STATEWIDE PLANNING GOAL 7:

To protect people and property from natural hazards.

CLATSOP COUNTY GOAL 7:

To protect people and property in Clatsop County from natural hazards.

OVERVIEW

Statewide Planning Goal 7 requires local comprehensive plans to address Oregon's natural hazards. Protecting people and property from natural hazards requires knowledge, planning, coordination, and education. Goal 7 requires local governments to adopt inventories, policies and implementing measures to reduce risk to people and property from the following natural hazards:

- Floods
- Landslides
- Earthquakes
- Tsunamis
- Coastal erosion
- Wildfires

Goal 7 also allows local governments to plan for other natural hazards specific to their jurisdictions.

Clatsop County has been planning for some of Oregon's natural hazards for over 40 years. River and coastal floods, landslide, wildfires, and coastal erosion are a consistent presence in Oregon and in Clatsop County. In recent years, more awareness has been developing about the possibility of a major earthquake and tsunami from the Cascadia Subduction Zone (CSZ). Good planning does not put buildings or people in harm's way. Planning, especially for the location of essential services like schools, hospitals, fire and police stations, is done with sensitivity to the potential impact of nearby hazards.

In order to address natural hazards in its comprehensive land use plan the County must adopt a natural hazard inventory, and supporting plans and policies.

In Clatsop County two departments focus on natural hazards planning: Emergency Management and Community Development. State partners with the County in the natural hazards planning area include:

- Oregon Department of Emergency Management
- Oregon Department of Land Conservation and Development

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- Oregon Department of Geology and Mineral Industries
- Federal Emergency Management Agency

Clatsop County Public Works and law enforcement have primary roles during and post-disaster.

In 2021, the County completed an update of its Multi-Jurisdictional Natural Hazards Mitigation Plan (MJNHMP). This plan also analyzes the County's risk from drought, volcanic ash fall and wind/winter storms and provides recommended mitigation actions.

HISTORICAL PERSPECTIVE

When Clatsop County's first comprehensive plan was adopted in 1980, consideration was given to the suitability of various land for development. Physical characteristics that were hazardous or limiting were analyzed and regulations were developed for those areas to minimize loss of life and property and to avoid expensive and burdensome corrective measures. Historically, natural hazards of concern in Clatsop County were identified as:

- Flooding
- Tsunamis
- Mass movement (landslides)
- Earthquakes
- High groundwater and compressible soils
- Erosion and deposition

The following narrative and tables document the historical incidents of each of the natural hazards within Clatsop County that are covered by Statewide Planning 7. The narrative and tables also address winter storms, which were analyzed in the MJNHMP, and compressible soils and high groundwater, which are included in the current.

FLOODING

Oregon has a history of flooding with flood records dating back to the 1860s. The principal types of flood that are a threat to Clatsop County include:

- Riverine flooding from freshwater rivers and streams;
- Ocean flooding from high tides or wind- driven waves;
- Dams, levees, and tide gates.

Riverine Flooding

There are many large rivers within Clatsop County that either drain to the Pacific Ocean or the Columbia River. The major rivers within the county are:

- Lewis and Clark
- Necanicum
- Nehalem

- North Fork Nehalem
- Skipanon
- John Day
- Walluski
- Youngs

Debris Washed onto Residential Deck by 2021 Storm

The Columbia River defines the north boundary of the county and separates Oregon from Washington. These rivers are all subject to flooding, which can cause damage to buildings within the Special Flood Hazard Area. Other flooding events are due to coastal flooding from the Pacific Ocean for low-lying coastal developments and from the many estuaries within the county.

Ocean Flooding

Flooding from wind-driven waves is a common event on the Oregon coast. This is particularly true during the winter storm season, during El Niño events, and when spring and King tides occur. While ocean storms can and do occur annually, El Niño events tend to occur every three to five years. These types of events can wash large debris ashore, cause property damage and endanger humans.

Dams, Levees and Tide Gates

Dam failure can be caused by destabilizing events such as large snowpack, heavy rains, or extreme floods that exceed spillway capacity. Seismic events can structurally damage dams, creating or exacerbating structural issues that increase vulnerability to otherwise normal snow and rain events. Regular maintenance and inspections are required to ensure the structural soundness of these types of facilities. In Clatsop County, there are five dams, as noted in **Table 1**.

Table 1: Dams in Clatsop County

Name	Hazard Level	Height	Storage (acre-feet)	Owner	Notes
Bear Creek Dam	High[1]	94 FT	800	City of Astoria	Water Supply / Bear Creek
Middle Reservoir	High	39 FT	168	City of Astoria	Water Supply / Bear Creek
Wickiup Lake	High	30 FT	340	City of Astoria	Water Supply / Bear Creek
Seaside City Reservoir	High	45 FT	170	City of Seaside	Water Supply / Necanicum River

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Fishhawk Lake	Significant[2]	40 FT	1,650	Fishhawk Lake HOA	Dam repair underway / lake drained in 2019

Source: 2021 Clatsop County Multi-Jurisdictional Natural Hazards Mitigation Plan: U.S. Army Corps of Engineers National Inventory of Dams, 2020.
[1]High: Failure would present a strong risk for loss of life, annual inspection, Emergency Action Plan (EAP) required
[2]Significant: Failure would present a strong risk for loss of major infrastructure, inspection every 3 years, EAP not required

Levees that are unmaintained or that have been designed for different conditions may cause flooding under various conditions. There are over 8,000 acres of lowlands in Clatsop County that depend on over 35 miles of dikes for flood control. Many of these dikes are in poor condition and are expensive to maintain and repair. A list of diking districts and their status is listed in Goal 6.

Tide gates are structures designed to protect farm land and other development from salt water and high tides. Due to the expense and time associated with permitting in estuaries it can be cost-prohibited to replace them when the break. Most tide gates are well past the end of their useful lives and may be impossible to operate, making it difficult to drain freshwater flood flows. Thus, tide gates can result in back-flooding at these locations. This back-flooding can cause erosion, structure failure, and variations in the local fresh-salt water chemistry that may not benefit native species or estuarine products.

FEMA

FEMA has mapped Clatsop County water bodies for 10-, 50-, 100-, and 500- year flood events, with the probability of flooding in a year being 10%, 2%, 1%, and 0.2% respectively. Areas subject to these floods are depicted on FEMA Flood Insurance Rate Maps (FIRMs) and profiled in an accompanying Flood Insurance Study (FIS). Recurrence intervals can differ between reaches of the same stream. For example, certain reaches of the Young's River may experience a 100-year (1%) flood while other sections of the river may be having a 50-year (2%) or perhaps a 500-year (0.2%) flood event.

FEMA's National Flood Insurance Program (NFIP) requires jurisdictions that regulate development, such as a county or municipality, to use FEMA's Flood Insurance Rate Maps (FIRMs) for managing the local floodplain. FIRMs depict flood conditions and the associate Flood Insurance Study (FIS) provides details about the location, source and nature of flooding in the County. In Clatsop County, two Flood Insurance Studies are used in the unincorporated areas:

- #41007CV001B and #41007CV002B, dated June 20, 2018, Version Number 2.3.2.0
- #41007CV001A and #41007CV2A, dated September 17, 2010

It should be noted that FEMA's flood maps do not consider future conditions, such as sea level rise. The effect of rising sea levels on the county's estuaries has not yet been mapped. **Table 2** details historic flooding events in Clatsop County and on the North Oregon Coast from 1876-January 2021.

Table 2: Historic Flood Events

Date	Location	Event Type	Magnitude	Details
Jan. 2021 (01/03/2021)	Clatsop County	Flood, Heavy Rain		A strong westerly upper level jet over the northern Pacific was directed at the Oregon coast, driving a plume of deep moisture toward NW Oregon Street flooding stranded vehicles along Circle Creek, approximately 1 mile south of Seaside.
Jan. 2018 (01/18/2018)	N. Oregon Coast	Flood, Coastal Erosion	3 ft. waves	A strong stationary low pressure system brought high seas with wave heights up to 37'. Seaside and Cannon Beach had water in their streets.
Oct. 2017 (10/21/2017)	N. Oregon Coast	High Wind, Heavy Rain	53 mph. on Astoria-Megler Bridge	A very potent atmospheric river brought strong winds to the north Oregon Coast and Coast Range on October 21st. What followed was a tremendous amount of rain for locations along the north Oregon Coast and Coast Range.
Nov. 2016 (11/24/2016)	Bradwood, Clatsop County	Heavy Rain	3.52 in. of rain	A moist Pacific front moving slowly across the area produced heavy rainfall, resulting in flooding of several rivers across Northwest Oregon and at least two landslides.
Dec. 2007 (12/01/2007-12/03/2007)	Clatsop County	High Wind, Heavy Rain, Mudslides	A series of powerful Pacific storms brought straight-line winds, rain, and mudslides.	A series of powerful Pacific storms Dec. 1-3, 2007 brought straight-line winds, rain, and mudslides resulting in Presidential Disaster Declaration; $180 million in damage in the state, power outages for several days, and five deaths attributed to the storm.
Dec. 2006 (12/14/2006, 12/15/2006)	Clatsop, Tillamook Counties	High Wind, Heavy Rain		$10,000 in damages.
Nov. 2006 (11/05/2006-11/08/2006)	Clatsop County	High Wind, Heavy Rain		Severe storms, flooding, landslides, mudslides.
Dec. 2004 (12/08/2004-12/09/2004)	W. Oregon	Winter Storm, High Wind, Heavy Snow, High Surf	2.5 ft. of snow on Mt Hood; Lightning in Astoria; 25 ft. Surf	A large powerful Pacific storm brought a wide variety of weather to Northwestern Oregon. High winds along the Coast heralded the approach of the storm early in the morning. A City employee was struck by lightning. Heavy rain accompanied this storm resulting in mud slides. The storm also generated high seas, which created high surf along the Northern and Central Oregon Coast the next day. Buoys 20 miles off the Oregon Coast reported maximum seas of 25 to 26 feet.
Jan. 2004 (01/27/2004-01/29/2004)	Clatsop	Heavy Rain	4 in. rain in Seaside; 4.29 in. rain at Astoria Airport	A series of strong Pacific storm systems brought heavy rain to Northwest Oregon.
Dec. 2003 (12/12/2003 - 12/14/2003)	Clatsop	Heavy Rain	1-3 in.	A strong very moist Pacific system moved into the are producing heavy rains.
Mar. 2003	Clatsop	Heavy Rain	1-3 in.	Heavy rains once again moved into Northwest Oregon. Many stations reported 1 to 3 inches during the same 24-hour period.

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Date	Location	Event Type	Magnitude	Details
Jan 2003 (01/29/2003-01/31/2003)	Clatsop	Heavy Rain, Floods	1-3 in.	Heavy rains associated with a strong Pacific weather system brought 2 days of heavy rains to the area. Numerous locations reported 1 to 3 inches. These heavy rains filled many small streams, 2 feet of water covered Highway 101 between Seaside and Cannon Beach.
Jan. 2002	N. Oregon Coast	Winter Storm: High Winds, Heavy Rains	63 mph.	A winter storm brought high winds, heavy rain, and warmer temperatures to the area, resulting in flooding and mud and landslides. High winds knocked out power along the coast from Cannon Beach and Seaside to Warrenton for varying periods of time. Reported winds included Cannon Beach 40 to 45 mph with gusts to 63 mph.
2001	Clatsop	n/a		A dike failure required a significant emergency repair effort to prevent significant flood losses.
Aug. 2001 (08/22/2001-08/23/2001)	Clatsop	Heavy Rain		n/a – Unknown if above event is connected to this Aug. event.
Dec. 1996 (12/26/1996-12/31/1996)	N. Oregon Coast	Heavy Rain, Floods	16 rivers flooded	Heavy rains caused 16 rivers in NW Oregon to flood during the last week of December 1996 and into early January 1997. Dozens of homes were flooded on various rivers and numerous highways were rendered impassable.
Nov. 1996 - Dec. 1996	Five Western States	Heavy Rain, Freezing Rain/Heavy Wet Snow	6-18 in. rain west of the Cascades; 8 in. in 24 hrs. in Coast Range	During the period from mid-November to mid-December 1996, many areas received above-normal precipitation, greatly increasing the snowpack over mid and high elevations. Three sequential storms brought moderate to heavy rain, with the last creating a rain-on-snow event which resulted in incredible amounts of runoff.
Nov. 1996 (11/18/1996-11/20/1996)	N. Oregon Coast	Heavy Rain, Floods	11 rivers reached flood stage	Road damage from landslides; high velocity flows, damage from erosion and undermining of structures. Heavy rainfall over Oregon caused many rivers in Northwestern Oregon to flood. The first small streams began flooding on November 18th with 11 larger rivers reaching flood stage on the 19th and 20th. Major rivers such as the lower reaches of the Willamette remained above flood stage until November 23rd. Initial damage estimates from this flooding exceeded $3 million.
Feb. 1996 (2/5/1996-2/9/1996)	N. Oregon Coast	Floods, Debris Flow	Astoria 7.68 in. rain in 3 days	A river of subtropical atmospheric moisture flowed above northern Oregon producing very heavy rainfall, particularly in the northwestern part of the state. Runoff from heavy rains and melting mountain snow caused major floods upon many northern Oregon rivers. Six rivers set all time high river stage records, and 7 people lost their lives as a direct result of flooding. Statewide damage was estimated at over 285 million dollars with an estimated five thousand

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Date	Location	Event Type	Magnitude	Details
				homes destroyed. Numerous mudslides were triggered, disrupting transportation in mountainous areas of western Oregon.
Nov. 1991	Oregon Coast	High Wind, High Surf	25 ft. waves	This slow-moving storm generated 25-foot waves and resulted in damage to buildings, boats, and transmission lines.
1982	Clatsop	Dike failure		Caused almost $200,000 in damage (Clatsop EOP, 2018).
Nov.-Dec. 1977	Western Oregon	Heavy Rain, Floods	n/a	Rain on snow event; $16.5 million in damages.
Jan. 1972	Western Oregon	Heavy Rain, Floods	n/a	Record flows on coastal rivers.
Dec. 1964 (12/24/1964)	Oregon	Floods, Heavy Rain, Winter Storm	100-year flood event; Benchmark	The Christmas flood of 1964 was driven by a series of storms, known as atmospheric rivers or "pineapple expresses," that battered the region producing as much as 15 inches of rain in 24 hours at some locations. The combination of heavy rain, melting snow, and frozen ground caused extreme runoff, erosion, and flooding.
Dec. 1964 - Jan. 1965	Oregon	Floods, Heavy Rain, Winter Storm		Rain on snow event; record flood on many rivers.
Mar. 1964	Oregon Coast	Flood	n/a	n/a
Jan. 1956	Western Oregon	High Wind, Heavy Rain, Mudslides		Heavy rains, high winds, mud slides resulted in estimated damages of $95,000.
May - June 1948	Columbia River Basin	Flood	n/a	Rain on snow event; Rocky Mountain snow melt.
May 1928	Columbia River Basin	Flood	n/a	Rain on snow event; Rocky Mountain snow melt.
June 1913	Columbia River Basin	Flood	n/a	Rain on snow event; Rocky Mountain snow melt.
Feb. 1907	Western Oregon	Flood	n/a	
June 1894	Columbia River Basin	Flood	33 ft. in Portland	Rain on snow event; Rocky Mountain snow melt.
May - June 1884	Columbia River Basin	Flood	n/a	Rain on snow event; Rocky Mountain snow melt.
June 1880	Columbia River Basin	Flood	27.4 ft. in Portland	Rain on snow event; Rocky Mountain snow melt.
Mar. 1876	Columbia River Basin	Flood	< 27.0 ft in Portland	Rain on snow event; Rocky Mountain snow melt.

Source: NOAA Storm Events Database, https://www.ncdc.noaa.gov/stormevents/, accessed 12/2/2019.

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MASS MOVEMENT / LANDSLIDE

In simplest terms, 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 types of materials that are transported. In understanding a landslide, two forces are at work:

- gravity, the driving forces that cause the material to move down slope, and
- friction, the 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.

Clatsop County has significant chronic risks from landslides, particularly on steep forested slopes subject to heavy rainfall each winter. However, the potential for catastrophic risk is posed by an earthquake that could trigger landslides resulting in road closures and isolation. Most slopes in Clatsop County steeper than 70% have a risk of rapidly moving landslide activity regardless of geologic unit. Areas directly below these slopes in the paths of potential landslides are at risk as well. The combination of steep slopes and geologic formation (sedimentary rock units) contributes to the increased hazard risk. There is a strong correlation between intense winter rainstorms and the occurrence of rapidly moving landslides (debris flows).

Landslides accompany nearly every major storm system that impacts western Oregon. In recent events, landslides companied storms in 1964, 1966, 1982, 1996, and 2007. Two major landslide-producing winter storms occurred in Oregon during November 1996. Intense rainfall triggered over 9,500 landslides and debris flows that resulted in eight fatalities throughout the state. The fatalities and losses resulting from the 1996 landslide events brought about the passage of Oregon Senate Bill 12, which set site development standards, authorized the mapping of areas subject to rapidly moving landslides and the development of model landslide (steep slope) ordinances. During the December 2007 storm, a landslide occurred near Woodson in neighboring Columbia County, a few miles east of the eastern border of Clatsop County. This slide sent a debris flow across Highway 30 and into Westport Slough, destroying several residential structures and covering the highway with mud and large woody debris. In 2021, a landslide triggered by heavy rains caused a landslide that damaged a water transmission line owned by the City of Astoria. This line serves several water districts in unincorporated areas of Clatsop County and resulted in a boil water notice that lasted several days. **Table 3** details historic landslide events in unincorporated Clatsop County.

Landslide on Old 77 Vesper Road, 2017

Table 3: Historic Landslide Events

Date	Location	Details
Nov. 2021	Bear Creek Watershed, east of Astoria city limits	Heavy rains and steep slope saturation caused a water transmission line to rupture. The break impacted outlying water districts, including Willowdale, Fernhill, John Day, Olney, Walluski, Riverpoint and Williamsport. A boil-water notice was in place for several days
Jan. 2021	Hwy 30 east of Liberty Lane	Large amount of material damaged at least one vehicle and closed Hwy 30 for multiple days
Jan. 2020	Ecola State Park; crescent Beach Trail and other locations	An active landslide closed the park indefinitely due to road problems, a trail shearing off slope, and slope instability
Mar. 2017	Old 77 Vesper Road	Approximately 3,000-5,000 CY of soil material and several hundred trees collapsed onto a 0.25-mile segment of the County road. The roadway was closed to all access
2009	Near Astoria's Water Main	An active landslide threatened the City of Astoria's potable water main
Dec. 2007	Woodson Slide at Hwy 30 / Westport Slough	The slide destroyed several residential structures; covered the highway with mud and debris

Source: GeoScience, 2008; DOGAMI)-13-05; Daily Astorian, Feb. 2020

EARHTQUAKE / CASCADIA SUBDUCTION ZONE

Earthquakes in the Pacific Northwest states of Washington and Oregon result from movement called "slip" on faults in a variety of geographic and geologic settings. Earthquakes in much of the region are a consequence of stresses associated with motion of the Juan de Fuca Oceanic Plate to the northeast with respect to the North America Continental Plate at a rate of several centimeters per year. This relative motion is largely made possible because the Juan de Fuca plate descends into the Earth's mantle below the North American continent along what is called the Cascadia Subduction Zone, which extends from northwestern California through western Oregon and western Washington to Vancouver Island, Canada.

The US Geological Survey defines Pacific NW earthquakes in three seismological categories: crustal, deep, and megathrust. While all three types of quakes possess the potential to cause major damage, Cascadian Subduction Zone (CSZ) earthquakes pose the greatest danger due to the close proximity to the fault of the Pacific Northwest, the anticipated magnitude of an earthquake event, and the size and speed of arrival of the subsequent tsunami it would cause due to the displacement of water caused by the fault movement. A major CSZ event could generate an earthquake with a magnitude of 9.0 or greater which would result in devastating damage and loss of life. The proximity of the CSZ to the coastal areas of Clatsop County make them especially threatened by earthquakes and tsunamis.

Clatsop County has not been the center point of any recorded earthquakes. The earthquake risk that faces the communities of the Oregon coast has really only come to be understood since the 1960s. Before then, the seismic risk of the Pacific Rim was associated with volcanoes, but earthquakes were not understood to be a natural hazard of high potential magnitude to which Oregon is very vulnerable. On April 13, 1949, a major earthquake (magnitude 6.8) originating

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near Olympia, Washington caused eight deaths and estimated $25 million in damage. In Oregon, widespread damage was observed, including injuries in Astoria. This event and then the Alaska earthquake of 1964 with its resulting tsunami that impacted the Oregon coast was a major catalyst for the scientists in the field of seismic study. Emerging tools and scientific vigor set several researchers on the path to discover the Cascadia subduction zone and arrangement of plates in the Pacific Northwest, but also to develop methodologies to document the history of tsunamis that affirm the occurrence of high magnitude earthquakes in the historical record.

In 1989, the devastating Loma Prieta earthquake in the San Francisco Bay Area instigated awareness and action around the risks of earthquakes in Oregon. The science was conclusive enough to be acted upon by policy makers that citizens demanded—the groundswell of knowledge and advocacy coming from the north coast of Oregon. By 1991, the Oregon Seismic Safety Policy Advisory Commission (OSSPAC), or Earthquake Commission, was formed as a result of Senate Bill 96 spurring regional partnerships with other states and scientists, and the support for seismic safety standards in State building code. **Table 4** lists the historic earthquakes that have occurred in the Pacific Northwest.

Table 4: Historic Earthquake Events

Date	Magnitude	Location	Details
Aug. 2018 (08/22/2018)	6.2	170 miles west of Coos Bay.	10.0 km depth; MMI: IV.
Aug. 2010 (08/28/2010)	5.2	80 miles offshore from Reedsport.	
Feb. 2001 (02/28/2001)	6.8	Nisqually, WA	400 injured; $2 billion in damage; ‘Deep’ earthquake.
July 1999 (07/02/1999)	5.9	Satsop, Washington	
Dec. 1993 (12/04/1993)	5.1	Klamath Falls, Oregon	4.8 km depth; MMI: VI.
Sept. 1993 (09/21/1993)	5.9 and 6.0	Klamath Falls, Oregon	2 dead; $10 million in damage from these “crustal” earthquakes; 8.5 and 8.6 km depth respectively.
Mar. 1993 (03/25/1993)	5.6	Scotts Mills, Oregon (east of Woodburn)	$30 million in damage from this “crustal” earthquake; MMI: VI.
Nov. 1980 (11/08/1980)	7.0	off N.CA Coast	19.0 km depth; MMI: VI.
May 1980 (05/18/1980)	5.1	Mt. St. Helens	Associated with eruption.
Jun. 1973 (06/16/1973)	5.6	80 miles offshore from Lincoln City.	
Apr. 1965 (04/29/1965)	6.5	Renton, Washington	7 dead; $50 million in damage
Mar. 1964 (03/28/1964)	9.2	Prince William Sound, Alaska	140 dead; $311 million in damage. Largest recorded earthquake in the U.S.
Dec. 1963 (12/27/1963)	4.5	Oregon	33.0 km depth
Nov. 1962 (11/06/1962)	5.2	Portland, Oregon	16.0 km depth

Dec. 1953 (12/16/1953)	5.0	Portland, Oregon	n/a depth
Apr. 1949 (04/13/1949)	6.8	Olympia, Washington	8 dead; $25 million in damage; 'Deep' earthquake at 70 km depth.
Dec. 1941 (12/19/1941)	5.6	Portland, Oregon	
July 1936 (07/16/1936)	5.8	Milton-Freewater, Oregon	
May 1916 (05/13/1916)	5.7	Richland, Washington	
Apr. 1906 (04/18/1906)	8.3	San Francisco, California	3,000 dead; $374 million in damage
Jan. 1700 (01/26/1700)	9.0	off Pacific NW coast	

Source: USGS, https://earthquake.usgs.gov/earthquakes/; Sullivan, W.L., 2018.

TSUNAMI

A tsunami is a series of waves that can travel great distances from its origin and can cause serious flooding and damage to coastal communities. The wavelength of a tsunami may be 100 miles or more in the ocean, with a surface wave height of only a few feet or more. These waves have the potential to travel up to 500 mph—when this incredible force reaches shore it has enough energy to destroy human settlements and flatten river channels for several miles upstream. There are two sources of tsunamis that can affect Clatsop County:

- **Local Tsunami**: Generated by an earthquake immediately offshore of the Oregon Coast (e.g., a CSZ earthquake) and would result in a tsunami coming onshore within 10 to 20 minutes following the earthquake.
- **Distant Tsunami**: Generated by a distant earthquake (e.g., large event occurring off a distant coastline, such as Japan) and would result in a tsunami coming onshore 4 or more hours following an earthquake on another subduction zone.

A significant portion of new residential growth is centered in the Clatsop Plains and coastal areas of Clatsop County. This increase in development may also be reflected in a corresponding increase in loss of life and/or property damage when a tsunami occurs.

In 2015, a Tsunami Hazard Overlay (THO) was drafted and proposed to the Board (Ordinance 15-04). The purpose of the proposed THO was to reduce loss of life: damage to private and public property; and social, emotional and economic disruptions. The ordinance was also intended to increase the ability of the community to respond and recover from a tsunami.

Based upon public comment and input, the Board at that time tabled the item indefinitely. The public comment received focused on the following concerns:

- General unintended consequences
- Restrictions on future development
- Stricter building code requirements

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- Disclosure statement would affect property sales
- Increased costs for new homes
- Restrictions on the use of density credits
- Increased insurance rates
- Decline in property values

Although the Board at that time did not move forward with the TOZ, adoption of the Tsunami Overlay Zone is a recommended mitigation action in the adopted Multi-Jurisdictional Natural Hazards Mitigation Plan.

Since 1812, Oregon has experienced about a dozen tsunamis with wave heights greater than 3 feet; some of these were destructive. Ten of these were generated by distant earthquakes near Alaska, Chile or Japan. The worst damage and loss of life resulted from the 1964 Alaskan earthquake, the resulting tsunami killed four people (campers on a beach in Newport) and caused around one million dollars in damage to bridges, houses, cars, boats, and sea walls in Oregon (DOGAMI, 2013). The greatest tsunami damage in Oregon occurred in the estuary channels located further inland, not along the coast as expected. The estuary channels amplified the tsunami wave heights and caused extreme flooding. Seaside, which was struck by a 10-foot wave, was the hardest hit city in Oregon due to its level topography and proximity to the ocean.

In March 2011, the Tohoku, Japan earthquake, a magnitude 9.0 subduction zone earthquake, triggered a tsunami that inundated the northeast coast of Japan, killing 15,845 persons. More than 1.1 million buildings were damaged or destroyed, including schools and hospitals. That event created a heightened awareness of a Cascadia Subduction Zone event in the Pacific Northwest. State agencies such as the Department of Geology and Mineral Industries (DOGAMI), began promoting a culture of preparedness and resiliency. In 2013, released updated maps showing tsunami inundation zones, evacuation routes and assembly points for communities in Clatsop County.

On January 15, 2022, a tsunami advisory was issued by the National Tsunami Warning Center for coastal areas in Washington, Oregon, and California, including Clatsop County. The advisory was issued following an underwater volcanic eruption near Tonga in the Pacific Ocean.

HB 3309 (2019)

During the 2019 legislative session, the Oregon Legislature adopted HB 3309. This bill eliminated a statewide prohibition regarding location of new essential facilities in the tsunami inundation zone. A prohibition regarding the placement of new critical facilities in the tsunami inundation zone still exists in Clatsop County's *Land and Water Development and Use Code.*

A complete list of historic tsunami events is shown in **Table 5**.

Table 5: Historic Tsunami Events – Pacific Northwest

Date	Magnitude	Location	Details

Feb. 2001 (02/28/2001)	6.8	Puget Sound	400 injured; $2 billion in damage
Nov. 1980 (11/08/1980)	7.0	off Oregon Coast	
May 1980 (05/18/1980)	5.1	Mt. St. Helens	Triggered by eruption
Jun. 1973 (06/16/1973)	5.6	80 miles offshore from Lincoln City.	
May-July 1968	up to 5.1	Adel, Oregon (east of Lakeview)	
Apr. 1965 (04/29/1965)	6.5	Renton, Washington	7 dead; $50 million in damage
Mar. 1964 (03/28/1964)	9.2	Prince William Sound, Alaska	140 dead; $311 million in damage. Largest recorded earthquake in the U.S.

Sources: 2021 Clatsop County Multi-Jurisdictional Natural Hazards Mitigation Plan; USGS, https://earthquake.usgs.gov/earthquakes/events/alaska1964/; Sullivan, W.L., 2018.

EROSION

Coastal Erosion

Coastal erosion occurs through a complex interaction of many geologic, atmospheric, and oceanic factors. Beaches, sand spits, dunes and bluffs are constantly affected by waves, currents, tides, and storms resulting in chronic erosion, landslides, and flooding. Changes may be gradual over a season or many years. Changes may also be drastic, occurring during the course of a single storm event. Two important natural variables for coastal change are the beach sand budget (balance of sand entering and leaving the system) and processes (waves, currents, tides, and wind) that drive the changes. Erosion becomes a hazard when human development, life, and safety are threatened.

Coastal erosion occurs via the following mechanisms:

- Beach, dune and bluff erosion caused by wind, waves, runoff, and disturbance;
- Mass wasting of sea cliffs in the form of landslides and slumps due to gravity, constant wave and tidal effects, and geologic instability;
- Storm surges, high ocean waves and the flooding of low-lying lands during major storms;
- Sand inundation;
- Erosion due to the occurrence of El Niño’s and from rip current embayments; and
- Recession of coastal bluffs due to long-term changes in mean sea level and the magnitude and frequency of storm systems.

Clatsop County’s coastal erosion is largely driven by major storm events that can produce waves 20 to 50 feet in height. Coastal bluffs comprised of uplifted marine terrace deposits and sand dunes are especially vulnerable to erosion. Beaches and dunes are highly susceptible to erosion, especially during large storms coupled with high ocean water levels. Vegetated dunes have eroded back as much as 50 meters in just one or two winters in some areas. Unlike bluff-backed shorelines, dunes can accrete back during cycles of decreased storm activity, which may erase signs of long-term erosion rates, and mask the potential for catastrophic erosion events.

Table 6 details occurrences of severe coastal erosion.

Table 6: Historic Coastal Erosion Events

Date	Location	Description	Notes
Jan. 2018 (01/18/2018)	N. Oregon Coast	Flood, Coastal Erosion	Severe beach erosion and damage to trails near the Peter Iredale Shipwreck, about 5 to 6 ft. of dune entirely eroded and swept out to sea. Logs and other debris washed up on roads.
1980-2018	Falcon Cove	High Waves, Coastal Erosion	Five homes lost to coastal erosion.
1997-1998	N. Oregon Coast	High Waves, Coastal Erosion	El Niño events
1982-1983	N. Oregon Coast	High Waves, Coastal Erosion	El Niño events
1978	Nestucca Spit	High Waves, Coastal Erosion	Winter storm caused beach and cliff erosion.
1972	Siletz Spit	High Waves, Coastal Erosion	Winter storm caused beach and cliff erosion.

Source: C. Dice, 2019; NOAA Storm Events Database, https://www.ncdc.noaa.gov/stormevents/, accessed 12/2/2019.

Streambank Erosion

Areas of most active streambank erosion are recognized by steep slopes, little vegetation cover, and position on the outside of stream and river channels. In addition to the loss of land, stream erosion can contribute to the deterioration of water quality, destruction of fish spawning grounds and silt deposition, resulting in the clogging of streams and estuaries.

WILDFIRE

Fire is an essential part of Oregon's ecosystem, but it is also a serious threat to life and property particularly in the state's growing rural communities. Wildfires are fires occurring in areas having large areas of flammable vegetation that require a suppression response. Areas of wildfire risk exist throughout the state with areas in central, southwest and northeast Oregon having the highest risk. The Oregon Department of Forestry has estimated that there are about 200,000 homes in areas of serious wildfire risk.

Wildfire can be divided into three categories: interface, wildland, and firestorms. Although Clatsop County is most susceptible to interface fires, wildland and firestorm events are also possible. Clatsop County has not had many significant wildfires in the past. This is mostly due to its wet climate. **Table 7** provides information on the previous occurrences of hazard events.

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Table 7: Historic Wildfire Events

Date	Location	Description	Notes
Nov. 13, 2014	Arch Cape Fire #2	~100 acres	
2013	Arch Cape and Falcon Cove Fire	~300 acres	
Oct. 27, 2007	Crane/Crusher Fire	68 acres	
Nov. 23, 2022	Elk Mountain Fire	40-60 acres	Cost: $22,989 Cause: Debris burning
Sept. 9, 1988	Strum Creek Fire	45 acres	Cost: $237,363 Cause: Debris burning
June 30, 1985	McFarlane Creek Fire	125 acres	Cost: $87,257 Cause: Debris burning
Aug. 3, 1977	Oldy 17 Fire	834 acres	Possibly Fire 77521062 (483 acres) Cost: $443,101 Cause: Debris burning
Oct. 17, 1976	Cronin Creek Fire	483 acres	See above
Aug. 21, 1973	Crawford Ridge Fire	110-112 acres	Cost: $50,814 Cause: Smoking
Aug. 28, 1939	Saddle Mountain Fire	207,000 acres	Largest recorded fire this century in Clatsop County
1933-1951	Tillamook Burn	355,000 acres	The Tillamook Burn was a catastrophic series of large forest fires in the northern Oregon Coast Range beginning in 1933 and striking at six-year intervals through 1951

Source: Ballou, B., 2004; ODF, 2012

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WINTER STORM AND WINDSTORM

High winds are a regular occurrence throughout Clatsop County. Destructive windstorms are less frequent, but the manner in which they occur are consistent. Destructive windstorms and severe winter events typically occur in fall and winter in Clatsop County, from October through March. Severe summer weather is associated with thunderstorms which can cause tornadoes and water spouts (NOAA, 2018). Severe winter weather produces high winds, rain, freezing rain, ice, and snow. A windstorm can be any of the following type of events: straight-line wind, down-slope wind, thunderstorm, downburst, or tornado. The list of historic storm events in **Table 8** provides significant context for the frequency, magnitude, and impacts associated with wind and winter storm events in Clatsop County.

Table 8: Historic Wind and Winter Storm Events

Date	Location	Event Type	Magnitude	Details
Feb. 2019 (02/12/2019)	Coast Range of NW Oregon	Heavy Snow	1 to 2 feet of snow in Columbia Gorge	Back-to-back low-pressure systems dropping south along the coast of British Columbia and Washington brought cold air south into NW Oregon as well as plenty of moisture. Seine Creek SNOTEL around 2000 feet recorded 8 inches of snow in a 7-hour period.
Feb. 2019 (02/08/2019-02/09/2019)	Coast Range of NW Oregon	Heavy Snow	6 to 12 inches of snow was observed above 1000 feet elevation	A low-pressure system brought arctic air and heavy snow south out of Canada into the Columbia Basin and Coast Range.
Jan. 2019 (01/15/2019)	N. Oregon Coast	High Wind	65 mph on Astoria-Megler Bridge	A strong low-pressure system moving up the coast from the south brought strong southerly winds across all of northwest Oregon.
Dec. 2019 (12/20/2018)	N. Oregon Coast	High Wind	75 mph on Astoria-Megler Bridge	A low-pressure system tracked northeast toward Victoria Island. The trailing cold front moved onto the coast, bringing strong southerly winds ahead of the front to the coast and the coast range.
Dec. 2019 (12/17/2018)	N. Oregon Coast	High Wind, High Surf	65 mph on Astoria-Megler Bridge	A strong low-pressure system over the Gulf of Alaska brought a strong cold front through. This generated strong winds across northwest Oregon, resulting in heavy rain, flooding, and coastal erosion.
Dec. 2019 (12/14/2018)	N. Oregon Coast	High Wind	43 mph on Astoria-Megler Bridge	A strong low-pressure system tracked northeast into British Columbia. The associated cold front brought with it strong southerly winds on the north and central Oregon coast.
Nov. 2018 (11/26/2018)	N. Oregon Coast	High Wind	78 mph on Astoria-Megler Bridge	A strong cold front moved onto the coast, bringing high winds, mainly to beaches and headlands along the coast.
April 2018 (04/10/2019)	N. Oregon Coast	High Wind	61 mph on Astoria-Megler Bridge	A shortwave lifting NNE brought a quick-hitting cold front into northwest Oregon. The front brought a short period of high winds to beaches and headlands along the coast.
April 2018 (04/07/2019)	N. Oregon Coast	High Wind	64 mph on Astoria-Megler Bridge	A strong low-pressure system tracking northeast towards Vancouver Island generated strong winds along the Coast and in the Willamette Valley.
Mar. 2018 (03/08/2019)	N. Oregon Coast	High Wind	69 mph	Strong low-pressure system moving up from the south brought high winds to the Coast and Coast Range.
Feb. 2018 (02/21/2018)	N. Oregon Coast	Winter Weather	1" of snow in Astoria	Low pressure system drifting southward along the Oregon Coast pulled cold air all the way to the coast and brought snow levels down to sea level. One (indirect) fatality resulting from icy streets.
Feb. 2018 (02/18/2018)	Coast Range of NW Oregon	Heavy Snow	6-7 inches of snow on Coast Range summits	Cold low-pressure system brought 5 to 10 inches of snow which accumulated quickly. ODOT weather stations recorded 6-7 inches of snow at summits through the Coast Range.
Jan. 2018 (01/27/2018)	N. Oregon Coast	High Wind	62 mph on Astoria-Megler Bridge	A strong cold front moving into western Oregon brought strong southerly winds to the north Oregon beaches and headlands and coastal communities along Oregon's central coast.

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Date	Location	Event Type	Magnitude	Details
Jan. 2018 (01/23/2018)	N. Oregon Coast	High Wind	63 mph on Astoria-Megler Bridge	Low pressure moving into British Columbia pushed a cold front across western Oregon. This brought strong southerly winds to the coastal beaches and headlands.
Jan. 2018 (01/18/2018)	Seaside	Hail	1.00 -2.00 in. hail	A broad low-pressure system off the coast of Washington and Oregon destabilized the atmosphere enough to generate a severe thunderstorm that moved through Seaside, dropping large hail.
Dec. 2017 (12/29/2017)	N. Oregon Coast	High Wind	67 mph on Astoria-Megler Bridge	A strong cold front moved through the area, bringing high winds mainly to beaches and headlands, but also to a few higher elevation spots in the Coast Range as well.
Oct. 2017 (10/21/2017)	N. Oregon Coast	High Wind, Heavy Rain	53 mph on Astoria-Megler Bridge	A very potent atmospheric river brought strong winds to the north Oregon Coast and Coast Range on October 21st. What followed was a tremendous amount of rain for locations along the north Oregon Coast and Coast Range.
Oct. 2017 (10/18/2017)	N. Oregon Coast	High Wind	47 mph on Astoria-Megler Bridge	A low-pressure system moving eastward into the Pacific Northwest brought a strong cold front which generated southerly sustained winds up to 47 mph along the Oregon Coast.
Apr. 2017 (04/07/2017)	N. Oregon Coast	High Wind	73 mph	A strong low-pressure system moved northeasterly up the Oregon coast, creating a strong pressure gradient that brought strong winds to all of northwest Oregon. The event brought down many trees across the area and two fatalities.
Feb. 2017 (02/08/2017 - 02/09/2017)	N. Oregon Coast	High Wind	71 mph	A warm front starting the snow in the Columbia Gorge came through on the 7th, then a trailing cold front moved through on the 8th through the 9th bringing high winds to the Oregon Coast and Coast Range and snow and ice to the Columbia Gorge.
Feb. 2017 (02/05/2017 - 02/06/2017)	N. Oregon Coast	Heavy Snow	5.5 in. of snow	A low-pressure system with an associated cold front brought impactful snow and high winds to the Oregon Coast.
Jan. 2017 (01/17/2017 - 01/18/2017)	N. Oregon Coast	High Wind	63 mph	An approaching low-pressure system brought rain across the Columbia River and freezing conditions in other counties.
Jan. 2017 (01/10/2017 - 01/11/2017)	Coast Range of NW Oregon	Heavy Snow	12 in. in Banks, OR	A strong low-pressure system moved up from the southwest and overran an existing cold, deep airmass. Surface temperatures as precipitation started were just above freezing, but with heavy showers, precipitation quickly turned over to snow during the early evening hours. Embedded thunderstorms enhanced snowfall rates around the Portland Metro area for a crippling snowstorm Tuesday evening.
Jan. 2017 (01/07/2017 - 01/08/2017)	Coast Range of NW Oregon	Winter Storm	0.89 in. of ice (liquid equivalent while temperatures were well below freezing)	A broad shortwave trough brought multiple rounds of precipitation, including a wintry mix of snow and ice for many locations across Northwest Oregon.
Dec. 2016 (12/19/2016)	N. Oregon Coast	High Wind	47 mph on Astoria-Megler Bridge	A warmer low-pressure system moved into to Northwest Oregon, bringing high winds along the North and Central Oregon Coast. Cold east winds through the Columbia River Gorge continued for the first part of the event, leading to light accumulations of snow and sleet in portions of far northwest Oregon.

Date	Location	Event Type	Magnitude	Details
Dec. 2016 (12/08/2016)	Coast Range of NW Oregon	Heavy Snow	3-6 in. of snow	A strong frontal system brought strong east winds and a mix of snow, sleet, and freezing rain
Nov. 2016 (11/24/2016)	N. Oregon Coast	High Wind	65 mph at Cannon Beach	A strong cold front moving southeastward onto the Coast brought high winds to the Northwest Oregon Coast.
Nov. 2016 (11/24/2016)	Bradwood, Clatsop County	Heavy Rain	3.52 in. of rain	A moist Pacific front moving slowly across the area produced heavy rainfall, resulting in flooding of several rivers across Northwest Oregon and at least two landslides.
Nov. 2016 (11/12/2016)	N. Oregon Coast	High Wind	45 mph on Astoria-Megler Bridge	A low-pressure system tracking northeastward off the Coast brought high winds to the far North Oregon Coast.
Oct. 2016 (10/15/2016)	N. Oregon Coast	High Wind	61 mph on Clatsop Spit	A deepening low-pressure system passed north along the Coast bringing strong winds to Northwest Oregon.
Oct. 2016 (10/14/2016)	Clatsop Spit (Ft. Stevens, Hammond)	Hail	1.0 -1.5 in. diameter	Behind the front that moved through on October 13, unstable airmass generated strong convective showers and thunderstorms. A few of these thunderstorms produced tornadoes, strong winds, hail, and heavy rain.
Mar. 2016 (03/05/2016)	N. Oregon Coast	High Wind	52 mph on Megler Bridge	A cold front produced a burst of strong winds for the north Oregon Coast in the early morning.
Mar. 2016 (03/01/2016)	N. Oregon Coast	High Wind	52 mph	A cold front backed by a deep surface low resulted in strong winds across Northwest Oregon. Thunderstorms along the front produced damaging winds. Strong winds ahead of the front blew down a weak tree onto a moving vehicle, and resulted in one fatality.
Feb. 2016 (02/05/2016)	N. Oregon Coast	High Wind	45 mph	A low-level jet ahead of an occluded front produced several hours of strong winds to the North Oregon coast.
Jan. 2016 (01/28/2016)	N. Oregon Coast	High Wind	69 mph gusts	A strong cold front produced a few hours of high winds along the North Oregon Coast.
Dec. 2015 (12/22/2015 - 12/24/2015)	Coast Range of NW Oregon	Heavy Snow	6-14 in. of snow	Moist onshore winds produced a steady stream of showers over the area with snow levels between 1000 and 2000 feet. This resulted in heavy snow for the Northern Oregon Cascades and Coast Range.
Dec. 2015 (12/21/2015)	N. Oregon Coast	High Wind	59 mph gusts	High winds impacted Northwest Oregon as a 980 millibar low moved onshore in Pacific County, Washington. The winds resulted in widespread tree damage and power outages.
Dec. 2015 (12/17/2015, 12/21/2015)	N. Oregon Coast	High Wind	51-59 mph	Two events in five days. 1) A low-pressure system resulted in strong winds along the Northern and Central Oregon Coast. 2) High winds impacted Northwest Oregon as a 980 millibar low moved onshore in Pacific County, Washington. The winds resulted in widespread tree damage and power outages.

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Date	Location	Event Type	Magnitude	Details
Dec. 2015 (12/06/2015, 12/07/2015, 12/08/2015, 12/10/2015, 12/12/2015)	N. Oregon Coast	High Wind	40-56 mph gusts	Five events in seven days. Several weather stations along the North Oregon Coast measured high winds with sustained winds ranging between 40 and 45 mph. The Clatsop and Tillamook County Emergency Managers reported several trees downed from the winds with widespread power outages.
Nov. 2015 (11/17/2015)	N. Oregon Coast	High Wind	40-50 mph gusts	A cold front produced strong winds that resulted in a lot of downed trees, power outages, and road closures.
Oct. 2015 (10/31/2015)	N. Oregon Coast	High Wind	45 mph sustained winds on Astoria-Megler Bridge	A strong front produced a burst of strong winds as it moved across northwest Oregon.
Oct. 2015 (10/10/2015)	N. Oregon Coast	High Wind	63 mph peak gusts on Astoria-Megler Bridge	A strong cold front produced a brief burst of strong winds across the northwest Oregon coast and coast range.
Aug. 2015 (08/29/2015)	N. Oregon Coast	High Wind	58 mph with gusts to 90 mph at Oceanside	An unusually early and strong low-pressure system resulted in high winds along the coast and strong winds inland. Downed trees and power lines resulted in power outages, minor damage, and traffic delays.
Mar. 2015 (03/15/2015)	N. Oregon Coast	High Wind	59 mph	A surface low produced strong gusty winds across Northwest Oregon as it moved north offshore the Central and Northern Oregon coasts before making landfall in Southwest Washington. Soils were well saturated due to a prolonged period of heavy rain, and many trees were downed impacting life and property.
Feb. 2015 (02/07/2015)	N. Oregon Coast	High Wind	64 mph. on the Astoria-Megler Bridge	A surface low moved from south to north just offshore the coast from the Central Oregon Coast to the South Washington Coast, and produced a burst of strong winds.
Feb. 2015 (02/05/2015)	N. Oregon Coast	High Wind	47 mph. gusts to 62 mph. on the Astoria-Megler Bridge	A low-level jet ahead of a cold front brought a burst of strong winds to the North Oregon Coast.
Jan. 2015 (01/17/2015)	N. Oregon Coast	High Wind	60 mph gusts	A frontal system accompanied by an upper jet resulted in a burst of gusty winds for the Northwest Oregon Coast, Coast range and Cascades.
Feb. 2014 (02/15/2014)	N. Oregon Coast	High Wind	72 mph gusts on Clatsop Spit, other Clatsop locations	A strong cold front produced strong winds for the North Oregon coast and coast range on February 15, 2014. Highways 26 and 53 were closed due to downed trees. Several weather stations along the entire North Oregon coast measured high winds on February 15, 2014. The strongest wind gust was 86 mph which was measured at Garibaldi NOS (TLB03). Pacific City (AT297), Astoria-Megler Bridge (ODT76), and Clatsop Spit (3CLO3) measured peak wind gusts between 69 and 72 mph.
Feb. 2014 (02/06/2014)	N. Oregon Coast	Heavy Snow	4-8" snow	A preceding cold arctic airmass combined with a moist Pacific storm resulted in widespread heavy snow for Northwest Oregon including the coast and the Willamette Valley. A 30-mile wide band of heavy snow set up along the Oregon coast in the morning on the 6th and resulted in 4 to 8 inches of snow from Tillamook to Manzanita.

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Date	Location	Event Type	Magnitude	Details
Nov. 2012 (11/18/2012-11/19/2012)	N. Oregon Coast	High Wind	78 mph	A strong pacific frontal system brought high winds to the Coast and coast range of Northwest Oregon. Strong winds were reported at Garibaldi with sustained winds of 59 mph with gusts to 83 mph. Strong winds were also reported at Pacific City and Clatsop spit with wind gusts to 68 mph.
Dec. 2010 (12/13/2010)	Clatsop, Ft. Stevens	High Wind, Thunderstorm	64 mph	A strong cold pool of air aloft produced a very unstable airmass over western Oregon. A vigorous low-pressure center was just off the Washington Coast with a surface trough moving through western Oregon. This trough served as a focus for thunderstorms during the day. These thunderstorms produced strong, gusty winds in several locations. Strong, gusty winds were reported at Clatsop Spit with sustained winds of 35 mph and gusts to 56 mph.
Mar. 2009 (03/07/2009-03/08/2009 and 03/14/2009-03/15/2009)	N. Oregon Coast	Heavy Snow	6" snow	Ahead of a deep, incoming trough, a weather system brought snow to some higher elevations in northwest Oregon. Then, a potent late season frontal system brought heavy snow to the higher elevations of northwest Oregon.
Dec. 2008 (12/26/2008)	N. Oregon Coast	High Wind	63 mph on Clatsop Spit	A strong Pacific winter storm system brought high winds to the coastal region northwest Oregon.
Dec. 2008 (12/24/2008 - 12/25/2008)	Coast Range of NW Oregon	Winter Storm Heavy Snow	11 - 15 in. of snow over two days	A snow storm on Christmas Day left 6 to 10 inches of snow in the Coast Range of northwest Oregon.
Dec. 2008 (12/12/2008 - 12/13/2008)	Coast Range of NW Oregon	Heavy Snow	8-10 in. of snow on the Coast Range passes	A strong and very cold Pacific system brought heavy snow accumulations to northwest Oregon.
Dec. 2008 (12/12/2008)	N. Oregon Coast	High Wind	41 mph with gusts to 70 mph on Clatsop Spit	A strong Pacific winter storm system brought high winds to the coastal region and Cascades of northwest Oregon. The strong winds ahead of the approaching frontal system caused several power outages along the coast and resulted in nearly $8 million in estimated property and crop damages for Clatsop, Lane, Tillamook, and Lincoln Counties.
Nov. 2008 (11/08/2008, 11/11/2008)	N. Oregon Coast	High Wind	40-50 mph with gusts to 70 mph	A typical late-fall Pacific low-pressure system brought strong winds to the coast of northwest Oregon.
Dec. 2007 (12/01/2007-12/03/2007)	Clatsop County	High Wind, Heavy Rain, Mudslides	Gusts 85-130 mph in Knappa/Svensen; 3.5 in rain Astoria	A series of powerful Pacific storms Dec. 1-3, 2007 brought straight-line winds, rain, and mudslides resulting in Presidential Disaster Declaration; $180 million in damage in the state, power outages and communication isolation for several days, and five deaths attributed to the storm. https://en.wikipedia.org/wiki/Great_Coastal_Gale_of_2007
Nov. 2007	Clatsop, Tillamook Counties	storm with high winds		$10,000 in damages.

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Date	Location	Event Type	Magnitude	Details
Dec. 2006 (12/14/2006, 12/15/2006)	Clatsop, Tillamook Counties	High Wind, Heavy Rain		$10,000 in damages.
Nov. 2006 (11/05/2006-11/08/2006)	Clatsop County	High Wind, Heavy Rain		Severe storms, flooding, landslides, mudslides.
Mar. 2006 (03/20/2006)	Clatsop, Tillamook, Lincoln, Lane Counties	High Wind	60 mph, 75 mph	Two wind storm events with winds measured at 60 mph and 75 mph resulted in $75,000 and $211,000 in estimated property damage among all four coastal counties; the storms also impacted 10 other counties outside of Region 1.
Feb. 2006	Clatsop, Tillamook, Lincoln, Lane Counties	High Wind	77 mph	More than $200,000 in estimated property damage among all four coastal counties; the storm also impacted nine other counties outside of Region 1.
Jan. 2006	Clatsop, Tillamook, Lincoln, Lane Counties	High Wind	86 mph, 103 mph	Two storm events with high winds of 86 mph and 103 mph resulted in $388,888 in property damage among all four coastal counties; the storm also impacted 5 other counties outside Region 1.
Dec. 2004 (12/08/2004-12/09/2004)	W. Oregon	Winter Storm, High Wind, Heavy Snow, High Surf	2.5' of snow on Mt Hood; Lightning in Astoria; 25' Surf	A large powerful Pacific storm brought a wide variety of weather to Northwestern Oregon. High winds along the Coast heralded the approach of the storm early in the morning. Heavy rain accompanied this storm resulting in mud slides. The storm also generated high seas, which created high surf along the Northern and Central Oregon Coast the next day. Buoys 20 miles off the Oregon Coast reported maximum seas of 25 to 26 feet.
Jan. 2004 (01/27/2004-01/29/2004)	Clatsop	Heavy Rain	4" in Seaside; 4.29" Astoria Airport	A series of strong Pacific storm systems brought heavy rain to Northwest Oregon.
Mar. 2003	Clatsop	Heavy Rain	1”-3"	Heavy rains once again moved into Northwest Oregon. Many stations reported 1 to 3 inches during the same 24-hour period.
Jan 2003 (01/29/2003-01/31/2003)	Clatsop	Heavy Rain, Floods	1”-3"	Heavy rains associated with a strong Pacific weather system brought 2 days of heavy rains to the area. Numerous locations reported 1 to 3 inches. These heavy rains filled many small streams, 2 feet of water covered Highway 101 between Seaside and Cannon Beach.
Jan. 2002	N. Oregon Coast	Winter Storm: High Winds, Heavy Rains	63 mph	A winter storm brought high winds, heavy rain, and warmer temperatures to the area, resulting in flooding and mud and landslides. High winds knocked out power along the coast from Cannon Beach and Seaside to Warrenton for varying periods of time. A private single engine plane was flipped by the gusty winds at the Astoria Regional Airport in Warrenton. Reported winds included Cannon Beach 40 to 45 mph with gusts to 63 mph.

Date	Location	Event Type	Magnitude	Details
Aug. 2001 (08/22/2001-08/23/2001)	Clatsop	Heavy Rain		
Jan. 2000	Clatsop, Tillamook	High Wind	70 mph	Strong winds associated with a strong offshore storm buffeted the North and Central Oregon Coast. Cannon Beach reported gusts to 70 mph and Astoria reported gusts to 59 mph.
Jan. 1999	Clatsop, Tillamook	High Wind	61 mph	A Pacific storm caused gusts of 61 mph in Cannon Beach.
Jan. 1998 (01/11/1998-01/12/1998)	Clatsop, Tillamook	Ice Storm	6" snow	The event began when an arctic front brought very cold air from Alaska, resulting in widespread snow. Snow turned to freezing rain in the Gorge Monday, and persisted there and within the reach of strong east winds blowing out of the west end of the Gorge. Trees and large tree limbs were knocked down over a large area, and there were widespread power outages. One fatality, a 43 year old man was found dead from exposure in the back yard of his home in Astoria.
Jan. 1998 (01/05/1998)	Seaside, Clatsop County	Tornado	F0	A weak tornado did minor damage to the Kinni-Kinnic Lodge and an adjacent home on Beach Street in Seaside (estimated property damage was $3,000).
Dec. 1997 (12/22/1997)	Clatsop, Tillamook	Heavy Snow	3" of snow	A weak Pacific storm dumped three inches of snow on Wilson river and Sunset summit passes in the Coast Range before the snow turned to rain.
Nov. 1997	Western Oregon	High Wind, High Surf	gusts to 89 mph at Florence	Severe beach erosion; trees toppled.
Nov. 1997 (11/19/1997)	N. Oregon Coast	High Wind	80 mph	A powerful Pacific storm brought high winds to the Oregon coast. The highest wind speeds reported included sustained 60 mph with gusts to 80 mph at Tillamook.
Dec. 1996 (12/29/1996 - 12/30/1996)	N. Oregon Coast	High Wind	55 mph gusting to 66 mph at Cannon Beach	The first in a series of strong Pacific storms lashed the North Oregon Coast with winds up to 110 mph.
Dec. 1996 (12/26/1996-12/31/1996)	N. Oregon Coast	Heavy Rain, Floods	16 rivers flooded	Heavy rains caused 16 rivers in NW Oregon to flood during the last week of December 1996 and into early January 1997. Dozens of homes were flooded on various rivers and numerous highways were rendered impassable.
Nov. 1996 - Dec. 1996	Five Western States	Heavy Rain, Freezing Rain/Heavy Wet Snow	6-18" West of the Cascades; 8" in 24 hrs in Coast Range	During the period from mid-November to mid-December 1996, many areas received above-normal precipitation, greatly increasing the snowpack over mid and high elevations. Three sequential storms brought moderate to heavy rain, with the last creating a rain-on-snow event which resulted in incredible amounts of runoff.

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Date	Location	Event Type	Magnitude	Details
Nov. 1996 (11/18/1996-11/20/1996)	N. Oregon Coast	Heavy Rain, Floods	11 rivers reached flood stage	Heavy rainfall over Oregon caused many rivers in Northwestern Oregon to flood. The first small streams began flooding on November 18th with 11 larger rivers reaching flood stage on the 19th and 20th. Major rivers such as the lower reaches of the Willamette remained above flood stage until November 23rd. Initial damage estimates from this flooding exceeded $3 million.
Dec. 1995	Statewide	High Wind	Over 100 mph	Wind gusts of over 100 mph; e.g. Sea Lion Caves gusts to 119 mph. The storm followed the path of Columbus Day Storm (Dec. 1962) and resulted in four fatalities, many injuries, and widespread damage (FEMA-1107-DR-Oregon).
Feb. 1994	Warrenton	Tornado		Damage in a local park.
Jan. 1993	Oregon Coast	High Wind	98 mph	Inauguration Day Storm resulted in a major disaster declaration in Washington State. Tillamook wind gusts to 98 mph resulted in widespread damage, especially in the Nehalem Valley.
Nov. 1991	Oregon Coast	High Wind, High Surf	25-foot waves	This slow-moving storm generated 25-foot waves and resulted in damage to buildings, boats, and transmission lines.
Jan. 1991	Most of Oregon	High Wind	Gusts of 57 mph at Seaside	75-foot trawler sank NW of Astoria
Feb. 1990	Oregon Coast	High Wind	53 mph	Wind gusts resulted in damage to docks, piers, and boats.
Jan. 1990 (01/24/1990)	Statewide	High Wind	100 mph wind gusts	One fatality; damaged buildings; falling trees resulted in a disaster declaration in Oregon (FEMA-853-DR-Oregon).
Mar. 1988	North and Central Coast	High Wind	wind gusts 55–75 mph	One fatality near Ecola State Park; uprooted trees.
Dec. 1987	Oregon Coast / NW Oregon	High Wind	winds on coast 60 mph	Saturated ground enabled winds to uproot trees.
Jan. 1987	Oregon Coast	High Wind	wind gusts to 96 mph at Cape Blanco	Significant erosion occurred along highways and beaches; several injuries.
Jan. 1986	North and Central Coast	High Wind	75 mph winds	Damaged trees, buildings, and power lines.
Nov. 1981 (11/13/1981, 11/15/1981)	Oregon Coast, North Willamette Valley	High Wind		Back to back windstorms

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Date	Location	Event Type	Magnitude	Details
Mar. 1971	Most of Oregon	High Wind		Falling trees took out power lines; building damage; notable damage in Newport.
Feb. 1971 (02/13/1971)				wind/rain
Oct. 1967	Western Oregon	High Wind	winds on Oregon Coast 100–115 mph	Significant damage to buildings, agriculture, and timber.
Oct. 1967 (10/03/1967)	Clatsop County, Warrenton	Tornado	F1	$25k in property damage; Impact area: 0.5 mi x 70 yds.
Oct. 1966	Seaside	Tornado	F0	Windows broken, telephone lines down, outdoor signs destroyed.
Oct. 1966 (10/20/1966)	Near Astoria Airport	Tornado/ Waterspout	F0	Began over ocean and moved inland; several homes and commercial buildings damaged.
Dec. 1964 (12/24/1964)	Oregon	Floods, Heavy Rain, Winter Storm	100-year flood event; Benchmark; 15 inches of rain in 24 hours	The Christmas flood of 1964 was driven by a series of storms, known as atmospheric rivers or “pineapple expresses,” that battered the region producing as much as 15 inches of rain in 24 hours at some locations. The combination of heavy rain, melting snow, and frozen ground caused extreme runoff, erosion and flooding. https://www.usgs.gov/news/christmas-flood-1964
Mar. 1963	NW Oregon Coast	High Wind	100 mph gusts (unofficial)	widespread damage
Oct. 1962 (10/12/1962)	Statewide	High Wind	131 mph	Oregon’s most destructive storm, the Columbus Day Windstorm Event, produced a barometric pressure low of 960 mb and resulted in wind speeds of 131 mph on the Oregon coast resulting in 23 fatalities and $170 million in damages.
Nov. 1958	Northern/ Northwest Oregon	High Wind	Gusts to 75 mph at Astoria	Wind gusts across the Oregon, Idaho, Montana, Wyoming resulted in damage to buildings and utility lines; wind gusts to 75 mph at Astoria; gusts to 131 mph at Hebo.
June 1957 (06/05/1957)	Clatsop	High Wind	96 mph gusts	Thunderstorm, Wind
Jan. 1956	Western Oregon	High Wind, Heavy Rain, Mudslides		Heavy rains, high winds, mud slides resulted in estimated damages of $95,000.
Dec. 1955 (12/29/1955)	Western Oregon	High Wind	up to 90 mph	Wind gusts at North Bend up to 90 mph resulted in significant damage to buildings and farms.

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Date	Location	Event Type	Magnitude	Details
Dec. 1951	Most of Oregon	High Wind	60–100 mph	Winds 60-100 mph and a barometric pressure low of 968.5 mb near Astoria resulted in many damaged buildings and telephone/power lines down.
Nov. 1951	Most of Oregon	High Wind	40–60 mph with 75–80 mph gusts	Winds 40–60 mph with 75–80 mph gusts resulted in widespread damage, especially to transmission lines.
Apr. 1931	Western Oregon	High Wind	78 mph	Wind speeds up to 78 mph resulted in widespread damage.
Jan. 1921	Oregon Coast/ Lower Columbia	High Wind	130 mph gusts in Astoria	Winds recorded at 113 mph at the mouth of the Columbia River; 130 mph in Astoria.
Jan. 1880	Western Oregon	High Wind	65-80 mph	Very high winds, 65-80 mph near Portland, resulted in flying debris and fallen trees.

Sources: NOAA Storm Events Database, https://www.ncdc.noaa.gov/stormevents/, accessed 12/2/2019. Oregon DOT weather sensor is located on Astoria-Megler Bridge.; Taylor and Hatton, 1999, The Oregon Weather Book, pp. 130-137; Tillamook County NHMP, 2018.; FEMA <http://www.fema.gov/news/disasters_state.fema?id=41>,

DROUGHT

Watershed in Clatsop County are largely rain-dominated systems, meaning the drivers of drought and water scarcity are different than across much of the western United States, where mountain snowpack contributes to streamflow. As with other areas of the Pacific Northwest, Clatsop County typically experiences wet winters and dry summers. This seasonal cycle of precipitation means that sever drought is rare during the rainy winters on the Oregon coast, but the region is prone to periods of summertime water scarcity, especially when precipitation is lower than average in the should seasons of spring and fall. This scarcity is exacerbated by a lack of natural storage, such as snowpack, and by a lack of built storage in the form of reservoirs.

Table 9 provides information on historic drought events within Oregon.

Table 9: Historic Drought Events

Date	Location	Description
2015	25 counties in Oregon	Clatsop County did not have a drought declaration but did experience a dry and hot spring and summer following two years of lower moisture and higher temperatures (2013-2014)
2001-02	Statewide, except Portland metro area and Willamette Valley	The second most intense drought in Oregon's history; 18 counties with state drought declaration (2001); 23 counties state-declared drought (2002); some of the 2001 and 2002 drought declarations were in effect through June or December 2003; Coos and Curry Counties in Region 1 were not under a drought declaration until December of 2002.

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1985-1997	Oregon	Generally, a dry period, capped by statewide droughts in 1992 and 1994
1992	Statewide	1992 fell toward the end of a generally dry period, which caused problems throughout the state; the 1992 drought was most intense in eastern Oregon, with severe drought occurring in Region 1; the winter of 1991-1992 was a moderate El Niño event, which can manifest itself in warmer and dried winters in Oregon; Governor declared a drought for all 36 counties in September 1992.
1976-1981	Western Oregon	Intense drought; 1976-1977 was the single driest water year of the century.
1939-1941	Oregon	A three-year intense drought; Water Year 1939 was one of the more significant drought years on the Oregon Coast during that period.
1917-1931	Oregon	A very dry period, punctuated by brief wet spells in 1920-21 and 1927. The 1920s and 1930s, know more commonly as the Dust Bowl, were a period of prolonged, mostly drier than normal conditions across much of the state and country; moderate to severe drought affected much of the state except southeastern Oregon
1924	Oregon	A prolonged statewide drought that caused major problems for agriculture
1904-1905	Oregon	A drought period of about 18 months

Source: Taylor and Hatton, 1999, 2015 Clatsop NHMP; 2016 Tillamook NHMP; 2021 Clatsop County MJNHMP

VOLCANIC ASH FALL

According to the Department of Geology and Mineral Industries (DOGAMI), Mt. Hood and Mt. St. Helens are the two volcanoes that could impact Clatsop County. Of all the Washington volcanoes, only Glacier Peak (north of Mt. Rainier) and Mt. Saint Helens have generated very large explosive eruptions in the past 15,000 years.

On May 18, 1980, Mt. St. Helens in Washington State erupted. The eruption killed 57 persons, destroyed more than 200 houses and cabins, and destroyed or damaged more than 185 miles of highways and roads and 15 miles of railways. In Clatsop County, ash fall from the volcanic eruption covered houses, damaged vehicles and equipment, and impacted animals and livestock.

Mt. Hood is approximately 90 miles southeast of the southeastern corner of the County. Given that most of Clatsop County's
population in located in the northern and western areas of the County and that volcanic ash would follow eastward wind patterns, it is unlikely that a volcanic event at Mt. Hood would significantly impact Clatsop County. There have been no recorded effects from eruptions of Mt. Hood in the past century. During the 1900s, however, there were numerous small lahars and debris avalanches, preceded by steam explosions and ash explosions in the mid-1800s. **Table 10** details historic volcanic events from 1781 through the present.

Table 10: Historic Volcanic Events

Date	Event	Location

May 18, 1980	Eruption	Mount St. Helens
1781	Most recent eruptive period began	Mount Hood, White River and Sandy River valleys

Source: USGS; Sullivan, W.L., 2018; Clatsop County *Multi-Jurisdictional Natural Hazards Mitigation Plan,* 2021

HIGH GROUNDWATER AND COMPRESSIBLE SOILS

In the alluvial lowland areas near streams and rivers and in the interdune areas of the Clatsop Plains, the groundwater table is at or near the ground surface much of the year. Problems associated with high groundwater include hydrostatic pressure causing buoyancy of underground tanks or fracturing of basement floors and walls and health hazards from improperly working septic systems.

Most of the soils with high groundwater levels also experience problems due to the compressible properties of the soils. Construction on compressible soils can result in differential settling of homes and roads. Engineering solutions include excavation and backfilling with a more suitable materials, preloading, and the use of piling or spread footings depending upon the nature of the specific structure being considered and the degree of severity of the hazard.

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CURRENT CONDITIONS

Each of Clatsop County's communities is subject to some or all of the natural hazards listed in Statewide Planning Goal 7. Beginning in 2019, Clatsop County, with technical assistance from the Department of Land Conservation and Development (DLCD) undertook an update of its 2015 Natural Hazards Mitigation Plan. The MJNHMP includes a hazard vulnerability analysis for unincorporated Clatsop County, which is shown in **Table 11**.

Table 11: Clatsop County Hazard Vulnerability Analysis

Hazard	Risk
Flood	High
Landslide	Low
Earthquake	High
Tsunami	High
Coastal Erosion	Medium
Wildfire	Low
Winter Storm	High

Source: Clatsop County 2019.

The following details the rationale for the rankings, as noted in the MJNHMP.

FLOOD

Flood risk was ranked based on the annual, primarily coastal, flooding that occurs in the County, putting infrastructure and structures at risk. Annually, Highway 202 and tide gates get overwhelmed with high tides, as do areas in the City of Seaside and along U. S. Highway 101. During the 1996 flood, coastal flooding inundated the Surf Pines areas near Gearhart. Between January 3-6 2022, melting snow and heavy rainfall resulted in $144,082 in damages, resulting in an emergency declaration. Flooding, breached dikes, landslides, downed trees and power lines harmed public infrastructure and private property and blocked roads.

The extent of the damage and risk to people caused by flood events is primarily dependent on the depth and velocity of floodwaters. Fast moving floodwaters can wash buildings off their foundations and sweep vehicles downstream. Extensive flood damage to residences and other structures also results from basement flooding and landslide damage related to soil saturation. Surface water entering into crawlspaces, basements and daylight basements is common during flood events not only in or near flooded areas but also on hillsides and other areas far removed from floodplains. Most damage is caused by water saturating materials susceptible to loss (e.g., wood, insulation, wallboard, fabric, furnishings, floor coverings and appliances.)

Homes in frequently flooded areas can also experience blocked sewer lines and damage to septic systems and drain fields. This is particularly the case of residences in rural flood prone areas who commonly utilize private individual sewage treatment systems. Inundation of these systems can result in the leakage of wastewater into surrounding areas creating the risk of serious water pollution and public health threats. This kind damage can render homes unlivable.

Roads, bridges, other infrastructure, and lifelines (pipelines, utility, water, sewer, communications systems, etc.) can be seriously damaged when high water combines with flood debris, mud and ice. Bridges are a major concern during flood events as they provide critical links in road networks by crossing watercourses and other significant natural features. Bridges and the supporting structures, however, can also be obstructions in flood-swollen watercourses and can inhibit the rapid flow of water during flood events. Flood events impact businesses by damaging property and interrupting commerce. Flood events can cut off customer access and close businesses for repairs. A quick response to the needs of businesses affected by flood events can help a community maintain economic viability in the face of flood damage.

Table 12 details forecasted loss from flood events.

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Table 12: Flood Exposure

				(1% 100-year flood event)				
Community	**Total Number of Buildings**	**Total Estimated Building Value ($)**	**Total Population**	**Potentially Displaced Residents from Flood Exposure**	**% Potentially Displaced Residents from Flood Exposure**	**Number of Flood Exposed Buildings**	**% of Flood Exposed Buildings**	**Number of Flood Exposed Buildings Without Damage****
Unincorp. County (rural)	8,214	1,378,964	9,477	1,175	12.4%	1,175	14.3%	131
Arch Cape	462	113,684	183	9	5.1%	22	4.8%	7
Svensen-Knappa	1,652	178,049	3,013	17	0.6%	7	0.4%	1
Westport	348	24,928	498	0	0.0%	3	0.9%	1
Total Unincorp. County	10,676	1,695,624	13,171	1,201	9.1%	1,207	11.3%	140

*1% results include coastal flooding source. ** Building first-floor height is above flood elevation. **Source:** Williams et al, 2020

LANDSLIDE

Landslide risk for Clatsop County is ubiquitous – more than half of all the buildings in the County are at risk of at least moderate susceptibility to landslide risk. Landslides, however, are not common occurrences and when they do occur, impact a limited number of residents and structures unlike an earthquake or tsunami. For this reason, the risk was rated as "Low" in the hazard vulnerability analysis.

Depending upon the type, location, severity and area affected, severe property damage, injuries and loss of life can be caused by landslide hazards. Landslides can damage or temporarily disrupt utility services, roads and other transportation systems and critical lifeline services such as police, fire, medical, utility and communication systems, and emergency response. In addition to the immediate damage and loss of services, serious disruption of roads, infrastructure and critical facilities and services may also have longer-term impacts on the economy of the community and surrounding area. **Table 13** details anticipated impacts due to landslide exposure.

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Table 13: Landslide Exposure

(all dollar amounts in thousands)

			Very High Susceptibility			High Susceptibility			Moderate Susceptibility		
Community	**Total Number of Buildings**	**Total Estimated Building Value ($)**	**Number of Buildings**	**Building Value ($)**	**Percent of Building Value Exposed**	**Number of Buildings**	**Building Value ($)**	**Percent of Building Value Exposed**	**Number of Buildings**	**Building Value ($)**	**Percent of Building Value Exposed**
Unincorp. County (rural)	8,214	1,378,964	952	133,908	9.7%	1,561	146,865	11%	2,284	300,221	22%
Arch Cape	462	113,684	69	17,412	15%	66	13,960	12%	167	40,595	36%
Svensen-Knappa	1,652	178,049	119	12,201	7%	600	56,657	32%	441	55,810	31%
Westport	348	24,928	116	7,207	29%	19	2,859	12%	17	1,402	6%
Total Unincorp. County	10,676	1,695,624	1,256	170,728	10%	2,246	220,342	13%	2,909	398,028	23%

*1% results include coastal flooding source. ** Building first-floor height is above flood elevation. **Source:** Williams et al, 2020

EARTHQUAKE

Earthquake risk was ranked for a Cascadia earthquake event scenario. The 2018 DOGAMI Natural Hazard Risk Report for Clatsop County indicated that very high liquefaction soils are found throughout most of the populated coastal portions of Clatsop County and within low-laying areas of the City of Warrenton. **Table 14** details the projected monetary and structural impacts from earthquakes.

Generally, the older the home is, the greater the risk of damage from natural disasters. This is because stricter building codes have been developed with improved scientific understanding of plate tectonics and earthquake risk. For example, structures built after the late 1960s in the Northwest use earthquake-resistant designs and construction techniques. Those built before 1960 (47.1% of homes in Clatsop County) are not likely to be earthquake resistant. “Unreinforced masonry” (or URM) buildings are known to be the most susceptible to damage.

While buildings and other structures can be designed or retrofitted to withstand earthquakes, it can be prohibitively expensive to design for the highest magnitude events. Most buildings are designed with life-safety integrity for the occupants to safely survive the event and evacuate, but not necessarily to protect the building from damage. The advantage of improved seismic design requirements is that they can protect lives and maintain the functionality of the structure in lesser magnitude events. Buildings that were not built to an adequate seismic standard often can be

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retrofitted and strengthened to help withstand earthquakes and provide life safety.

Roads, bridges, ports, and utilities (telecom, gas, water, powerlines, etc.) also suffer damage in earthquakes. Damage and loss of life can be very severe if structures are not designed to withstand shaking, are on ground that amplifies shaking, or ground which liquefies due to shaking. Earthquake damage to roads and bridges can be particularly serious by hampering or cutting off the movement of people and goods and disrupting the provision of emergency response services. Such effects in turn can produce serious impacts on the local and regional economy by disconnecting people from work, home, food, school and needed commercial, medical and social services. A major earthquake can separate businesses and other employers from their employees, customers, and suppliers thereby further hurting the economy. Following an earthquake event, the cleanup of debris can be a huge challenge for the community.

Ports face the challenge of both the proximity to water and the instability of the large vessels/craft docked at piers and on runways. The high cost of maintenance and the age of the many maritime structures means that the forces associated with an earthquake could easily be catastrophically
damaging.

Utilities face the risk of lines breaking, particularly at connections. These are ideal and affordable choices for retrofitting because adding flexibility to a length of pipe at its connection point can help prevent damage. However, gas utilities and all infrastructure using liquid or pressurized fuel should use automatic shut-off valves to prevent leaks, spills, explosions, and fire following a seismic event.

Water impoundments are a risk in an earthquake event due to the weight of water and the fact that containers used for the stationary storage of water (dams, levees, tanks, pools, reservoirs, etc.) may not have the strength of material to withstand the motion of water due to ground shaking. The ability of dams to withstand earthquake forces should be considered. This is especially important as three dams in Clatsop County have been designated as “high hazard”: Bear Creek (Astoria), Middle Reservoir, and Wickiup Lake. For more information about the dams in Clatsop County, see the Flood hazard section of this plan.

Four dams in Clatsop County have been designated as “high hazard”, meaning they would pose a risk to downstream populations if they failed in an earthquake event. All have Emergency Action Plans in place: Bear Creek, Middle Reservoir, and Wickiup Lake, all managed for water supply by the City of Astoria, and the Seaside City Reservoir (Peterson Point Dam) established in 1996 also used for domestic water supply.

One of the most important preparations that can be made for a major earthquake event is to prevent the release of toxic gases and flammable fuels. Not only could the release of chlorine gas for water disinfection be lethal or fires started from liquid or pressurized fuels, the control of these releases is imminently more difficult without power, roads, or structural integrity of untested systems. Due to the importance of these concerns, the State of Oregon recently released a Fuel Plan and Clatsop County is similarly conducting an inventory of county fuel storage sites. Local water providers are required to meet standards for the storage of water treatment chemicals, but local regulations and coordination should be conducted locally to ensure that private entities managing pools or small, private water sources are similarly protecting the public by considering the seismic resilience of their systems to withstand a major earthquake.

Table 14: Earthquake Exposure

			(all dollar amounts in thousands)									
			Total Earthquake Damage*		**Earthquake Damage outside of Medium Tsunami Zone**							
			Buildings Damaged		**Buildings Damaged**				**Building Design Level Upgraded to at Least Moderate Code**			
Community	**Total Number of Buildings**	**Total Estimated Building Value ($)**	**Sum of Economic Loss**	**Loss Ratio**	**Yellow-Tagged Buildings**	**Red-Tagged Buildings**	**Sum of Economic Loss**	**Loss Ratio**	**Yellow-Tagged Buildings**	**Red-Tagged Buildings**	**Sum of Economic Loss**	**Loss Ratio**
Unincorp. County (rural)	8,214	1,378,964	504,969	37%	619	2,251	480,396	34.8%	648	1,404	321,707	23.3%
Arch Cape	462	113,684	23,820	21%	18	59	16,694	14.7%	9	45	12,676	11.2%
Svensen-Knappa	1,652	178,049	38,280	22%	146	377	38,280	21%	118	236	27,790	16%
Westport	348	24,928	9,592	39%	37	154	9,592	38.5%	59	84	7,157	28.7%
Total Unincorp. County	10,676	1,695,624	576,661	34%	820	2,840	544,962	32%	833	1,769	369,331	22%

Source: Williams et al, 2020

TSUNAMI

Tsunami risk was ranked for a Cascadia earthquake event scenario. During certain periods of the year, the population of Clatsop County can increase by 25% or more as visitors travel to the beach and other coastal areas. The beaches and the coastal cities frequented by these tourists are located within the tsunami inundation zone.   **Table 15** details the projected monetary and structural impacts from earthquakes.

The combination of earthquake and tsunami will have a significant impact to the entire coastal and estuarine portions of rural Clatsop County. Low-lying areas within coastal and estuarine communities are predicted to be inundated by the Medium-sized tsunami scenario. Approximately a third of the county’s buildings have exposure to tsunami inundation from the Medium-sized scenario. In some communities a very high percentage (50% - 80%) of development is exposed to tsunami hazard. Over 11,000 permanent residents, included residents of incorporated cities and

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unincorporated Clatsop County could be impacted from a CSZ tsunami event and require medical and shelter services. Because there is high risk of tsunami along the entire coast and estuarine areas of Clatsop County, awareness is important for future planning and mitigation efforts in the areas at risk.

Table 15: Tsunami Exposure

(all dollar amounts in thousands)

			Small (Low Severity)			Medium (Moderate Severity)			Large (High Severity)			X Large (Very High Severity)			XX Large (Extreme Severity)		
Community	**Total Number of Buildings**	**Total Estimated Building Value ($)**	**# of Bldgs**	**Building Value ($)**	**Percent of Building Value Exposed**	**# of Bldgs**	**Building Value ($)**	**Percent of Building Value Exposed**	**# of Bldgs**	**Building Value ($)**	**Percent of Building Value Exposed**	**# of Bldgs**	**Building Value ($)**	**Percent of Building Value Exposed**	**# of Bldgs**	**Building Value ($)**	**Percent of Building Value Exposed**
Unincorp. County (rural)	8,214	1,378,964	879	52,749	3.8%	1,040	67,075	4.9%	1,801	221,393	16%	3,145	475,022	34%	3,222	490,567	36%
Arch Cape	462	113,684	69	16,910	15%	162	43,350	38%	233	60,639	53%	360	90,490	80%	372	92,486	81%
Svensen-Knappa	1,652	178,049	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Westport	348	24,928	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Total Unincorp. County	10,676	1,695,624	948	69,659	4.1%	1,202	110,425	6.5%	2,034	282,032	17%	3,505	475,812	33%	3,594	583,053	34%

Source: Clatsop County Multi-Jurisdictional Natural Hazards Mitigation Plan, 2021; Williams et al, 2020

COASTAL EROSION

Coastal erosion is increasingly affecting people due to development near the beach or coastal bluffs. Structures and infrastructure that serve homes are the primary vulnerability of this hazard. People who purchase real estate in areas subject to coastal erosion are the primary individuals at personal risk of this hazard, although first responders and other emergency personnel are likely at greater hazard as they will be required to assist in coastal erosion-related rescues in recreational settings. Typically, shoreline stabilization efforts using riprap are not an effective long-term mitigation and such measures are strictly regulated under Goal 18.

According to the regional risk assessment for the Oregon Coast, the following assets and locations are generally the most vulnerable to coastal erosion (Oregon DLCD, 2015):

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- Buildings, parks, and infrastructure along low-lying areas adjacent to bays or the ocean and at higher elevations where buildings and infrastructure have been located on readily erodible materials (e.g., consolidated sand, weakly cemented sandstone, siltstone, etc.).
- Areas subject to flooding with wave action—while few of Oregon's coastal developments are within FEMA-designated Velocity (V) zones, those that are appear to be constructed according to V- zone standards which fall under the regulatory purview of local jurisdictions compliant with the National Flood Insurance Program (NFIP).
- Coastal highways are strongly impacted by coastal erosion. In Clatsop County much of the problem is linked to the local geology. Bedrock conditions change abruptly within very short distances. This results in an inconsistent highway foundation; some sections are more susceptible to erosion than others and require continuous maintenance.

Table 16 details the projected monetary and structural impacts from coastal erosion events.

Table 16: Coastal Erosion Exposure

			(all dollar amounts in thousands)								
			Low Hazard			**Moderate Hazard**			**High Hazard**		
Community	**Total Number of Buildings**	**Total Estimated Building Value ($)**	**# of Bldgs**	**Building Value ($)**	**Percent of Building Value Exposed**	**# of Bldgs**	**Building Value ($)**	**Percent of Building Value Exposed**	**# of Bldgs**	**Building Value ($)**	**Percent of Building Value Exposed**
Unincorp. County (rural)	8,214	1,378,964	17	2,505	0.2%	20	2,595	0.2%	54	15,544	1.1%
Arch Cape	462	113,684	0	0	0%	50	12,270	11%	121	33,051	29%
Total Unincorp. County	8,676	1,492,648	17	2,505	0.2%	70	14,865	1%	175	48,595	3.3%

Source: Williams et al, 2020, DLCD Note: Falcon Cove is included in the Arch Cape unincorporated area. For the purposes of the 2020 Natural Hazard Risk Report, DOGAMI designated Astoria, Knappa-Svensen, and Westport, as 'non-coastal communities', thus this table excludes building numbers for those communities. Astoria has some coastal erosion along Youngs Bay but is not included in DOGAMI report.

WILDFIRE

Generally, unincorporated Clatsop County is at low risk from wildfire risk due to high coastal humidity. In the intermittent dry periods with east winds from summer to late fall, however, wildfire risk can elevate quickly. The *Natural Hazard Risk Report for Clatsop County Oregon,* prepared by DOGAMI, indicates that 11% of Clatsop County is subject to high wildfire risk and 44% of the County is subject to moderate wildfire risk.

The effects of fire on ecosystem resources can include damages, benefits, or some combination of both. Ultimately, a fire's effects depend largely on the characteristics of the fire site, the severity of the fire, its duration and the value of the resources affected by the fire.

The effects of a wildfire on the built environment, particularly in the face of a major wildfire event, can be devastating to people, homes, businesses, and communities. Fuel, topography, weather and the extent of development are the key determinants for wildfires. A number of other factors also have been identified which affect the degree of risk to people and property in identified wildfire interface areas. These include:

- Combustible roofing material (for example, cedar shakes)
- Wood construction
- Homes and other structures with no defensible space
- Roads and streets with substandard width, grades, weight-load, and connectivity standards making evacuation and fire response more difficult
- Subdivisions and homes surrounded by heavy natural fuel types
- Structures on steep slopes covered with flammable vegetation
- Limited on-site or community water supply
- Locations with normal prevailing winds over 30 miles per hour

The 2018 DOGAMI Natural hazard risk report for Clatsop County identified locations within the study area that are comparatively more vulnerable or at greater risk to wildfire hazard. Wildfire risk is high for hundreds of homes in the low-laying forested areas in the unincorporated county along the Columbia River. This area also includes the communities of Warrenton, Westport, and to a lesser extent Astoria and Svensen-Knappa. The following communities within Clatsop County are considered “Interface Communities”:

- Arch Cape
- Astoria
- Brownsmead
- Cannon Beach
- Coastal Strip
- Elsie-Vinemaple
- Fern Hill
- Hamlet
- Jewell
- Knappa-Svensen
- Lewis & Clark
- Necanicum
- Olney
- Warrenton
- Westport

The Clatsop County Community Wildfire Protection Plan wildland fire risk assessment analyzes the potential losses to life, property, and natural resources. Objectives of the risk assessment are to identify the Wildland-Urban Interface, develop and conduct a wildland fire risk assessment, and identify and prioritize hazardous fuels treatment projects.

Table 17 details the projected monetary and structural impacts from wildfires.

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Table 17: Wildfire Exposure

Community	Total Number of Buildings	Total Estimated Building Value ($)	Moderate Hazard: # of Bldgs	Moderate Hazard: Building Value ($)	Moderate Hazard: Percent of Building Value Exposed	High Hazard: # of Bldgs	High Hazard: Building Value ($)	High Hazard: Percent of Building Value Exposed
			(all dollar amounts in thousands)					
Unincorp. County (rural)	8,214	1,378,964	1,324	145,792	11%	4,083	605,685	44%
Arch Cape	462	113,684	3	838	1%	227	52,459	46.1%
Svensen-Knappa	1,652	178,049	58	5,607	3%	993	107,642	60%
Westport	348	24,928	63	2,524	10%	82	7,334	29%
Total Unincorp. County	10,676	1,695,624	1,448	154,762	9.1%	5,385	773,120	46%

Source: Williams et al, 2020

WINDSTORM AND WINTER STORM

Windstorm and winter storm risk was ranked based on the 2007 storm event. All of the County is considered at risk from windstorms and winter storms annually. The primary impacts are interruptions in electricity, communication, and travel. The scenario considered was the 2007 event that resulted in closed roads and loss of power and telecommunications across the County for nearly two weeks. The lack of access to Portland hospitals and the inability to communicate with people with medical needs were two major life safety concerns.

Many buildings, utilities, and transportation systems in Clatsop County are vulnerable to wind damage. This is especially true in open areas, such as in the Clatsop Plains area, natural grasslands, or farmland. It also is true in forested areas with above-ground utility lines. A windstorm can knock down trees and power lines which results in road closures, power outages, and tons of debris. Fallen trees block roads and rails for long periods, which can affect emergency and commercial operations. Clatsop County works with utility companies in identifying problem areas and tree maintenance/removal is an ongoing mitigation action.

Tree-lined coastal roads and highways present a special problem in Clatsop County, especially along Highways 30 and 101. Wind-driven waves are common along the Oregon coast and are responsible for road and highway wash-outs and the erosion of beaches and headlands. These problems are addressed under Flood Hazards (i.e., Ocean flooding and wave action). Bridges spanning bays or the lower Columbia River would be closed during high wind periods.

Damage data and loss estimates related to windstorms and winter storms are not consistently collected except in the case of severe events when a request for public and/or individual assistance is made as part of a disaster declaration request. These post-disaster damage estimates can be found following presidentially-declared disasters. Damages from the December 2007 storm, for example, were estimated at $12,353,136 in rural Clatsop County (excludes cities).

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DROUGHT

Drought can affect all segments of a jurisdiction's population, particularly those employed in water-dependent and water-related activities (e.g., agriculture, hydroelectric generation, recreation, etc.). Domestic water users may also be subject to stringent conservation measures (e.g., rationing) and could be faced with significant increases in electricity rates.

Water-borne transportation systems (e.g., ferries, barges, etc.) could be impacted by periods of low water. A prolonged drought in forests promotes an increase of insect pests, which in turn, damage trees already weakened by a lack of water. A moisture-deficient forest constitutes a significant fire hazard. In addition, drought and water scarcity add another dimension of stress to species listed pursuant to the Endangered Species Act (ESA) of 1973.

Drought poses a risk of reduced water availability for communities and agricultural producers during peak demand in late summer. This limits the growth of community development and of overall production of products that have a late summer water demand.

VOLCANIC ASH FALL

While ash fall is the primary risk for Clatsop County, the City of Astoria and the Port of Astoria also identify debris flow as a potential hazard. Most of Clatsop County is isolated climatically from the impacts of volcanic gases such as those emitted from a volcanic event before, during, or after a volcanic eruption due to its proximity to the Pacific Ocean and Columbia River.

Structural damage can result from the weight of volcanic ash, especially if it is wet. Four inches of wet ash may cause buildings to collapse. A half- inch of ash can impede the movement of most vehicles and disrupt transportation, communication, and utility systems, and cause problems for human and animal respiratory systems. It is extremely dangerous for aircraft, particularly jet planes; volcanic ash can damage critical engine components, coat exposed electrical components, and erode exposed structure.

Ashfall may severely decrease visibility, and can even cause darkness, which can further disrupt transportation and other systems. Ashfall can severely degrade air quality, triggering health problems. In areas with considerable ashfall, people with breathing problems might need additional services from doctors or emergency rooms. In severe events, an air quality warning could be issued, similar to those given on poor air quality days during the summer. This would, for example, warn people with breathing problems not to go outside.

On roads and streets, ashfall can create serious traffic problems as well as road damage. Vehicles moving over even a thin coating of ash can cause clouds of ash to swell. This results in visibility problems for other drivers, calling for speed restrictions, and often forcing road closures. It also adds to the potential for health problems for residents in the area. Extremely wet ash creates very slippery and hazardous road conditions. Ash that fills roadside ditches and culverts can prevent proper drainage and cause shoulder erosion and road damage. Blocked drainages can also trigger debris flows or lahars if they cause water to pool on or above susceptible slopes. Conventional snow removal methods do not work on dry ash, as they only stir it up and cause it to resettle on the roadway. When ash is pushed to the side of travel lanes, wind and vehicle movement continue to cause it to billow.

To identify the areas that are likely to be affected by future events, prehistoric rock deposits are mapped and studied to learn about the types and frequency of past eruptions at each volcano. This information helps scientists to better anticipate future activity at a volcano and provides a basis for preparing for the effects of future eruptions through emergency planning. Scientists also use wind direction to predict areas that might be affected by volcanic ash; during an eruption that emits ash, the ashfall deposition is controlled by the prevailing wind direction. The predominant wind pattern over the Cascades is from the west, and previous eruptions seen in the geologic record have resulted in most ashfall drifting to the east of the volcanoes.

CURRENT ON-GOING PLANNING EFFORTS

Tsunami Evacuation Facilities Improvement Plan (TEFIP)

On August 22, 2019, the County received an award letter from the Oregon Transportation and Growth Management Program to prepare a Tsunami Evacuation Facilities Improvement Plan (TEFIP). This plan will augment existing efforts by the Emergency Management Division of Clatsop County, which in past years has installed "You are Here" signs at a majority of beach access points. An emphasis will be placed on identifying trails and paths that can provide year-round recreational opportunities while also functioning as evacuation routes in the event of a disaster. The project began in January 2020 and is expected to be completed in early 2022.

FUTURE CONDITIONS

FLOOD

Per information from the MJNHMP and the *Future Climate Projections Clatsop County* (Oregon Climate Change Research Institute, February 2020), changes to climate conditions are projected to have the following impacts on flooding within Clatsop County:

- Coastal rain-dominated watersheds may experience an increase in winter flood risk due to projected greater precipitation and warmer winter temperatures, in addition to increases in the frequency and intensity of flood-producing atmospheric river events.
- Flood risk from the Columbia River is not expected to change due to projected decreases in peak flows and the fact that it is highly managed for flood control.
- Coastal wetland ecosystems are sensitive to rising sea levels, increases in coastal storms and wave height, warming air and water temperatures, changing precipitation patterns and freshwater runoff, saltwater intrusion, and ocean acidification, which can lead to

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changes in biological, chemical, and physical processes; shifts in species and biodiversity loss; and altered location and spatial extent of tidal wetlands.

- The Necanicum River Estuary is projected to gain potential tidal wetland area as sea level rises.
- Sea level rise and changing wave dynamics are key climate change impacts expected to increase the risk of coastal erosion and flooding hazards on the Oregon Coast. Local sea level rise in Clatsop County is projected to reach 0.8 to 4.8 feet by 2100. These estimates include vertical land movement trend estimates and are based on two global sea level scenarios used in the 2018 US National Climate Assessment.
- The likelihood of a 4-foot flood event, that is, water reaching four feet above mean high tide, ranges from 4%-38% by the 2030s, 19%-100% by the 2050s, and 98-100% by 2100.
- Climate change is expected to exacerbate coastal erosion in Clatsop County. By 2100 or before, assets and people within the 4-foot inundation zone are highly likely to be impacted or displaced—including 3,407 people, $138 million in property value, and a half-mile of state, county, and local roads.

LANDSLIDE

The February 2020 OCCRI *Clatsop County Future Projections* report does not indicate any increased climate risks specific to landslide hazards. Overall population growth, however, increases the percentage of population and structures that may be exposed to impacts from landslides.

EARTHQUAKE

The Cascadia Subduction Zone has not produced an earthquake since 1700 and is building up pressure where the Juan de Fuca Plate is subsiding underneath the North American plate. ~~Currently,~~ Per information from the Oregon Office of Emergency Management, scientists are predicting that there is about a 37% ~~percent~~ chance that a megathrust earthquake of 7.1+ magnitude in this fault zone will occur in the next 50 years. This event will be felt throughout the Pacific Northwest.

The February 2020 OCCRI *Clatsop County Future Projections* report does not indicate any increased climate risks specific to the earthquake hazard. Continued expansion of tourism, coupled with population growth, greatly raises the potential impacts to life and property that will occur during a CSZ event.

TSUNAMI

~~The February 2020 OCCRI *Clatsop County Future Projections* report does not indicate any increased climate risks specific to the earthquake hazard.~~ Many of the visitors to Clatsop County, whether day visitors or overnight tourists, come to the area to be in close proximity to the ocean and beach. During peak tourism times, including holidays and special events, population in coastal areas may swell by several thousand. Many of those visitors may not be familiar with the location of evacuation routes or safety protocols when a tsunami warning is issued. Continual public outreach and education, clearly marked evacuation routes and assembly points are needed to assist both residents and visitors during a tsunami event. During public meetings held as part of the Tsunami Evacuation Facilities Improvement Plan (TEFIP) preparation, several vertical structures may be required in highly touristed coastal areas, including Fort Stevens State Park. Consideration should be given to implementing the recommendations contained in the final TEFIP report.

COASTAL EROSION

Sea level rise and changing wave dynamics are key climate change impacts expected to increase the risk of coastal erosion and flooding hazards on the Oregon Coast. Local sea level rise in Clatsop County is projected to reach 0.8 to 4.8 feet by 2100. These estimates include vertical land movement trend estimates and are based on two global sea level scenarios used in the 2018 U.S. National Climate Assessment. The likelihood of a 4-foot flood event, that is, water reaching four feet above mean high tide, ranges from 4%-38% by the 2030s, 19%-100% by the 2050s, and 98-100% by 2100 (Dalton, M.M., 2020, p.38). Climate change is expected to exacerbate coastal erosion in Clatsop County. By 2100 or before, assets and people within the 4-foot inundation zone are highly likely to be impacted or displaced—including 3,407 people, $138 million in property value, and a half-mile of state, county, and local roads (Dalton, M.M., 2020, p.38). “The projected increase in local sea levels along the Oregon coast raises the starting point for storm surges and high tides making coastal hazards more severe and more frequent in the future (Climate Central, 2019; Dalton, M.M., 2020, p.35).”

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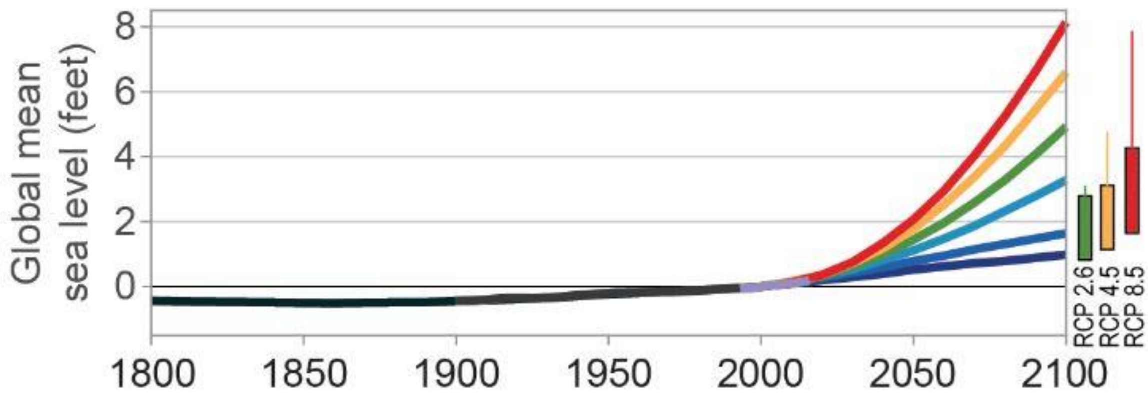
Figure 1: Global Mean Sea Level Rise (1800-2100)



Scenario	RCP2.6	RCP4.5	RCP8.5
Low (1 ft)	94%	98%	100%
Intermediate-Low (1.6 ft)	49%	73%	96%
Intermediate (3.3 ft)	2%	3%	17%
Intermediate-High (4.9 ft)	0.4%	0.5%	1.3%
High (6.6 ft)	0.1%	0.1%	0.3%
Extreme (8.2 ft)	0.05%	0.05%	0.1%

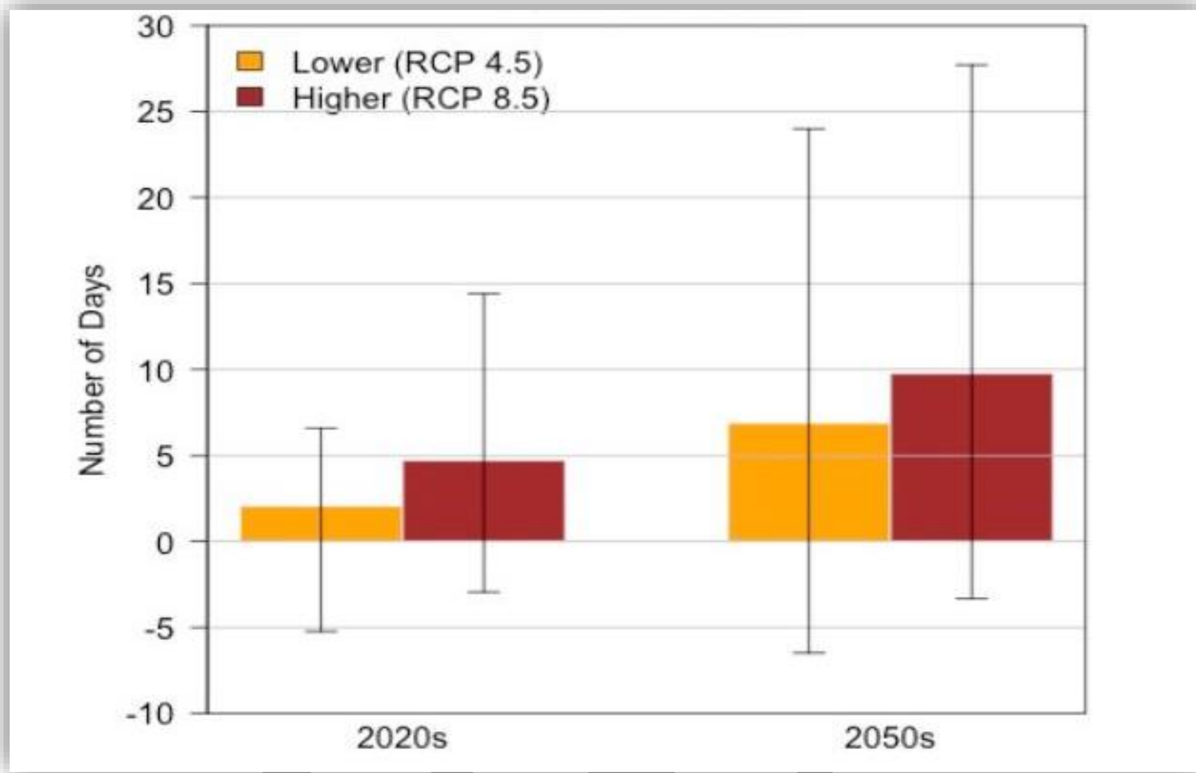
Source: *Clatsop County Future Projections,* Oregon Climate Change Research Institute, February 2020

WILDFIRE

Climate change impacts are anticipated to increase the frequency, duration, and intensity of extreme heat due to continued warming temperatures (Dalton, M.M., 2020, p. 13). Associated risks to air quality of warmer temperatures include increased ground level ozone pollution, increased smoke and particulates from wildfires, and more potent pollen seasons, resulting in increased risk of respiratory and cardiovascular illness, increased allergies, and greater rates of asthma. While woodstove smoke and diesel emissions are other contributors of particulates, wildfires are primarily responsible for the days when air quality standards for PM2.5 are exceeded in western Oregon. The number of “smoke wave” days in Clatsop County is projected to increase (Dalton, M.M., 2020, p. 28).

Wildfire risk is expressed in the frequency of very high fire danger days—and the frequency of very high fire danger days is expected to increase under future climate change scenarios for Clatsop County. Under the higher emissions scenario by the 2050s, the number of very high fire danger days is expected to increase by 10 days compared to the historic baseline—this translates to an annual increase of about 27% (Dalton M.M., 2020, p.27).

Figure 2: Change in Annual Very High Fire Danger Days



Source: *Future Climate Projections Clatsop County,* OCCRI, February 2020

WIND AND WINTER STORM

Climate change has the potential to alter surface winds through changes in the large-scale free atmospheric circulation and storm systems, and through changes in the connection between the free atmosphere and the surface. Future projections indicate a slight northward shift in the jet stream and the extratropical cyclone activity, but there is as yet no consensus on whether or not extratropical storms and associated extreme winds will intensify or become more frequent along the Northwest coast under a warmer climate. The *Future Climate Projections Clatsop County* report, prepared by the Oregon Climate Change Research Institute and issued in February 2020, notes the following impacts from climate change on wind and winter storm events:

- Climate change will cause very little, if any, change to the frequency or intensity of windstorms in the Pacific Northwest.
- Cold extremes are still expected from time to time, but with less frequency and intensity as the climate warms. Under the higher emissions scenario, by the 2050s, the coldest

night of the year is projected to increase by about 6 degrees F (range 0-10 degrees F) and annually have one less day per year below freezing.

- Regionally, the occurrence of rain-on-snow, or precipitation occurring as rain instead of snow, is likely to increase which could contribute to deficits in late-summer water supply for regional agricultural producers or higher temperatures for cold water-dependent fish like trout and salmon.

DROUGHT

Drought conditions, as represented by low summer soil moisture, low spring snowpack, low summer runoff, low summer precipitation, and high summer evaporation are projected to become more frequent in Clatsop County by the 2050s (Dalton, M.M., 2020, p.25).

In Clatsop County, spring snowpack (that is, the snow water equivalent on April 1), summer runoff, summer soil moisture, and summer precipitation are projected to decline while summer evaporation is projected to increase under both lower (RCP 4.5) and higher (RCP 8.5) emissions scenarios by the 2050s (2040–2069). This leads to the magnitude of low summer soil moisture, low spring snowpack, low summer runoff, low summer precipitation, and high summer evaporation expected with a 20% chance in any given year of the historical period being projected to occur much more frequently by the 2050s under both emissions scenarios. The 2020s (2010–2039) were not evaluated in this drought analysis due to data limitations but can be expected to be similar but of smaller magnitude to the changes for the 2050s (Dalton M.M., 2020, p.24).

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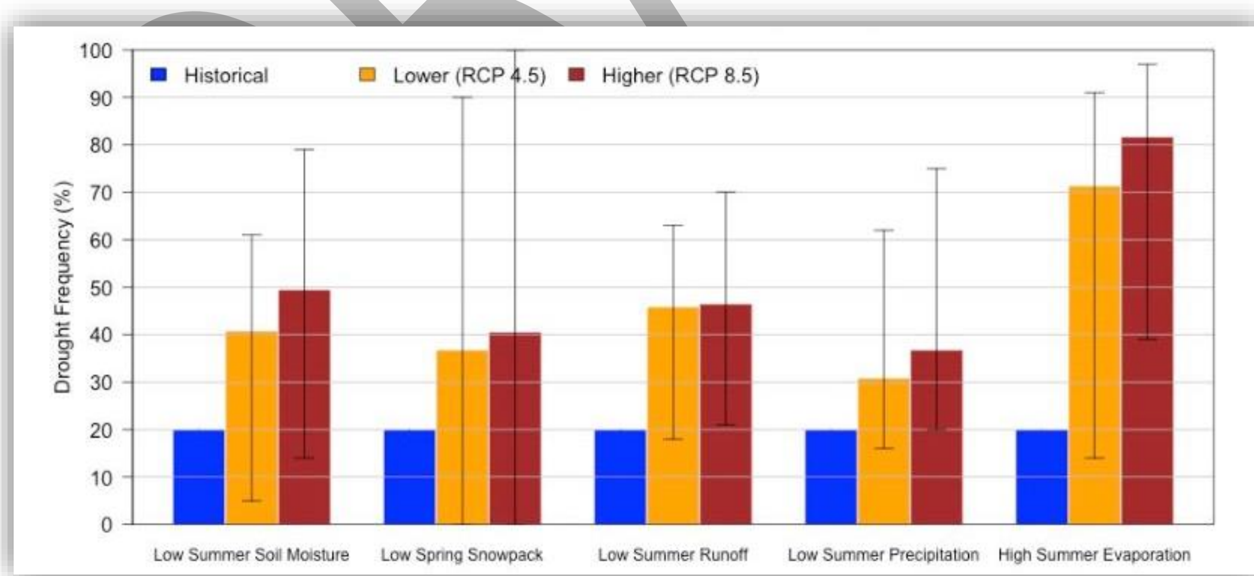
Figure 3: Drought Metrics for Clatsop County



Source: *Future Climate Projections Clatsop County,* OCCRI, February 2020

VOLCANIC ASH FALL

The February 2020 OCCRI *Clatsop County Future Projections* report does not indicate any increased climate risks specific to volcanic events or volcanic ash fall. Continued expansion of tourism, coupled with population growth, greatly raises the potential impacts to life and property that might occur during a volcanic event.

OTHER ISSUES AND TRENDS

FEMA Biological Opinion (BiOp)

The National Flood Insurance Program (NFIP) provides flood insurance for homeowners and property owners. The NFIP is administered by the Federal Emergency Management Agency (FEMA). FEMA sets standards for local governments participating in the NFIP, including requirements for local floodplain development ordinances. The Department of Land Conservation and Development (DLCD) is designated as Oregon's NFIP coordinating agency and assists local governments with implementation of the federal standards.

Because the NFIP has a direct effect on development that occurs in areas adjacent to local streams, rivers, and waterbodies, it is important for the NFIP to consider its effects on endangered species. Marine and anadromous species are protected by the Endangered Species Act (ESA) which is administered by the National Marine Fisheries Service (NMFS), a branch of the National Oceanic Atmospheric Administration (NOAA). This branch is also known as NOAA-Fisheries. The ESA provides for the conservation of threatened and endangered plants and animals and the habitats in which they are found. The ESA requires federal agencies to ensure that actions they authorize, fund, or carry out do not jeopardize the continued existence of any ESA listed species.

For several years, the NMFS and FEMA have been discussing measures that could be used to reduce negative impacts from the National Flood Insurance Program (NFIP) on salmon, steelhead and other species listed as threatened under the Endangered Species Act (ESA). In April 2016, NMFS delivered a jeopardy Biological Opinion (BiOp) to FEMA, stating that parts of the NFIP could have a negative impact on the habitat of endangered salmon species.

Local governments that participate in the NFIP, including Clatsop County, will likely need to change their review process for floodplain development permits. FEMA Region X, State and local government staff have been meeting since 2016 to respond to the finding and recommendations in the BiOp and to determine the best ways to implement the interim measures described in the Reasonable and Prudent Alternative (RPA). In October 2021, FEMA released a draft of its *Oregon Implementation Plan for NFIP-ESA Integration*.

OBJECTIVES AND POLICIES

Objective 1: To reduce or prevent the risk of injury or death from natural hazards.

Objective 2: To reduce or eliminate damage to critical facilities, services, and equipment from a natural hazard event.

Objective 3: To reduce or prevent damage to public and private services, buildings, and infrastructure; protect natural and cultural resources as a part of those efforts.

Objective 4: To increase cooperation and collaboration among mitigation partners to protect the economic engines of Clatsop County.

Objective 5: To raise awareness about the risks of natural hazards and the strategies to mitigate them.

Objective 6: Consider the likely post-Cascadia landscape, and encourage the development and redevelopment of key facilities when siting them today.

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GENERAL NATURAL HAZARD POLICIES

Policy A: The County should develop a centralized County 911 system and resilient back-up communications system.

Policy B: In coordination with the cities and appropriate visitor and tourism agencies, the County should develop a pre-plan of how to accommodate visitors to the coast following a major disaster.

Policy C: The County shall develop post-disaster recovery plans for unincorporated communities and areas within Clatsop County.

Policy D: In order to facilitate recovery efforts, the County shall develop a debris management plan.

Policy E: The County ~~should~~ shall continue to analyze the costs and risks associated with maintaining critical county-owned public safety facilities within the tsunami inundation zone and study the relocation of these facilities.

Policy F: The County should develop emergency shelter facilities throughout the County.

Policy G: The County should create and maintain an inventory of available generators and fuel distribution sites.

Policy H: The County should continue to conduct outreach and education efforts to community organizations active in disasters and that may have control over structures and areas that may be designated as relief sites during periods of emergency response and recovery.

Policy I: The County encourages power companies to update and improve powerlines to protect from wildfires, storms and promote resiliency.

FLOOD POLICIES

Policy A: Clatsop County recognizes the value of an integrated flood hazard management program in order to protect life and property and shall continue participation in the ~~Federal~~ National Flood Insurance Program.

Policy B: Through an integrated flood hazard management program, the county will implement and administer appropriate land use planning techniques and construction standards.

Policy C: The County will develop and maintain educational efforts regarding the public benefit derived from an integrated flood hazard management program.

Policy D: The County shall limit land uses in the floodplain to those uses identified by the adopted floodplain regulations as suitable.

Policy E: The County shall strive to make flood hazard information, including that related to tsunamis, available to the public to ensure that owners and potential buyers of flood prone land are aware of the hazard. County property ~~deeds~~ maps should ~~shall~~ indicate when the property is in a mapped tsunami zone.

Policy F: To provide continued flood protection, the County encourages the maintenance and repair of existing flood control structures except when dike breaching is carried out to restore natural ~~animal and plant~~ habitat and/or reduce flooding of critical infrastructure. The construction of new dikes, for the purpose of establishing future development in floodplain areas, shall be discouraged.

Policy G: Agriculture, forestry, open space and recreation shall be the preferred uses of flood prone areas.

Policy H: The County shall prohibit the placement of hospitals, public schools, nursing homes, and other similar public uses within areas subject to flooding.

Policy I: Subdivisions occurring within floodplain areas shall be encouraged to cluster land uses outside of the floodplain area leaving the floodplain in open space.

Policy J: For specified areas, the County will consider the adoption of regulations requiring the preparation and implementation of a drainage plan as part of

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its review and approval of conditional use permits and development permits.

Policy K: Clatsop County should explore public support for becoming a Community Rating System (CRS) community.

Policy L: The county should engage and support the diking districts and drainage improvement companies in respect to accreditation of the County's levees.

LANDSLIDE POLICIES

Policy A: The County shall recognize the development limitations imposed by areas of mass movement potential.

Policy B: Mass movement hazards do not necessitate disapproval of development, but higher development standards can be expected in order to minimize potential damage and property loss.

Policy C: Clustering of development on stable or less steep portions of sites is encouraged in order to maintain steeper or unstable slopes in their natural conditions.

Policy D: Closely spaced septic tanks and drainfields should be restricted from moderately to steeply sloping areas because of the potential for sliding.

Policy E: Projects which include plans for modifying the topography of sloping areas or established drainage patterns shall be evaluated in terms of the effect these changes would have on slope stability, including neighboring properties.

Policy F: The presence of faults in an area may constitute justification for restricting development in areas of landslide topography.

Policy G: Structures should be planned to preserve natural slopes. Cut and fill construction methods shall be discouraged. Structures should be planned to preserve natural slopes. Cut and fill construction methods shall be discouraged.

Policy H: Access roads and driveways shall follow slope contours to reduce the need for grading and filling, reduce erosion, and prevent the rapid discharge of runoff into natural drainageways.

Policy I: Loss of ground cover for moderately to steeply sloping lands may cause land slippage and erosion problems by increasing runoff velocity. Development on moderate to steep slopes should generally leave the natural topography of the site intact. Existing vegetation, particularly trees, should be retained on the site.

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Policy J: The County, in coordination with appropriate state and local agencies should identify and develop alternative transportation routes around slide-prone areas within the county.

Policy K: The County shall utilize the Department of Geology and Mineral Inventories' Statewide Landslide Information Layer for Oregon (SLIDO), dated ~~XXXX~~ July 23, 2022, to determine properties that are in the moderate to very high landslide susceptibility category. Development on properties within the moderate to very high category shall be required to subject a geologic hazard report or request a waiver from that requirement.

EARTHQUAKE POLICIES

Policy A: The County shall develop and implement a program to retrofit County bridges that are identified by a seismic vulnerability assessment.

Policy B: Structures and public facilities owned and/or operated by Clatsop County should be seismically retrofitted.

Policy C: The County should work with private land owners to identify lifelines routes that can be utilized following a seismic event.

Policy D: The County should develop incentive programs to encourage homeowners and businesses to perform seismic retrofits to existing structures.

TSUNAMI POLICIES

Policy A: The County should identify viable sites for vertical evacuation construction.

Policy B: Clatsop County should implement a Tsunami Hazard Inundation overlay and develop regulations and maps for hazard mitigation planning.

Policy C: The County shall establish long-term supply and staging areas outside of inundation zones.

Policy D: Clatsop County shall continue to upgrade and improve tsunami evacuation routes.

Policy E: Consideration should be given to implementing the recommendations contained in the final TEFIP report.

Policy F: Property titles shall indicate when property in Clatsop County is in a mapped tsunami zone.

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Policy G: Clatsop County should engage Oregon DLCD and local municipalities in an exploration of options for changing land use designations on resource lands adjacent to UGBs to allow development outside of tsunami inundation zones.

Policy H: To protect life, minimize damage and facilitate rapid recovery from a local source Cascadia Subduction Zone earthquake and tsunami, the County will:

1. Support tsunami preparedness and related resilience efforts.
2. Take reasonable measures to protect life and property to the fullest ext3ent feasible, from the impact of a local source Cascadia tsunami.
3. Use the Oregon Department of Geology and Mineral Industries (DOGAMI) Tsunami Inundation Maps applicable to the County to develop tsunami hazard resiliency measures.
4. Enact design or performance implementing code components in identified tsunami hazard areas.
5. Implement land division provisions to further tsunami preparedness and related resilience efforts.
6. Consider potential land subsidence projections to plan for post Cascadia event earthquake and tsunami redevelopment.
7. Identify and secure the use of appropriate land above a tsunami inundation zone for temporary housing, business and community functions post event.
8. As part of a comprehensive pre-disaster land use planning effort, consistent with applicable statewide planning goals, identify appropriate locations above the tsunami inundation for relocation of housing, business and community functions post event.

Policy I: To facilitate the orderly and expedient evacuation of residents and visitors in a tsunami event, the County will:

1. Adopt a tsunami evacuation facilities improvement plan that identifies current and projected evacuation needs, designates routes and assembly areas, establishes system standards, and identifies needed improvements to the local evacuation system.
2. Identify and secure the use of appropriate land above a tsunami inundation zone for evacuation, assembly, and emergency response.
3. Ensure zoning allows for adequate storage and shelter facilities.
4. Provide development or other incentives to property owners that donate land for evacuation routes, assembly areas, and potential shelters.
5. Require needed evacuation route improvements, including improvements to route demarcation (way finding in all weather and lighting conditions),

vegetation management, for new development and substantial redevelopment in tsunami hazard areas.

6. Work with neighboring jurisdictions to identify inter-jurisdictional evacuation routes and assembly areas where necessary.
7. Provide for the development of vertical evacuation structures in areas where reaching high ground is impractical.
8. Evaluate multi-use paths and transportation policies for tsunami evacuation route planning.
9. Encourage suitable structures to incorporate vertical evacuation capacity in areas where evacuation to high ground is impractical.
10. Install signs to clearly mark evacuation routes and implement other way finding technologies (e.g., painting on pavement, power poles and other prominent features) to ensure that routes can be easily followed day or night and in all weather conditions.
11. Prepare informational materials related to tsunami evacuation routes and make them easily available to the public.

Policy J: In order to reduce development risk in high tsunami areas, the County will:

1. Prohibit comprehensive plan or zone map amendments that would result in increased residential densities or more intensive uses in tsunami hazard areas unless adequate mitigation is implemented. Mitigation measures should focus on life safety and tsunami resistant structure design and construction.
2. Encourage open space, public and private recreational and other minimally developed uses within the tsunami inundation zone area.
3. Prohibit the development of those essential facilities and special occupancy structures identified in ORS 455.446 and ORS 455.447 within the tsunami inundation area.
4. Consider the use of transferrable development credits as authorized by ORS 94.541-94.538 to facilitate development outside of tsunami inundation zones.
5. Encourage, through incentives, building techniques that address tsunami peak hydraulic forces which will minimize impacts and increase the likelihood that structures will remain in place.
6. Protect and enhance existing dune features and coastal vegetation to promote natural buffers and reduce erosion.

Policy K: With regard to hazard mitigation planning, the County will:

1. Address tsunami hazards and associated resilience strategies within the community's FEMA approved hazard mitigation plan.
2. Incorporate and adopt relevant sections of the hazard mitigation plan into the comprehensive plan.
3. Ensure hazard mitigation plan action items related to land use are implemented through the comprehensive plan and implementing ordinances.

Policy L: The County will promote tsunami awareness education and outreach by:

1. Encouraging and supporting tsunami education and outreach, training and practice.
2. Implementing a comprehensive and ongoing tsunami preparedness community education and outreach program.
3. Collaborating with local, state and federal planners and emergency managers for the purpose of developing a culture or preparedness supporting evacuation route planning and other land use measures that minimize risk and maximize resilience from tsunami events.

Policy M: The county will identify and work to secure the use of suitable areas within the tsunami inundation zone for short and long-term, post-disaster debris storage, sorting and management.

Policy N: The County will work with other public and private entities to establish mutual aid agreements for post-disaster debris removal and otherwise plan for needed heavy equipment in areas that may become isolated due to earthquake and tsunami damage.

Policy O: The County will limit or prohibit new hazardous facilities as defined in ORS 455.447 within tsunami inundation zones. Where limiting or prohibiting such facilities is not practical, require adequate mitigation measures consistent with state and federal requirements.

COASTAL EROSION POLICIES

Policy A: Clatsop County shall prohibit:

a. the destruction of stabilizing vegetation (including the inadvertent destruction by moisture loss or root damage)
b. the exposure of stable and conditionally stable areas to erosion, and

c. construction of shore structures which modify current or wave patterns or the beach sand supply

Policy B: Erosion shall be controlled and the soil stabilized by native, non-invasive vegetation and/or mechanical and/or structural means on all dune lands.

Policy C: Removal of vegetation during construction in any sand area shall be kept to the minimum required for building placement or other valid purpose. Removal of vegetation should not occur more than 30 days prior to grading or construction. Permanent revegetation shall be started on the site as soon as practical after construction, final grading or utility placement. Storage of sand and other materials should not suffocate vegetation.

Policy D: In all open sand areas, revegetation must be clearly monitored and carefully maintained, which may include restrictions on pedestrian or motorized vehicle traffic. Revegetation shall return the area to its pre-construction level of stability or better. Trees should be planted along with ground cover such as grass or shrubs. To encourage stabilization, a revegetation program with time limits shall be required by the Community Development Department as a condition of all land use actions (i.e. Comprehensive Plan changes, zone changes, subdivisions and partitions, planned developments, conditional use permits etc.).

Policy E: Removal of vegetation which provides wildlife habitat shall be limited. Unnecessary removal of shoreline vegetation shall be prohibited.

Policy F: Site specific investigations by a qualified person such as a geologist, soils scientist, or geomorphologist may be required by the County prior to the issuance of development permits in open sand areas, on the ocean front, in steep hillsides of dunes, regardless of the vegetative cover, and in any other conditionally stable dune area which, in the view of the Planning Community Development Director, may be subject to wind erosion or other hazard potential. Site investigations may be submitted to the Department of Geology and Mineral Industries and other agencies for review of recommendations.

Policy G: Log debris plays an important role in the formation and maintenance of foredunes. Therefore, driftwood removal from sand areas and beaches for both individual and commercial purposes should be regulated so that dune building processes and scenic values are not adversely affected.

Policy H: To prevent increasing coastal erosion, structures such as beach access stairs and decks, should be limited in the oceanfront setback areas of coastal bluff properties.

WILDFIRE POLICIES

Policy A: Clatsop County should develop informational materials to inform the community about how to protect themselves and their assets from wildfire.

Policy B: The County should develop hardening standards for new construction in wildfire risk areas. For example, require spark arresters, metal roofs, fire retardant siding, and vegetative clearing.

Policy C: Hardening of existing residential structures should be encouraged.

Policy D: New construction on rural residential lands adjacent to forest resource land should be required to utilize hardening techniques and materials .

Policy E: Creation of defensible space should be encouraged based upon the best practices identified by the Oregon State University Extension Service .

Policy F: The County should work with the OSU Forestry and Natural Resources Extension Fire Program staff to review and adapt best practices from the *Forest and Fire Toolkit*, prepared by the Klamath Siskiyou Wildlands Center.

Policy G: Information from the FireWise plant list should be made readily available to the public and use of those species should be encouraged.

Policy H: The County ~~shall~~ should consider other sources of information as they become available.

Policy I: The County shall encourage signage promoting fire safety along County roads.

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WIND / WINTER STORM POLICIES

Policy A: The County should promote hazard tree and vegetation management best practices and programs, but balance with vegetation for slope stabilization and scenic benefits.

Policy B: The County should promote tree planting projects on private and public properties, using "right tree, right place" methods.

Policy C: The County should direct residents to information regarding methods to tie down roofs, sheds and other structures.

Policy D: The County encourages new power lines to be placed underground.

STREAMBANK EROSION AND DEPOSITION POLICIES

Policy A: The County shall encourage the stabilization of the outside faces of dikes to prevent erosion as part of the regular maintenance of existing dikes.

Policy B: A buffer of riparian vegetation along streams and rivers should be encouraged in order to protect and stabilize the banks.

Policy C: The DEQ's best management practices for agricultural areas shall be supported to reduce erosion and sedimentation of streams.

Policy D: The County encourages appropriate agencies to work to obtain and enforce speed limits for boats in areas where dikes and private docks are affected by wave erosion.

Policy E: Clatsop County supports strict enforcement of the Forest Practices Act to reduce sedimentation of streams.

Policy F: Problems from natural erosion or the creation of situations where erosion would be increased due to actions on or adjacent to the river banks shall be avoided by carefully reviewing state and federal permits for shoreline stabilization to minimize impacts on adjacent land.

HIGH GROUNDWATER AND/OR COMPRESSIBLE SOILS POLICIES

Policy A: The County shall recognize the development limitations of lands with high groundwater and compressible soils during its planning process.

Policy B: All new development on compressible soils shall be engineered, as required by state and local building codes, to address structural issues associated with construction on compressible soils.

Policy C: The County should update its compressible soils and high water table maps as detailed soils information becomes available.

DROUGHT POLICIES

Policy A: The County should coordinate with local watershed organizations and soil and water conservation districts to implement best practices for water management.

Policy B: The County should encourage the development and implementation of water conservations plans by local residents, water districts and systems, businesses, and industries.

Policy C: The County should support the use of water conservation practices by agricultural, industrial and municipal water users.

Policy D: The County should develop metrics for conditions that determine local drought and provide citizens with appropriate public announcements.

VOLCANIC ASH FALL POLICIES

Policy A: The County should identify the type and amount of Personal Protective Equipment (PPE) that would be needed for vulnerable populations and essential workers if a volcanic event were to occur.

Policy B: The County should develop recommendations for health and safety of the general population and promote those recommendations.

Policy C: The County should identify the best practices that would need to be provided in public announcements in an ash fall event. Best practices should consider risks to livestock, agricultural products, homes (roofs, air systems(), vehicles (paint, air systems), commercial and industrial equipment.

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IMPLEMENTING OREGON ADMINISTRATIVE RULES (OAR):
None

COORDINATING STATE AGENCIES:
Oregon Department of Emergency Management (OEM)
Department of Geology and Mineral Inventories (DOGAMI)
Oregon Department of Land Conservation and Development (DLCD)
Federal Emergency Management Agency (FEMA)
Oregon Climate Change Research Institute (OCCRI)

BACKGROUND REPORTS AND SUPPORTING DATA:
Clatsop County Multi-Jurisdictional Hazard Mitigation Plan 2021
Future Climate Projections Clatsop County (Oregon Climate Change Research Institute, February 2020)