereign tribal nations, and the private sector.

Goal 4: Encourage Partnerships for Implementation

- Improve communication, coordination, and participation among and with public agencies, community members, community lifelines, and private sector organizations to prioritize and implement hazard mitigation activities and policies.
- Enhance efforts toward identifying and optimizing opportunities across state agencies, surrounding communities, and private entities for resource sharing, mutual aid, and funding sources/support.

Goal 5: Promote Public Awareness

- Build community resilience and awareness, and reduce the effects of natural hazards and climate change through community-wide engagement, collaboration, resource-sharing, learning, leadership-building, and identifying mitigation project-related funding opportunities.

Goal 6: Advance Equity and Inclusion

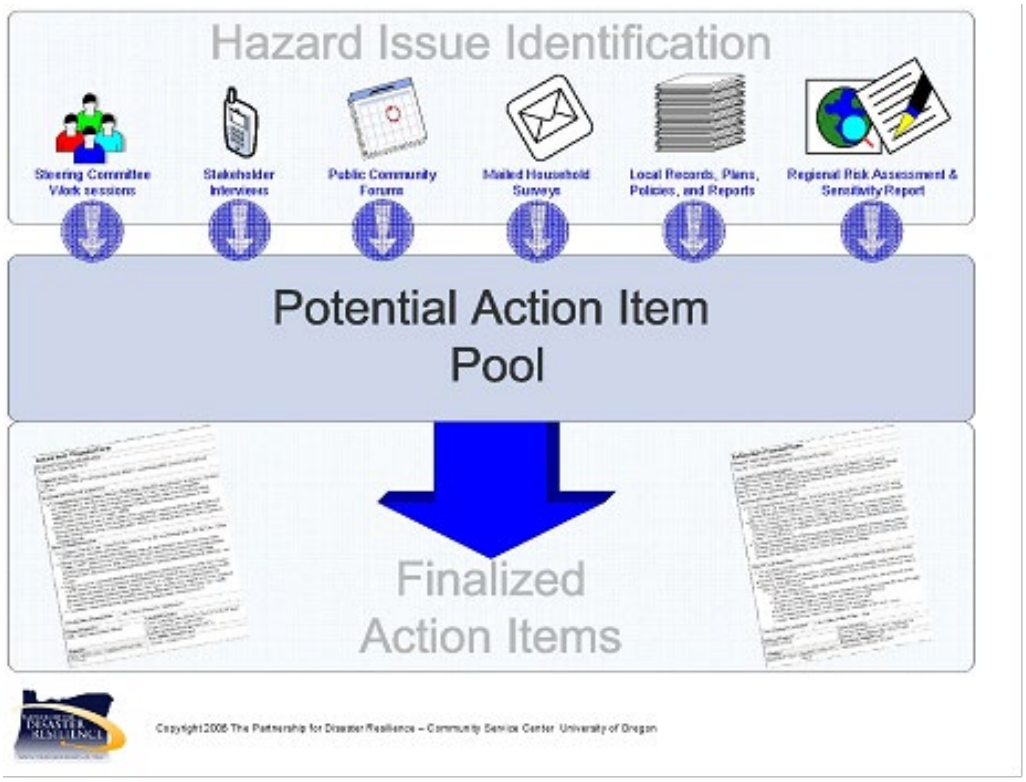
- Mitigate the inequitable impacts of natural hazards by prioritizing the directing of resources and efforts to build resilience and engagement in the most vulnerable communities least able to prepare, respond, and recover.
- Strengthen efforts aimed at increasing engagement, outreach, and collaboration with community and cultural organizations and agencies that are dedicated to providing services and support to vulnerable and underserved communities.

Action Item Development Process

Action items identified through the planning process are an important part of the mitigation plan. Action items are recommended activities that local departments and agencies, community organizations and members, and other interested parties can take to reduce risk. Development of action items is a multi-step, iterative process that involves brainstorming, discussion, review and revisions. Action items can be developed through many sources. Figure 3-1 illustrates some of these sources.

Most of the action items were first develped during previous NHMP planning processes, though many were updated to better reflect the current priorities of Clackamas County. During these processes, the HMAC developed maps of local vulnerable populations, facilities and infrastructure in respect to each identified hazard. Review of these maps generated discussion around potential actions to mitigate impacts to the vulnerable areas. The Oregon Partnership for Disaster Resilience (OPDR) provided guidance in the development of action items by presenting and discussing actions that were used in other communities. All actions were then reviewed by the HMAC, discussed at length and revised as necessary before becoming a part of this document.

Figure 3-1 Development of Action Items



NHMP Action Item Review

Part of assessing progress from the 2019 NHMP action items to the updated 2024 NHMP includes assessing the continued relevancy of the action item to the mitigation strategy. Action items often take years to achieve and can therefore remain relevant in updated versions of the NHMP. Action items may

even be in progress in the midst of implementation, but the overall action remains unfinished and should be included in the NHMP update. In contrast, action items may become irrelevant to the updated NHMP for a variety of reasons, including lack of adequate funding or lack of staff capacity to complete the activity.

During the HMAC meetings, 2019 action items were reviewed for their relevance to Clackamas County's current mitigation efforts, priorities, and capacity. In response to these conversations, action items were retained, updated, removed, or combined. Additionally, these discussions and the information compiled in the Hazard Profile (Volume 1, Part 3) provided critical information for when appropriately updating the pre-existing Actions Items and provided justification for the development of new Action Items.

Additionally, while updating pre-existing and developing new action items, consideration was taken of the last 5 years of natural disasters in Oregon and Clackamas County, their impact, and the policy changes they spurred. For example, after the destructive 2020 wildfire season occurred, the Oregon Legislature passed Senate Bill 762 (SB 762), which directed resources towards wildfire mitigation action items, generally wildfire risk mapping, creating and maintaining defensible space around buildings, and fuels reduction treatments in high-risk areas.

Action Item Prioritization

While all Action Items are important to the NHMP, the HMAC prioritized the action items within tiered priorities of low, medium, and high. The prioritization of 2024 NHMP action items emphasize current conditions and needs and focus on project implementation feasibility, funding source eligibility and competitiveness, and community impacts (see following pages and Appendices A and B for more information).

High-priority Action Items are those actions that will reduce the greatest risk and vulnerability in the community. They will require the most attention, responsibility, and resources to accomplish. In most cases, these projects will be funded through a various funding mechanism (e.g., FEMA BRIC or FMA), and thus will require additional capacity to apply, receive, and manage these funds. Additionally, they often will have the greatest impact on the community, both in a structural and policy sense. In this way, these are the mitigation actions that the public will be most impacted by and experience in some form (i.e., road updates or structure elevation).

Action Item Categories

Action Items were categorized into five (5) categories that broadly encapsulate the intended impact they will have on the county. If an action exists in more than one category it is listed below in the primary category (see Table 3-1 for full list of actions and categories). These categories were not altered since the last, 2019 NHMP, update.

Education and Outreach

This action item category is often a low-cost, high-benefit way to increase resilience throughout the county through encouraging learning, network, and connections, and by enhancing and supporting individual jurisdictional responsibility and accountability to provide community and jurisdictional outreach to community members. Additionally, there are many education and outreach programs that already exist and can be implemented into a community educational program. This Action Item Category can be both public facing – through leading/attending community event, and internal facing –

developing and implementing educational programs and opportunities used to educate and inform local officials about actions they can take to enhance their community resilience against natural hazards.

The high-priority Action Items under this category include:

- **Flood (FL) #1:** Identify opportunities to raise public awareness and implement education campaigns for community members within Clackamas County's public and private flood-prone properties.
- **Severe Weather (SW) #1:** Maintain a public awareness campaign regarding severe weather mitigation measures and the importance of personal safety.
- **Wildfire (WF) #2:** Encourage private landowners to create and maintain defensible space around homes and other buildings and make home hardening improvements.
- **Multi-Hazard (MH) #9:** Explore opportunities to stand up one or more resiliency HUBS designed to support residents and coordinate resource distribution before, during, or after a natural hazard event.

GIS/Mapping

Mapping needs are essential to the NHMPs risk assessment of each hazard. The capacity to utilize data gathered by the county's GIS department, as well as other local and state organizations, allow risk assessment to continually be updated, reviewed, and adjusted as needed to changing conditions.

The high-priority Action Items under this category include:

- **Multi-Hazard (MH) #4:** Utilize knowledge of natural ecosystems and hazards to link natural resource management and land use organizations with potential mitigation activities and provide technical assistance in high-risk locations.
- **Flood (FL) #6:** Identify and respond to problematic surface water drainage sites in all parts of unincorporated Clackamas County.

Maintenance/Planning

Stress the importance of the Clackamas County NHMP elements, and promote the development of plans and reports that support the goals of the Clackamas County NHMP.

The high-priority Action Items under this category include:

- **Multi-Hazard (MH) #1:** Integrate the goals and action items from the Clackamas County Natural Hazard Mitigation Plan into existing regulatory documents and programs.
- **Severe Weather (SW) #2:** Monitor and implement programs to mitigate potentially hazardous trees from endangering lives, property, and public infrastructure.
- **Wildfire (WF) #1:** Promote and support wildfire mitigation action items through the Clackamas County Community Wildfire Protection Plan.
- **Wildfire (WF) #3:** Update county and jurisdiction wildfire codes and ordinances in accordance with guidelines provided by OSFM/DLCD/ODF/BCD as part of SB 762 (2021) and SB 80 (2023).

Critical Infrastructure/Essential Facilities

Community Lifelines, such as critical infrastructure and public facilities, are essential to the basic functioning of society. They are fundamentally necessary for effective emergency operations, including:

response to a hazard, ability to recover quickly, and lead redevelopment efforts following a disaster event.

The high-priority Action Items under this category include:

- **Multi-Hazard (MH) #6:** Support/encourage electrical utilities to use underground construction methods where possible.
- **Multi-Hazard (MH) #8:** Develop and maintain risk assessment and Emergency Operation Plans for state-regulated dams identified as high hazard potential dams (private, public, and non-profit).
- **Flood (FL) #3:** Improve and refine existing flood warning systems by integrating flood monitoring, detection, and alert/notification systems.

Land Use/Development

Seek to utilize laws, regulations, and other tools regarding the use and development of land as methods of protecting lives, property, and natural ecovsystems.

The high-priority Action Items under this category include:

- **Flood (FL) #2:** Recommend revisions to the requirements, limitations, and exclusions for new development within the floodplains that have designated channel migration zones (CMZ).
- **Flood (FL) #5:** Encourage and facilitate the use of mitigation strategies in the management of existing flood-prone properties, either through home elevation or property acquisition.
- **Severe Weather (SW) #3:** Explore strategies to create new, or retrofit existing, housing and infrastructure that reduces heat or protects people from heat with a focus on the hottest areas in Clackamas County.
- **Severe Weather (SW) #4:** Explore zoning or land use policy opportunities to preserve existing, and expand, the tree canopy in Clackamas County, with a focus on areas identified as heat islands.

Action Item Framework

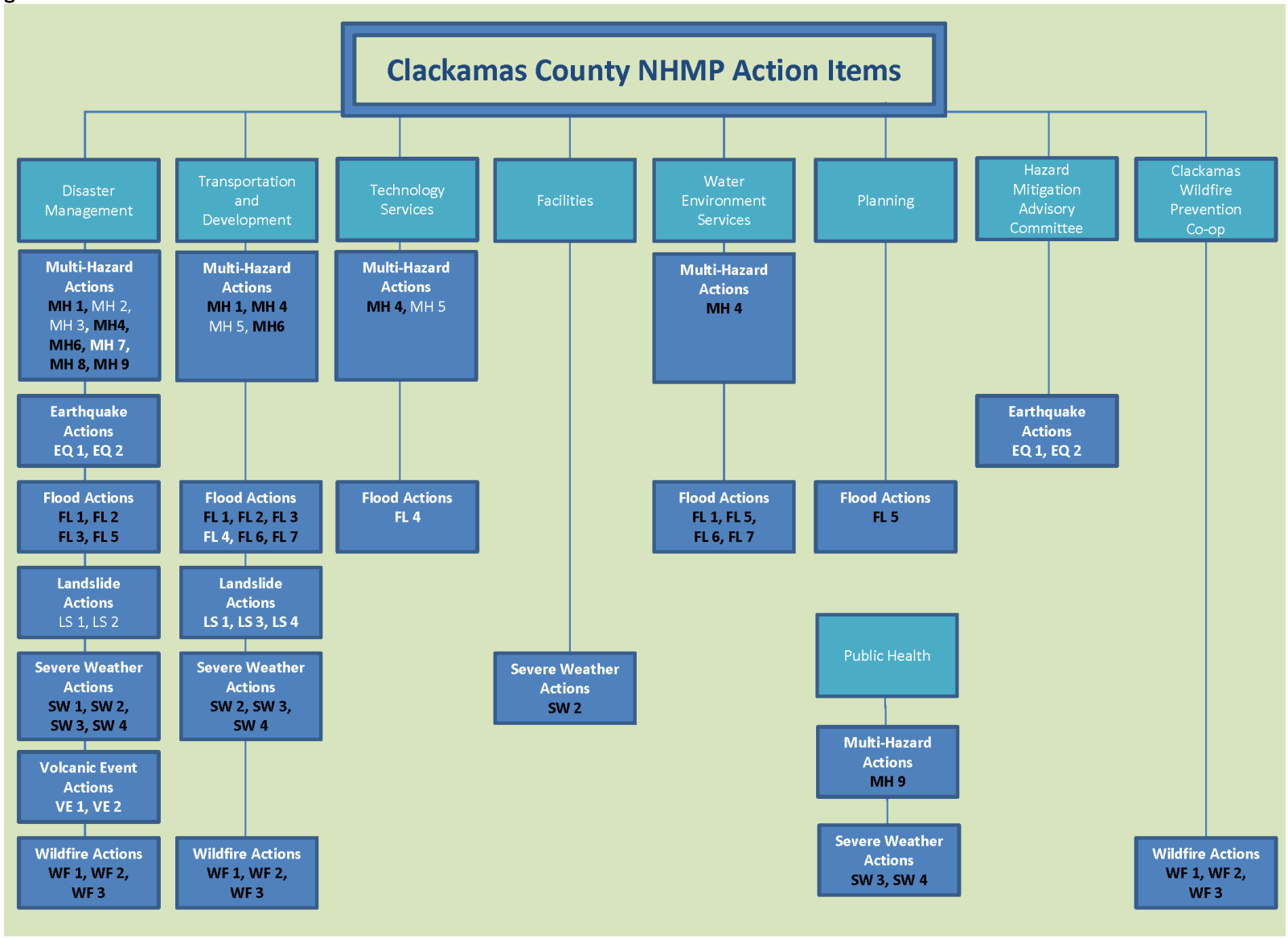
Many of the Clackamas County NHMP's recommendations are consistent with goals and objectives in existing County plans and policies. Where possible, Clackamas County will implement the NHMP's recommended actions through existing plans and policies. Plans and policies already in existence have support from residents, businesses, and policy makers.

Many land-use, comprehensive, and strategic plans get updated regularly, and can adapt relatively easily to changing conditions and needs. Implementing the NHMP's action items through such plans and policies increases their likelihood of being supported and implemented.

Figure 3-2 outlines which county department or committee leads or has a role for implementing and documenting progress on each action item. Table 3-1 connects each action with the impacted hazards and with the action item categories. See Volume III, Appendix A for the detailed forms for actions determined to be high priority.

See Volume II for the Priority Actions for each participating city.

Figure 3-2 Action Item Framework



Source: Clackamas County Hazard Mitigation Advisory Committee (2024)
Note: High Priority Actions are noted in **bold** black text

Table 3-1 Action Items: Impacted Hazard and Categories

Action Item #	Impacted Hazard									Action Item Categories				
	Drought	Earthquake	Extreme Heat	Flood	Landslide	Volcanic Event	Windstorm	Winter Storm	Wildfire	Education and Outreach	GIS Mapping	Maintenance/ Planning	Critical Infrastructure/ Essential Facilities	Land Use/ Development
MH #1	X	X	X	X	X	X	X	X	X			X		
MH #2	X	X	X	X	X	X	X	X	X	X		X		
MH #3	X	X	X	X	X	X	X	X	X				X	
MH #4	X	X		X	X	X	X	X	X		X			X
MH #5		X		X	X				X		X	X		
MH #6					X		X	X	X					X
MH #7		X		X					X	X				
MH #8		X		X	X							X		
MH #9	X	X	X	X	X	X	X	X	X	X				
EQ #1		X											X	
EQ #2		X								X				
FL #1				X						X				
FL #2				X										X
FL #3				X						X				
FL #4				X							X			
FL #5				X										X
FL #6				X									X	
FL #7				X								X		
LS #1					X					X				
LS #2					X						X			
LS #3					X					X				
LS #4					X									X
SW #1			X				X	X		X				
SW #2			X				X	X				X		
SW #3			X											X
SW #4			X											X
VE #1						X						X		
VE #2						X					X			
WF #1									X			X		
WF #2									X	X				
WF #3									X			X		X

Source: Clackamas County HMAC, updated 2024.

Table 3-2 Mitigation Strategy: Action Items

Action Item			Community Impact										Implementation and Maintenance			
#	Statement	Description	Protect Life	Community Lifelines	Climate Adaptation	Enhance Comm.	Vulnerable Pop	Encourage Res. Dev.	Enviro. Impact	Historic and Cultural	Repetitive Losses	Dams Posing Risk	Lead/ Partners	Timeline	Potential Funding Source	Estimated Cost
Multi-Hazard																
MH #1	Integrate the goals and action items from the Clackamas County Natural Hazard Mitigation Plan into existing regulatory documents and programs.	By continuing to work with the county on integrating action items for the NHMP into regulatory documents and programs, this will assist in facilitating opportunities for public and private collaboration and partnership	X			X		X					DM/ DTD Planning	Ongoing	County General Fund	Low
MH #2	Identify, improve, and sustain public and private partnerships and collaborations focused on natural hazard mitigation and risk reduction throughout Clackamas County.	Fostering these relationships will aid in the identification of potential natural hazard mitigation projects that will contribute to reducing community risks associated with natural hazards.	X	X	X	X	X		X				DM	Ongoing	County General Fund, HMA	Low
MH #3	Conduct exposure and strength assessments on County owned and/or operated buildings and facilities, potential shelter sites, and community lifelines to compile an inventory of at-risk and vulnerable buildings and infrastructure.	Such assessments will facilitate the prioritization, coordination, and implementation of suitable mitigation projects and strategies.	X	X	X		X	X	X	X			DM	Ongoing	HMA	Medium
MH #4	Utilize knowledge of natural ecosystems and hazards to link natural resource management and land use organizations with potential mitigation activities and provide technical assistance in high-risk locations.	Mapping high-risk areas, such as landslides, floodplains and channel migration zones, will identify areas in need of potential mitigation projects, as well as emphasizing where to educate property owners about ecosystem functions and related hazards.	X	X	X	X	X	X	X		X		DTD Planning/ DM, WES, TS-GIS	Ongoing	County General Fund, OWEB, Metro	High
MH #5	Enhance efforts to integrate and align the most recently updated NHMP's goals, risk assessment, and hazard mitigation strategies into the County Comprehensive Plan.	Enhanced integration of planning efforts can reduce community risk and improve community resilience by providing improved technical analyses of natural hazards for the purpose of improving land-use and zoning codes, building codes, and technical mapping requirements.	X		X	X		X	X				DTD Planning/ TS-GIS	Ongoing	HMA, County General Funds	Low
MH #6	Support/encourage electrical utilities to use underground construction methods where possible.	This will assist in reducing the overall number of power outages from windstorms, winter storms and prevent wildfire ignitions, as well as reduce the needs for Public Safety Power Shut-off events, all of which are becoming more and more prevalent due to changes in climate.	X	X	X	X	X	X	X				DM/ DTD, PGE	Ongoing	HMA (BRIC), County General Fund	High

Table 3-2 Mitigation Strategy: Action Items

Action Item			Community Impact										Implementation and Maintenance			
#	Statement	Description	Protect Life	Community Lifelines	Climate Adaptation	Enhance Comm.	Vulnerable Pop	Encourage Res. Dev.	Enviro. Impact	Historic and Cultural	Repetitive Losses	Dams Posing Risk	Lead/ Partners	Timeline	Potential Funding Source	Estimated Cost
MH #7	Encourage property owners to purchase appropriate hazard insurance, including earthquake, wildfire, or flood insurance.	Promote personal protection and safety from natural hazards among property owner by establishing a system to receive assistance if property damage occurs.	X		X		X	X	X		X		DM	Ongoing	County General Funds	Low
MH #8	Develop and maintain risk assessment and Emergency Operation Plans for state-regulated dams identified as high hazard potential dams (private, public, and non-profit).	The National Dam Safety Program Act authorizes FEMA to provide HHPD rehabilitation funding assistance for the rehabilitation of dams that fail to meet minimum dam safety standards and pose unacceptable risk to life and property, as long as the eligible dams are within a jurisdiction that has an approved local hazard mitigation plan that includes all dam risks and complies with the Robert T. Stafford Act.	X	X				X	X	X	X	X	DM	Ongoing	HHPD, HMGP, BRIC, FMA, SHSP	Low
MH #9	Explore opportunities to stand up one or more resiliency HUBS designed to support residents and coordinate resource distribution before, during, or after a natural hazard event.	Resilience Hubs are community-serving facilities that support residents, coordinate communication, distribute resources, and reduce carbon pollution while enhancing quality of life. Hubs provide an opportunity to effectively work at the nexus of community resilience, emergency management, climate change mitigation, and social equity while providing opportunities for communities to become more self-determining, socially connected, and successful before, during, and after disruptions.	X	X	X		X						DM/ Public Health	Medium	County General Funds, FEMA, HMA, ODHS	High
Earthquake																
EQ #1	Pursue funding opportunities supported through the state's Seismic Rehabilitation Grant Program for community asset retrofitting.	Funds will support structural and nonstructural retrofitting of schools, and emergency services facilities identified as seismically vulnerable and need to increase their seismic resiliency.	X	X			X	X	X	X			DM/ HMAC	Ongoing	OSRG	High
EQ #2	Promote public education and community outreach programs aimed at reducing nonstructural and structural earthquake hazards in homes, schools, businesses, and government offices.	Explore partnerships to provide retrofitting classes for homeowners, renters, building professionals, and contractors in conjunction with Shake Alert technology (minimize risk of buildings along with promoting shake alert).	X	X		X	X	X	X				DM/ HMAC	Ongoing	HMGP, BRIC	Low

Table 3-2 Mitigation Strategy: Action Items

Action Item			Community Impact										Implementation and Maintenance			
#	Statement	Description	Protect Life	Community Lifelines	Climate Adaptation	Enhance Comm.	Vulnerable Pop	Encourage Res. Dev.	Enviro. Impact	Historic and Cultural	Repetitive Losses	Dams Posing Risk	Lead/ Partners	Timeline	Potential Funding Source	Estimated Cost
Flood																
FL #1	Identify opportunities to raise public awareness and implement education campaigns for community members within Clackamas County's public and private flood-prone properties.	Flood education and awareness campaigns for those living on and/or owning property in flood-prone areas can provide community members with information about flood risk, safety and mitigation precautions, public alerts, and resources for how to prepare for floods.	X		X	X	X	X	X		X		DM/ DTD (Planning) WES	Ongoing	FMA, HMGP, BRIC, OWEB	Low
FL #2	Recommend revisions to the requirements, limitations, and exclusions for new development within the floodplains that have designated channel migration zones (CMZ).within the floodplain	Acquisition is the preferred approach for CMZ areas. The primary hazard in CMZ areas is rapid erosion or avulsion, where a stream channel relocates its course during high water. Home foundations are undercut so elevation is not a viable form of mitigation.	X		X		X	X	X		X		DTD/ DM	Ongoing	HMGP, BRIC, FMA, HUD, OWEB	Low
FL #3	Improve and refine existing flood warning systems by integrating flood monitoring, detection, and alert/notification systems.	Clackamas County Disaster Management used DR-1956-OR HMGP 5% project to install five electronic river gauges in the upper Sandy Basin on five County-owned bridges. Technical and communication problems have prevented the full implementation of this project. Currently HMGP-5327-PF is funding a 5% upgrade project for dedicated electric power and broadband communications for enhanced service and reliability to four of the five sites.	X	X	X	X	X	X	X		X		DM/ DTD	Long Term	HMGP, BRIC, FMA, County General Fund	Medium
FL #4	Maintain and develop floodplain data and mapping information within the county and within flood-prone areas outside designated floodplains.	Maintaining a floodplain database contributes to improve climate adaptation and resilience by enabling the monitoring of relevant climate change impacts, both current and anticipated impacts.	X		X	X	X	X			X		DTD/ (Planning), TS-GIS	Ongoing	FMA	Medium
FL #5	Encourage and facilitate the use of mitigation strategies in the management of existing flood-prone properties, either through home elevation or property acquisition.	There are many benefits to acquiring and/or elevating properties at high risk of flood, including providing open space for water run-off, improving water quality in the floodplain and surrounding properties, and minimizing the physical, financial, and emotional strains that accompany flood events.	X		X		X	X	X		X		DM/ Planning, CFM, WES	Ongoing	FMA, County General Fund, OWEB	High

Table 3-2 Mitigation Strategy: Action Items

Action Item			Community Impact										Implementation and Maintenance			
#	Statement	Description	Protect Life	Community Lifelines	Climate Adaptation	Enhance Comm.	Vulnerable Pop	Encourage Res. Dev.	Enviro. Impact	Historic and Cultural	Repetitive Losses	Dams Posing Risk	Lead/ Partners	Timeline	Potential Funding Source	Estimated Cost
FL #6	Identify and respond to problematic surface water drainage sites in all parts of unincorporated Clackamas County.	In certain areas, such as in urban areas and areas that may become problematic due to climate change impacts, there is capacity-limited storm infrastructure that requires replacement and repair. To minimize the damage from such areas, these areas must be identified and addressed.	X	X	X		X	X	X				DTD (Roads)/ WES, Watershed Councils	Ongoing	County Capital Funds, FMA, OWEB	Medium
FL #7	Develop and enact a method to compile and coordinate county-wide surface water and stormwater management plans and watershed council action plans into a collaborative and applicable resource.	Such resources will aid in determining appropriate and relevant mitigation strategies to mitigate flood risk and impact.	X	X	X	X		X	X				WES/ DTD, Watershed Councils	Long Term	FMA, EPA, OWEB	Medium
Landslide																
LS #1	Identify and map high risk landslide hazard areas.	There is a need to prioritize identifying areas that present a high risk of harm to vulnerable lives and properties, and that are ecologically susceptible to landslides such as burn scar areas.	X		X	X			X				DTD/ DM	Ongoing	HMGP, BRIC	Medium
LS #2	Collaborate with DOGAMI and the National Weather Service to develop educational tools geared toward community and county infrastructure positioned in high-risk debris flow and landslide areas.	Educational material can be developed from and organized around data garnered from the landslide identification and mapping project (LS #1), in order to be location specific and relevant to the concerns and needs of impacted community and county infrastructure.	X	X	X	X	X	X	X		X		DM	Ongoing	HMGP, BRIC	Medium
LS #3	Recommend adopting regulatory mechanisms and implementing public outreach activities intended to promote the limitation of development activities in areas identified as being high-risk and vulnerable to landslides or exhibiting historical landslide activity.	TAs Metro area populations increase there will be a demand for new housing and the expansion of the Urban Growth Boundary often into areas of higher landslide hazards. Improved polices for land use, zoning and building codes can help avoid unsuitable locations and improve geotechnical requirements for safer construction.	X		X			X					DTD	Ongoing	County General Fund	Low
LS #4	Recommend revising the definition of steep slope/high-risk areas in land use and comprehensive planning for future development in such areas.	Utilizing this information can assist in guiding the development of updated guidelines and placing restrictions on proposed and future development in such high-risk areas.	X	X	X			X	X				DTD (Planning)	Ongoing	HMGP	Low

Table 3-2 Mitigation Strategy: Action Items

Action Item			Community Impact										Implementation and Maintenance			
#	Statement	Description	Protect Life	Community Lifelines	Climate Adaptation	Enhance Comm.	Vulnerable Pop	Encourage Res. Dev.	Enviro. Impact	Historic and Cultural	Repetitive Losses	Dams Posing Risk	Lead/ Partners	Timeline	Potential Funding Source	Estimated Cost
Severe Weather																
SW #1	Maintain a public awareness campaign regarding severe weather mitigation measures and the importance of personal safety.	Severe weather public awareness campaigns can provide the public with information about severe weather, safety precautions, public alerts, and resources for how to prepare for such events as winter storms or extreme heat.	X		X	X	X						DM/ NWS	Ongoing	County General Fund, BRIC, HMGP	Low
SW #2	Monitor and implement programs to mitigate potentially hazardous trees from endangering lives, property, and public infrastructure.	Running programs geared toward reducing the risks associated with potentially hazardous trees allows the appropriate emergency management authority to intervene more effectively and efficiently either prior to a hazardous event - such as windstorms, winter storms, or extreme heat - or when a hazardous event does occur and leads to an incident involving these trees.	X	X	X		X		X				DTD/ DM, Facilities, Utilities	Ongoing	HMA, County General Fund	Medium
SW #3	Explore strategies to create new, or retrofit existing, housing and infrastructure that reduces heat or protects people from heat with a focus on the hottest areas in Clackamas County.	Urban settings tend to trap more heat than less densely populated areas — straining economic resources, grid capacity, and threatening the health of people living and working in those areas. One way for cities to address this issue is through infrastructure upgrades such as improved weatherization, use of heat pumps, and development of cooling roofs, which reflect more sunlight, keeping indoor temperatures down.	X	X	X		X	X	X				DM/ PHD, DTD	Ongoing	County General Fund, DLCD, OHA, Metro, BRIC C&CB	Medium
SW #4	Explore zoning or land use policy opportunities to preserve existing, and expand, the tree canopy in Clackamas County, with a focus on areas identified as heat islands.	Extreme heat can be dangerous to people, infrastructre and the environment. The hottest areas have fewer trees, more hard surfaces (like roads, rooftops and parking lots), and sprawling development patterns. The hottest areas in Clackamas County have been identified as suburban cities near highways and include land uses such a industrial, commerical uses with large parking areas. These areas are considered heat islands and are the most likely to negatively impact health and quality of life for people living there.	X		X		X	X	X				DM, PHD, DTD, Urban Forestry	Ongoing	County General Fund, DLCD, OHA, Metro, BRIC C&CB	Low

Table 3-2 Mitigation Strategy: Action Items

Action Item			Community Impact										Implementation and Maintenance			
#	Statement	Description	Protect Life	Community Lifelines	Climate Adaptation	Enhance Comm.	Vulnerable Pop	Encourage Res. Dev.	Enviro. Impact	Historic and Cultural	Repetitive Losses	Dams Posing Risk	Lead/ Partners	Timeline	Potential Funding Source	Estimated Cost
Volcanic Event																
VE #1	Coordinate with state and local government agencies to update and exercise the Mount Hood Inter-Agency Volcano Coordination Plan.	The Volcano Coordination plan is critical to maintain lines of communication between all authority levels and incorporate new monitoring capacities for Mt Hood, which is considered a very high hazard volcano.		X		X							DM	Ongoing	County General Fund	Low
VE #2	Partner with the USGS-CVO to enhance public education and outreach related to volcanic eruption hazards.	Volcano hazard education and outreach is an ongoing effort that requires support and engagement from the CVO scientists who are the experts in explaining the impacts from tephra fall, lahars and pyroclastic density currents.	X			X	X						DM	Ongoing	County General Fund	Low
Wildfire																
WF #1	Promote and support wildfire mitigation action items through the Clackamas County Community Wildfire Protection Plan.	Working to incorporate and align actions established in the Clackamas County Community Wildfire Protection Plan provides more consistency across planning entities, as well as supports Action Item: Multi-Hazard #1.	X		X	X							Clackamas Wildfire Collaborative / DM	Ongoing	HMGP-PF, BRIC, ODF, OSFM, USFS CWDG	Low
WF #2	Encourage private landowners to create and maintain defensible space around homes and other buildings and make home hardening improvements.	Along with a home's structural characteristics, a home's surroundings are the other most important factor in determining home ignitability in wildland-urban interface areas. Defensible space is the most effective way to reduce the risk of structural loss from wildfires that spread into residential areas. Proper implementation and maintenance of defensible space could significantly decrease risk to residential development.	X		X	X	X	X	X				Clackamas Wildfire Collaborative / DM, OSFM, DTD	Ongoing	HMGP-PF, BRIC, ODF, OSFM	Medium
WF #3	Update county and jurisdiction wildfire codes and ordinances in accordance with guidelines provided by OSFM/DLCD/ODF/BCD as part of SB 762 (2021) and SB 80 (2023).	Recent Oregon legislation following the 2020 wildfire disasters has brought a suite of new state wildfire mitigation programs with added staffing capacity and funding – to promote defensible space and home hardening standards based on updated wildfire hazard mapping and land use changes.		X	X	X							Clackamas Wildfire Collaborative / DM, OSFM, DTD	Medium Term	HMGP-PF, BRIC, ODF, OSFM, USFS CWDG	Low

Source: Clackamas County HMAC, updated 2024
Cost: Low (less than $50,000), Medium ($50,000-$100,000), High (more than $100,000)
Timing: Ongoing (continuous), Short (1-2 years), Medium (3-5 years), Long (5 or more years)
Priority Actions: Identified with orange highlight

Section 4: Plan Implementation and Maintenance

This section details the formal process that will ensure that the NHMP remains an active and relevant document. The NHMP implementation and maintenance process includes a schedule for monitoring and evaluating the NHMP semi-annually, as well as producing an updated NHMP every five years. Finally, this section describes how the County will integrate public participation throughout the NHMP maintenance and implementation process.

Implementing the NHMP

The success of the Clackamas County NHMP depends on how well the outlined action items are implemented. In an effort to ensure that the activities identified are implemented, the following steps will be taken: 1) the NHMP will be formally adopted, 2) a Hazard Mitigation Advisory Committee (HMAC) will be assigned, 3) a convener shall be designated, 4) semi-annual meetings will be held, 5) the identified activities will be prioritized and evaluated, and 6) the NHMP will be implemented through existing plans, programs and policies.

NHMP Adoption

The Clackamas County NHMP was developed and will be implemented through a collaborative process. After the NHMP is locally reviewed and deemed complete, the Clackamas County Resilience Coordinator, or their designee, shall submit it to the State Hazard Mitigation Officer (SHMO) at the Oregon Department of Emergency Management (OEM). OEM submits the NHMP to FEMA-Region X for review. This review addresses the federal criteria outlined in the FEMA Interim Final Rule 44 CFR Part 201. Upon acceptance by FEMA, the County will adopt the NHMP via resolution. At that point, the County will gain eligibility for the Building Resilient Infrastructure and Communities (BRIC), the Hazard Mitigation Grant Program (HMGP) and Flood Mitigation Assistance (FMA) grant program funds. Following adoption by the County, the participating jurisdictions should convene local decision makers and adopt the Clackamas County Multijurisdictional NHMP.

Convener

The Board of County Commissioners (BCC) will adopt the Clackamas County NHMP, and the HMAC will take responsibility for plan implementation. The County Administrator or designee (Clackamas County Resilience Coordinator) will serve as the NHMP convener to facilitate the HMAC meetings and will assign tasks such as updating and presenting the NHMP to the members of the committee.

- Coordinate HMAC meeting dates, times, locations, agendas and member notification;
- Document the discussions and outcomes of committee meetings;

- Serve as a communication conduit between the HMAC and community members;
- Identify emergency management-related funding sources for natural hazard mitigation projects; and
- Utilize the risk assessment as a tool for prioritizing proposed natural hazard risk reduction projects.
- NHMP implementation and evaluation will be a shared responsibility among all HMAC members.

Hazard Mitigation Advisory Committee

The Hazard Mitigation Advisory Committee (HMAC) serves as the coordinating body for the NHMP and is responsible for coordinating implementation of NHMP action items and undertaking the formal review process. The County Administrator will assign representatives from county agencies, including, but not limited to, the current HMAC members. For a current list of HMAC members see the acknowledgements section and Table PS-1 in the Plan Summary.

Roles and responsibilities of the HMAC include:

- Attending future meetings;
- Prioritizing projects and recommending funding for natural hazard risk reduction projects;
- Participation in the NHMP update process;
- Documenting successes and lessons learned;
- Evaluating and updating the NHMP following a disaster;
- Evaluating effectiveness of the NHMP at achieving its purpose and goals;
- Evaluating and updating the NHMP in accordance with the prescribed maintenance schedule; and
- Development and coordination of ad hoc and/or standing subcommittees as needed.

To make the coordination and review of the Clackamas County NHMP as broad and useful as possible, the HMAC will work to engage additional commmunity members and other relevant hazard mitigation organizations and agencies who can also implement the identified action items into practice.

Implementation through Existing Programs

The NHMP includes a range of action items that, when implemented, will reduce the county's risk and overals loss from hazard events. Within the NHMP, FEMA requires the identification of existing programs that might be used to implement these action items. Thus, to the extent possible, Clackamas County and participating cities and special districts will work to incorporate the recommended mitigation action items into existing programs and procedures. Clackamas County and the participating cities and special districts address these statewide planning goals and legislative requirements by working to incorporate mitigation action items into plans and policies such as their comprehensive land use plans, capital improvement plans, mandated standards and building codes.

Plans and policies already in existence often have support from residents, businesses and policy makers. Many land-use, comprehensive and strategic plans get updated regularly and can adapt easily to changing conditions and needs. Implementing the action items contained in the NHMP through such plans and policies increases their likelihood of being supported and implemented.Thus, by taking such

measures, many of the recommendations contained in the NHMP are consistent with the goals, objectives, and priorities of the participating City and County's existing plans, policies, and programs.

Examples of plans, policies, and programs that may be used to implement mitigation activities include

- City and County Budgets
- Climate Action Plan
- Community Wildfire Protection Plans
- Comprehensive Land Use Plans
- Economic Development Action Plans
- Watershed Action Plans
- Zoning Ordinances and Building Codes
- Climate Hazards Plan
- Climate Adaptation Plan

For additional examples of plans, programs or agencies that may be used to implement mitigation activities refer to list of plans in Volume I, Section 2.

Capability Assessment

The Capability Assessment identifies and describes the ability of Clackamas County to implement the mitigation strategy and associated action items. Capabilities can be evaluated through an examination of broad categories, including: existing authorities, policies, programs, funding, and resources. As applicable the 2019 NHMP was integrated into these authorities/documents over the last five years (e.g., land use regulations, water system master plan, capital improvement plan, etc.).

Existing Authorities

Hazard mitigation can be executed at a local scale through three (3) methods: integrating hazard mitigation actions into other local planning documents (i.e., plan integration), adopting building codes that account for best practices in structural hardening, and codifying land use regulations and zoning designations that prescribe mitigation into development requirements. The extent to which a municipality or multi-jurisdictional effort leverages these approaches is an indicator of that community's capabilities.

Comprehensive Plan

Oregon's Statewide Planning Goal 7 requires comprehensive planning within every jurisdiction that is designed to reduce risks to people and property from natural hazards. The Clackamas County Comprehensive plan provides the policy and regulatory foundation for all land use management in Clackamas County. It integrates policies and recommendations to meet the Oregon Statewide Planning Goals, including Statewide Planning Goal 7, Natural Hazards.

Chapter 3, Natural Resources and Energy, implements Statewide Planning Goal 7. This section was last amended in 2010, but remains largely based upon information and hazard assessments developed in the late 1980s. It does include polices related to geologic or hydrologic hazards, and conservation area policies for streams, rivers, and wetlands. Soils and engineering geologic studies are required for developments with slopes of 20 percent or greater.

Planned updates to the jurisdiction's Goal 7 element or its broader comprehensive plan will reflect the data and findings within this NHMP and integrate analyses of future climate and natural hazard impacts into the community's long-range plans.

Land Use Regulations

Existing land use policies that define zoning and address hazardous conditions provide another source of mitigation capability.

Wildfire Safety

The original Wildfire Safety code for Clackamas County was adopted via ordinance in 2004, and amended in 2010. Amendments included adoption of the Clackamas County Zoning Overlay Map relating to Hazardous Wildfire Areas and updates to the User's Guide Regarding Wildfire Safety, Emergency Vehicle Access, and Private Roads.

Land Use Codes

Clackamas County Zoning and Development Ordinance regulates land use and development in unincorporated areas throughout the county, including floodplain management. The Transportation & Development Department, Planning & Zoning Division administers state, regional and local land use and zoning regulations in unincorporated areas. This department reviews residential, commercial, and industrial development land use permits, and develops long-range planning strategies. Planning & Zoning also administers the Floodplain Management District.

703 Floodplain Management District (FMD)

The county regulates development in the floodplain through its Floodplain Management District, which may include requirements to elevate or floodproof new construction, or retrofit and elevate older structures being renovated that do not meet current floodplain development standards. Floodplain regulations also apply to streambank stabilization projects, and most development in the floodplain requires a floodplain development permit.

Section 703 applies to the FMD, which is applied to the special flood hazard areas (SFHAs) identified by the Federal Insurance Administration in a scientific and engineering report entitled, "The Flood Insurance Study for Clackamas County, Oregon & Incorporated Areas," (FIS) dated January 18, 2019, with accompanying Flood Insurance Rate Maps (FIRMs). This code section was updated in January 2019 to adopt these new maps and meet State and Federal requirements.

Structural Building Codes

The Oregon Legislature recently adopted updated building codes for both residential (2021 adoption) and commercial structures (2022) since the last update of this Plan. These building codes are based on the 2021 version of the International Building Code, International Fire Code, and International Existing Building Code. Clackamas County administers and enforces the most recent Oregon Structural and Oregon Specialty Codes (2022), and the 2022 Oregon Fire Code. As a result, both new residential and commercial structures will be required to build according to the latest seismic and wind hardening standards in addition to requiring fire resistant building materials for those structures constructed in proximity or within the WUI.

Policies and Programs

This Plan directs Clackamas County to explore integration into other planning documents and processes. Clackamas County has made significant progress in integrating the NHMP into its portfolio of planning processes and programs over the last five years.

Capital Improvement Plans

Clackamas County maintains 5-year capital improvement plans for its road system, airport, and parks.

Clackamas Water Environment Services

Clackamas Water Environment Services produces clean water, protects water quality, and recovers renewable resources. This intergovernmental entity within Clackamas County provides for regional, consistent, and efficient planning for future wastewater and surface water needs. Their stormwater standards and rules and regulations were updated adopted in 2023. These standards were adopted to meet current National Pollution Discharge Elimination System (NPDES) and Willamette Basin Total Maximum Daily Load (TMDL) requirements.

Clackamas County Climate Action Plan, 2023

The Clackamas County Climate Action Plan report outlines goals and objectives for addressing climate change throughout Clackamas County, and strategies to achieve the goal of carbon neutrality by 2050.

Clackamas County Emergency Operations Plan, 2022

The Clackamas County Emergency Operations Plan (EOP) is a framework that provides guidance for coordinated preparedness, response, and recovery activities in the county. It was developed through collaboration across County departments, local jurisdictions, special districts, and community partners.

Community Wildfire Fire Protection Plan (2024)

The Community Wildfire Protection Plan will be incorporated into this Plan as a functioning annex. This plan seeks to reduce the risk of wildfire to life, property and natural resources in Clackamas County by coordinating public agencies, community organizations, private landowners, and the public to increase their awareness of and responsibility for fire issues.

National Flood Insurance Program

Clackamas County participates in the National Flood Insurance Program. The Planning Division Director is responsible for administering the day-to-day activities of the County's floodplain program. They are assisted by the Building Official, Engineering, and by the County Administrator. The County's flood prevention code section is based on the Oregon Model Flood Hazard Prevention code, which includes provisions addressing substantial improvement/substantial damage.

Specifically, the floodplain manager:

- maintains and administers Clackamas County's floodplain regulations;
- reviews and issues floodplain development permits;
- maintains elevation certificates for all new and substantially improved structures (and maintains an extensive database of historic elevation certificates);
- ensures that encroachments do not occur within the regulated floodway;

- implements measures to ensure that new and substantially improved structures are protected from flood losses;
- maintains floodplain studies and maps and makes this information available to the public;
- maintains a flood information website with digital flood insurance rate map (DFIRM) data;
- conducts site visits to assess conditions and provide technical assistance to the public;
- maintains a library of historical flood related information;
- informs the public of flood insurance requirements; and
- conducts outreach and training about flood hazards and development within the floodplain.

Firewise

There are eight (8) communities within Clackamas County that participate in the National Fire Protection Association's Firewise program (noted in Table 9 of the Clackamas County CWPP).

Personnel

The following Clackamas County personnel have assignments related to natural hazard mitigation planning and implementation:

- **Emergency Management:** Disaster Management
- **Office of Emergency Services Coordinator**: Emergency preparedness and response
- **Public Information Officer:** Public and Government Affairs
- Floodplain Manager: Planning Director
- **Grant writing (for Public Works or emergency management):** Disaster Management (each department at the County designates their own grant writer)
- Capital improvement planning: Chief Operations Officer
- Capital improvement execution: Chief Operations Officer

These personnel integrate hazards and resilience planning into their greater work programs to the best of their abilities. However, there is limited capacity to expand upon their capabilities or workloads.

County Administration

The Board of County Commissioners of Clackamas County has the responsibility of developing and adopting the annual County budget. Integrating hazard mitigation goals and projects into the annual budget is key to implementing the plan. The Commission tries to broadly address resilience planning needs while it determines County and departmental priorities and looks for multiple-impact projects wherever possible. They also work with staff to apply for federal and state grant funding to pursue larger projects that are outside of general fund capacity.

County Emergency Management

Clackamas County Disaster Management (CCDM) is responsible for the mitigation, preparedness, planning, coordination of response, and recovery activities related to county emergencies and disasters. County Emergency Management also serves as the primary coordination point between local, State, and Federal agencies when emergency activities are affecting more than one jurisdiction, county department, incorporated city, unincorporated area, special district, or other partner agencies.

Partnering with Watershed Councils

Examples of how the CCDM Resilience Coordinator maintains close partnerships with regional partners includes their work with several of the watershed councils in Clackamas County. It is mutually beneficial to have coordination between NHMP flood mitigation action items and watershed council objectives and projects listed in their action plans. Below is a brief list of current or recent watershed council projects with CCDM involvement.

Greater Oregon City Watershed Council (GOCWC)

- CCDM has three flood acquired properties in the mid-Abernethy Creek watershed and has offered the GOCWC access for stream restoration projects.
- The GOCWC has used an OWEB public engagement grant to work with the Beaverlake HOA to explore the impacts of the Mompano Dam to Beaver Lake health, impact to ESA species, improvements for fish passage, and possible options, including dam removal. The CCDM Resilience Coordinator is an invited member of the planning subcommittee. Mompano Dam is one of two High Hazard Dams listed in the 2024 MJ-NHMP.

Molalla River Keeps (Watershed Council)

- Service area includes territory prone to wildfires.

North Clackamas Watershed Council (NCWC)

- CCDM has a history of working closely with the NCWC on urban flooding problems. There are two flood acquisitions on SE Rusk Road along Mt Scoot Creek, one in Clackamas County and the other in the City of Milwaukie. The County has offered access to NCWC for the sake of restoration and creek monitoring.
- NCWC has worked closely with County Water Environment Service (WES) on stream restoration in the Three Creeks Recreation Area to improve stream function and to attenuate flood hazards for downstream communities.

Pudding River Watershed Council

- Service area includes territory prone to wildfires and the Gladtiding Ground Water Critical Area where groundwater is currently limited.

Sandy River Watershed Council (SRWC)

- CCDM and other County departments worked closely with the SRWC following the 2011 floods on the upper Sandy River. The SRWC was a critical partner to help promote the County's "Flood of Information" program in the years following the 2011 flood and the determination of channel migration hazards and risk. They created a Community Handbook called "Restorative Flood Response" to help homeowners and HOAs make smart choices for flood mitigation.
- The SRWC used the 2015 Sandy River Flood Erosion Study published by CCDM to develop two restoration projects that opened disconnected side channels and reconnected flood plains to help manage erosion and improve habitat and stream function.

Capital Projects

Clackamas County has implemented recommendations from the last NHMP into its capital improvement projects over the last 5 years, including:

3-Creeks Natural Area Floodplain Enhancement

WES owns the 3-Creeks Natural Area, where Mt. Scott, Phillips and Deer (Dean) Creeks come together on 89 acres in Northern Clackamas County. WES is working on the final plans to enhance floodplain processes and the existing natural floodplain area, construct wetlands and floodplain terraces to increase flood storage, improve fish and wildlife habitat, restore wetlands, and restore natural floodplain function.

Pump Station Repairs and Upgrades:

(Bolton, River Street, Timberline Rim)

WES is investing in our infrastructure to provide resilient, reliable sanitary sewer service to protect the environment and serve your community. We will be upgrading electrical equipment, automatic controls, on site power generation and pumps at the facilities below. The pump stations are a vital part of our infrastructure that needs to be operational 24 hours a day 365 days a year pumping sanitary sewage safely on through the collection system to our water resource recovery facilities for treatment.

82nd Ave Pedestrian Bridge Upgrades

In 2020, Clackamas Water Environment Services (WES) reopened the 82nd Drive Pedestrian Bridge to pedestrians and bicyclists after completion of several upgrades, which include seismically-retrofitting the bridge to withstand a magnitude 9.0 earthquake. The bridge is now capable of providing vital passage for emergency vehicles across the Clackamas River should such a catastrophic earthquake occur.

Tri-City Water Resource Recovery Facility

Along with the facility's two existing digesters, the new digester will turn waste into methane gas that is converted to heat and power, which provides nearly half of the electricity used at the Tri-City facility and provides heat for the process and buildings The digester process also converts the solids into a natural soil amendment. A biopower upgrade at the Tri-City Water Resource Recovery Facility is helping Clackamas County meet climate-action goals and extend the benefits of renewable power to more residents. The new, low-emissions biogas project transforms organic waste into renewable energy. This co-generation system will produce heat for five buildings at the site and an estimated 4,324 megawatts of electricity a year—enough to offset nearly half of the facility's energy use. The new digester was needed to accommodate a population that has more than doubled over the past 30 years. In addition to protecting public health and the environment, the new digester will support future economic growth in the region.

Capital Resources

Clackamas County maintains several capital resources that have important roles to play in the implementation of the natural hazard mitigation plan. Most critical facilities have power generators for use during emergency blackouts. The County does not have any fuel storage capacity, county fleet relies on retail/cardlock locations. However, a handful of local jurisdictions and Clackamsa Fire and TVF&R have storage.

Findings

Several important findings from this capability assessment informed the design of the NHMP's mitigation strategy and aided in prioritizing action items.

Staffing Limitations and Capacity

Clackamas County staff are assigned hazard mitigation responsibilities as a part of their larger job responsibilities. Limited capacity reduces the breadth of the programming the community can undertake in any year. The County relies upon its relationships with the County and other cities within its region to expand its operations.

Reliance upon outside funding streams and local match requirements

Clackamas County operates on a limited budget with a small staff. This leaves few opportunities for using local financial resources to implement hazard mitigation work. They lean heavily upon state and federal grant funds as the primary means for securing mitigation funding. Hazard mitigation grants such as HMGP and BRIC require 10-25% local funding match, as well as extra staff capacity and expertise to navigate the application process and manage the funding.

Leveraging Partnerships with Public and Nonprofit Entities

Regional planning displayed in Community Wildfire Protection Planning process demonstrates the County's ability to effectively share information and identified priority needs.

NHMP Maintenance

NHMP maintenance is a critical component of the NHMP. Proper maintenance of the NHMP ensures that it will maximize the County and participating Cities' efforts to reduce the risks posed by natural hazards. This section includes a process to ensure that a regular review and update of the NHMP occurs. The HMAC and local staff are responsible for implementing this process, in addition to maintaining and updating the NHMP through a series of meetings outlined in the maintenance schedule below.

Meetings

The HMAC will meet on a semi-annual basis to complete the following tasks:

- Reviewing progress, issues, and trends in the achievement of desired results of Action Items;
- Review action items to prioritize potential mitigation projects and determine applicable funding source;
- Educate and train new members on the HMAC on the NHMP and mitigation in general;
- Identify issues that may not have been identified when the NHMP was developed;
- Review and discuss updates regarding risk assessment data;
- Discuss and implement methods for continued public involvement;
- Evaluate effectiveness of the NHMP at achieving its purpose and goals (use Table 4-1 as one tool to help measure effectiveness); and
- Document successes and lessons learned during NHMP process.

The county's Resilience Coordinator will host a meeting once a year with the city leads for participating jurisdictions. This meeting is an opportunity for the cities to report back to the county on progress that

has been made towards their NHMP Addenda. This meeting will also serve as a means for the Resilience Coordinator to provide information regarding potential funding sources for mitigation projects, as well as provide additional support for the participating jurisdictions' steering committees.

The convener will be responsible for documenting the outcome of the semi-annual meetings in Volume III, Appendix B. The process the coordinating body will use to prioritize mitigation projects is detailed in the section below. The NHMP's format allows the county and participating jurisdictions to review and update sections when new data becomes available. New data can be easily incorporated, resulting in a NHMP that remains current and relevant to the participating jurisdictions.

Project Prioritization Process

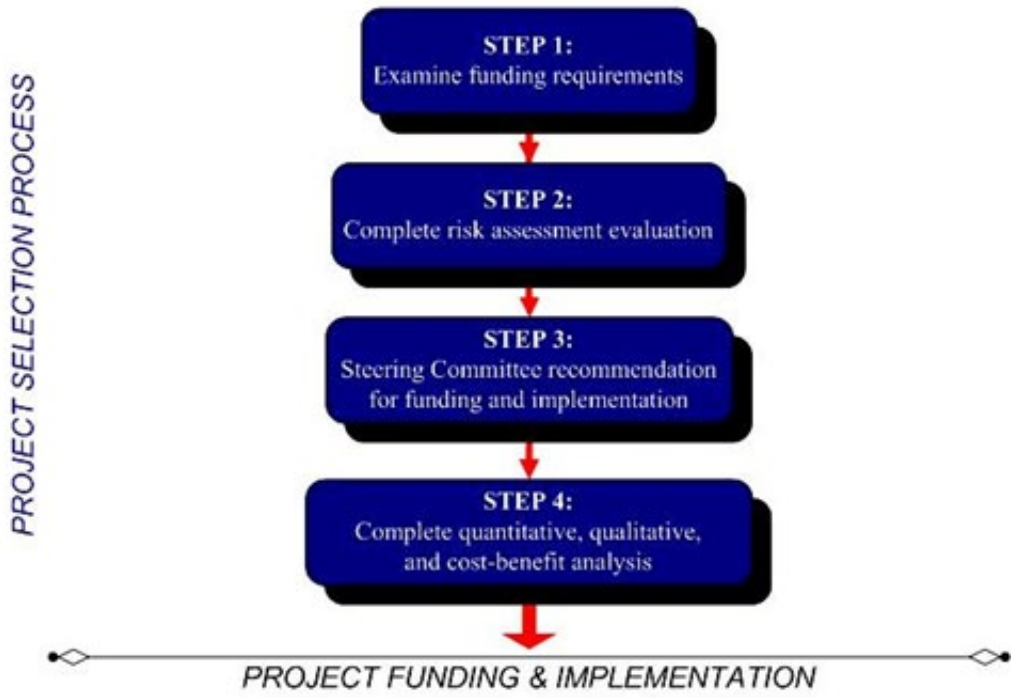
Chapter 3 describes the process the HMAC used to establish the current prioritization of action items. Understanding that priorities may change over time depending on new events or resource availability, the Disaster Mitigation Act of 2000 requires that jurisdictions identify a process for future action item prioritization. Potential mitigation activities often come from a variety of sources; therefore, the project prioritization process needs to be flexible and adaptable. Committee members and local government staff, as well as other planning documents or the hazard risk assessment may be sources to help and identify potential projects. Figure 4-1 illustrates the project development and prioritization process that the HMAC can use in the future.

Step 1: Examine funding requirements

The first step in prioritizing the NHMP's action items is to determine which funding sources are open for application and which funding sources is the project eligible to apply for. Several funding sources may be appropriate for the County's proposed mitigation projects. Examples of mitigation funding sources include but are not limited to: FEMA's Building Resilient Infrastructure and Communities (BRIC) competitive grant program, Hazard Mitigation Grant Program (HMGP), Flood Mitigation Assistance (FMA) grant program, National Fire Plan (NFP), Community Development Block Grants (CDBG), local general funds and private foundations, among others. Please see Volume II, Appendix F for a more comprehensive list of potential grant programs.

Because grant programs open and close on differing schedules, the HMAC will examine upcoming funding streams' requirements to determine which mitigation activities would be eligible. The HMAC may consult with the funding entity, OEM, or other appropriate state or regional organizations about project eligibility requirements. This examination of funding sources and requirements will happen during the HMAC's semi-annual NHMP maintenance meetings.

Figure 4-1 Action Item and Project Review Process



Source: Oregon Partnership for Disaster Resilience, 2008

Step 2: Complete risk assessment evaluation

The second step in prioritizing the NHMP's action items is to examine which hazards the selected actions are associated with and where these hazards rank in terms of community risk. The HMAC will determine whether the NHMP's risk assessment supports the implementation of eligible mitigation activities. This determination will be based on the location of the potential activities, their proximity to known hazard areas and whether community assets are at risk or are vulnerable. The HMAC will additionally consider whether the selected actions mitigate hazards that are likely to occur in the future and/or are likely to result in severe/catastrophic damages.

Step 3: Hazard Mitigation Advisory Committee Recommendation

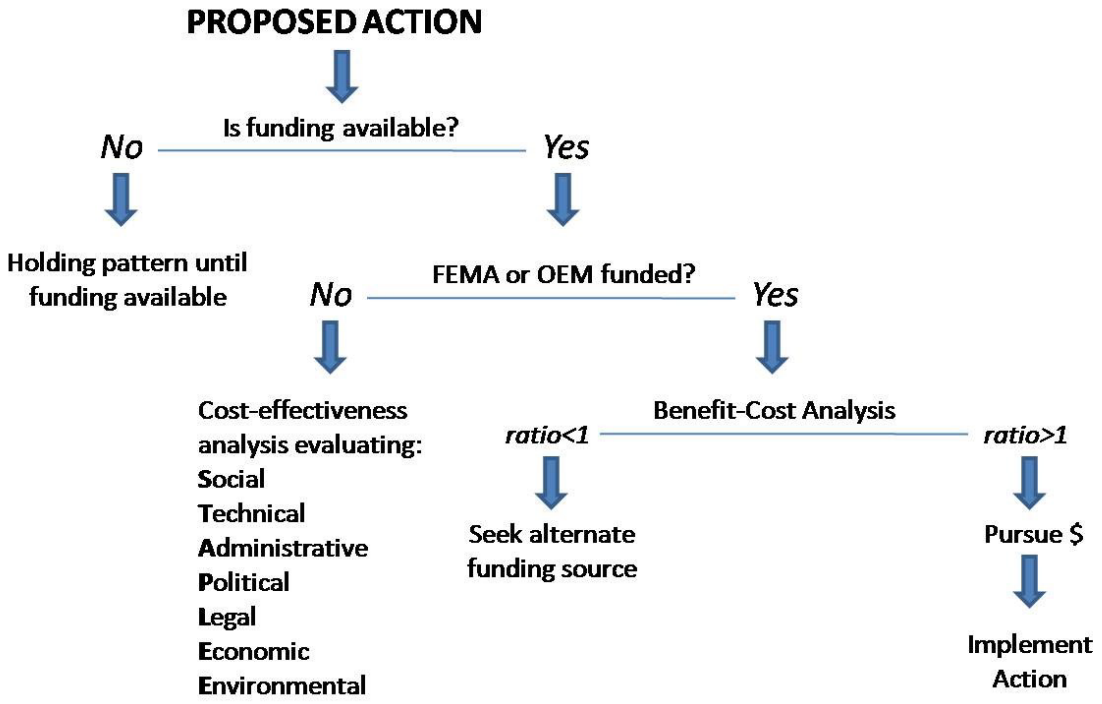
Based on the steps above, the HMAC will recommend which mitigation activities should be moved forward. If the HMAC decides to move forward with an action, the coordinating organization designated in the matrix will be responsible for taking further action and, if applicable, documenting success upon project completion. The HMAC will convene a meeting to review the issues surrounding grant applications and to share knowledge and/or resources. This process will afford greater coordination and less competition for limited funds.

Step 4: Complete quantitative and qualitative assessment and economic analysis

The fourth step is to identify the costs and benefits associated with the selected natural hazard mitigation strategies, measures, or projects. Two categories of analysis that are used in this step are: (1)

cost-benefit analysis and (2) cost-effectiveness analysis. Conducting cost-benefit analysis for a mitigation activity assists in determining whether a project is worth undertaking now, in order to avoid disaster-related damages later. Cost-effectiveness analysis evaluates how best to spend a given amount of money to achieve a specific goal. Determining the economic feasibility of mitigating natural hazards provides decision makers with an understanding of the potential benefits and costs of an activity, as well as a basis upon which to compare alternative projects. Figure 4-2 shows decision criteria for selecting the appropriate method of analysis.

Figure 4-2 Benefit Cost Decision Criteria



Source: Oregon Partnership for Disaster Resilience, 2010

If the activity requires federal funding for a structural project, the HMAC will use a FEMA-approved cost-benefit analysis tool to evaluate the appropriateness of the activity. A project must have a cost-benefit ratio of greater than one in order to be eligible for FEMA grant funding.

For non-federally funded or nonstructural projects, a qualitative assessment will be completed to determine the project's cost effectiveness. The HMAC will use a multivariable assessment technique called STAPLE/E to prioritize these actions. STAPLE/E stands for Social, Technical, Administrative, Political, Legal, Economic and Environmental. Assessing projects based upon these seven variables can help define a project's qualitative cost effectiveness. OPDR at the University of Oregon's Community Service Center has tailored the STAPLE/E technique for use in natural hazard action item prioritization.

Continued Public Involvement and Participation

The county and participating jurisdictions are dedicated to involving the public directly in the continual updating of the Clackamas County NHMP, in order to comply with 44 CFR 201.6(c)(4)(iii)] and ensure that ongoing "discussion on how the community will continue public participation in the plan maintenance process." Public awareness and engagement about hazard mitigation and mitigation

planning is exceptionally important for advancing the goals presented in this plan and ensure that the plan equitably addresses the risk of the community.

To ensure that these opportunities will continue, the County and participating jurisdictions will:

- Post copies of their NHMP on corresponding websites;
- Place articles in the local newspaper directing the public where to view and provide feedback;
- Use existing newsletters such as schools and utility bills to inform the public where to view and provide feedback;
- Continue to host a booth at the Clackamas County Fair and other countywide events on an annual basis and present information about hazard mitigation; and
- Continue to utilize social media platforms to involve and inform the public.

In addition to the involvement activities listed above, Clackamas County will ensure continued public involvement by posting the Clackamas County NHMP on the county's website (https://www.clackamas.us/dm/naturalhazard.html).

Incorporation into Exisiting and Future Plans

In accordance with 44 CFR 201.6 (c)(4)(ii)], Clackamas County will work to "establish a process by which local governments incorporate the requirements of the mitigation plan into other planning mechanisms such as comprehensive or capital improvement plans, when appropriate."

Mitigation is most successful when it is codified and incorporated into the functions and priorities of government, planning, and future development. Incorporating mitigation strategies into other planning documents is an effective way to leverage the support of affiliated agencies and departments while ensuring mutually supportive goals and policies. Likewise, the action items and strategies contained in other planning documents can be incorporated into the mission and goals of this Plan.

The action items contained within this version of the plan incorporated action items from other planning documents. This process includes incorporating action items contained within the CWPP, the Climate Action Plan, Emergency Operations Plan, and the Capital Improvement Plan. Incorporating these plan elements within the NHMP is a step towards bolstering integration across all of Clackamas County's planning documents and actions.

Five-Year Review of NHMP

This NHMP will be updated every five years in accordance with the update schedule outlined in the Disaster Mitigation Act of 2000. The Clackamas County NHMP is due to be updated before **September 11, 2029.** The Convener will be responsible for organizing the HMAC to address NHMP update needs. The HMAC will be responsible for updating any deficiencies found in the NHMP and for ultimately meeting the Disaster Mitigation Act of 2000's NHMP update requirements.

The following 'toolkit' can assist the Convener in determining which NHMP update activities can be discussed during regularly-scheduled NHMP maintenance meetings and which activities require additional meeting time and/or the formation of sub-committees.

Table 4-1 Natural Hazard Mitigation Plan Update Toolkit

Question	Yes	No	Plan Update Action
Is the planning process description still relevant?			Modify this section to include a description of the plan update process. Document how the planning team reviewed and analyzed each section of the plan, and whether each section was revised as part of the update process. (This toolkit will help you do that).
Do you have a public involvement strategy for the plan update process?			Decide how the public will be involved in the plan update process. Allow the public an opportunity to comment on the plan process and prior to plan approval.
Have public involvement activities taken place since the plan was adopted?			Document activities in the "planning process" section of the plan update
Are there new hazards that should be addressed?			Add new hazards to the risk assessment section
Have there been hazard events in the community since the plan was adopted?			Document hazard history in the risk assessment section
Have new studies or previous events identified changes in any hazard's location or extent?			Document changes in location and extent in the risk assessment section
Has vulnerability to any hazard changed?			Document changes in vulnerability in the risk assessment section
Have development patterns changed? Is there more development in hazard prone areas?			Document changes in vulnerability in the risk assessment section
Do future annexations include hazard prone areas?			Document changes in vulnerability in the risk assessment section
Are there new high risk populations?			Document changes in vulnerability in the risk assessment section
Are there completed mitigation actions that have decreased overall vulnerability?			Document changes in vulnerability in the risk assessment section
Did the plan document and/or address National Flood Insurance Program repetitive flood loss properties?			Document any changes to flood loss property status

Table 4-1 Natural Hazard Mitigation Plan Update Toolkit

Question	Yes	No	Plan Update Action
Did the plan identify the number and type of existing and future buildings, infrastructure, and critical facilities in hazards areas?			1) Update existing data in risk assessment section, or 2) determine whether adequate data exists. If so, add information to plan. If not, describe why this could not be done at the time of the plan update
Did the plan identify data limitations?			If yes, the plan update must address them: either state how deficiencies were overcome or why they couldn't be addressed
Did the plan identify potential dollar losses for vulnerable structures?			1) Update existing data in risk assessment section, or 2) determine whether adequate data exists. If so, add information to plan. If not, describe why this could not be done at the time of the plan update
Are the plan goals still relevant?			Document any updates in the plan goal section
What is the status of each mitigation action?			Document whether each action is completed or pending. For those that remain pending explain why. For completed actions, provide a 'success' story.
Are there new actions that should be added?			Add new actions to the plan. Make sure that the mitigation plan includes actions that reduce the effects of hazards on both new and existing buildings.
Is there an action dealing with continued compliance with the National Flood Insurance Program?			If not, add this action to meet minimum NFIP planning requirements
Are changes to the action item prioritization, implementation, and/or administration processes needed?			Document these changes in the plan implementation and maintenance section
Do you need to make any changes to the plan maintenance schedule?			Document these changes in the plan implementation and maintenance section
Is mitigation being implemented through existing planning mechanisms (such as comprehensive plans, or capital improvement plans)?			If the community has not made progress on process of implementing mitigation into existing mechanisms, further refine the process and document in the plan.

Source: Oregon Partnership for Disaster Resilience, 2010.

This page is intentionally left blank