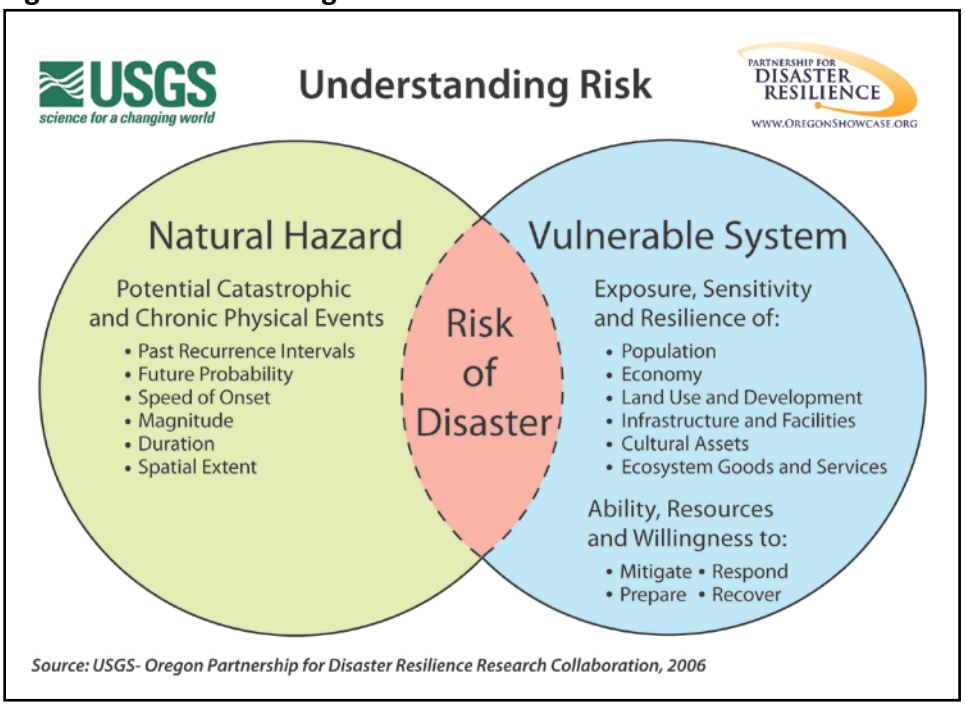
Section 2:
All-Hazard Risk Assessment

This section of the NHMP addresses 44 CFR 201.6(c)(2) - Risk Assessment. In addition, this chapter can serve as the factual basis for addressing Oregon Statewide Planning Goal 7 – Areas Subject to Natural Hazards. Assessing natural hazard risk begins with the identification of hazards that can impact the jurisdiction. Included in the hazard assessment is an evaluation of potential hazard impacts – type, location, extent, etc. The second step in the risk assessment process is the identification of important community assets and system vulnerabilities. Example vulnerabilities include people, businesses, homes, roads, historic places and drinking water sources. The last step is to evaluate the extent to which the identified hazards overlap with, or have an impact on, the important assets identified by the community.

The information presented below, along with hazard specific information presented in the Hazard Annex and community characteristics presented in the Community Profile Appendix, will be used as the local level rationale for the risk reduction actions identified in Section 4 – Mitigation Strategy. The risk assessment process is graphically depicted in Figure 2.1 below. Ultimately, the goal of hazard mitigation is to reduce the area where hazards and vulnerable systems overlap.

Figure 2.1 Understanding Risk



Source: OPDR

Hazard Identification

Table 2.1 presents the Clackamas County Hazard Overview and outlines each hazard and their generalized locations. While most hazards impact the county as a whole, each hazard type tends to have localized impacts. For example, winter storms are often characterized by heavy snow and freezing temperatures which will affect the entire county; however, the event may also result in isolated landslide and flooding events throughout the county.

Table 2.1 Clackamas County Hazard Overview

Hazard	Generalized Locations
Drought	Countywide
Earthquake	Countywide
Extreme Heat	Countywide
Flood	Localized Risks Countywide
Landslide	Localized Risks Countywide
Volcanic Event	Countywide
Wildfire	Primarily the Eastern portion of the county, with localized risks countywide
Windstorm	Localized Risks Countywide
Winter Storm	Localized Risks Countywide

Source: State of Oregon Natural Hazards Mitigation Plan, Region 2: Northern Willamette Valley/Portland Metro Regional Profile, 2012

Below are brief descriptions of the natural hazards present in Clackamas County. These descriptions were taken from the county's Emergency Operations Plan (EOP).[1] Further detail about each hazard is described in the Hazard Annexes presented in Volume II.

Drought

This hazard involves a period of prolonged dryness resulting from a lack of precipitation or diversion of available water supplies. The county has suffered periods of drought in the past; however impact has been to agriculture, fish, and wildlife, and an increased fire risk. A severe drought could require strict conservation measures to assure that an adequate supply of potable water is maintained.[2]

Earthquake

The Cascadia Subduction Zone is located just off the Oregon coast. This zone, where the Pacific plate sinks beneath the North American plate, is part of a larger Subduction system that includes the seismically active, and extremely hazardous, San Andreas Fault and Alaskan earthquake zones. Clackamas County is well within the impact area for a major Subduction earthquake occurring along the Cascadia Subduction Zone.

[1] Clackamas County Emergency Operations Plan, *Atmospheric Emergencies and Geologic* Emergencies Incident Annexes, 2011.

[2] Ibid.

In addition, there are several known crustal fault lines throughout the county with further geologic analyses ongoing. An earthquake measuring 5.6 on the Richter scale occurred in March 1993 and caused damage throughout the county, especially in the Molalla area.

Scientists estimate the chance in the next 50 years of a great Subduction zone earthquake is between 10 and 20 percent, assuming that the recurrence is on the order of 400 +/- 200 years. These events are estimated to have an average recurrence interval between 500 and 600 years, although the time interval between individual events ranges from 150 to 1000 years. The last Cascadia Subduction Zone event occurred approximately 300 years ago.[3]

Additional fault zones throughout the county and region may produce localized crustal earthquakes up to 6.0. Table 2.2 presents a list of the different Class A and B fault lines throughout the county. A local earthquake of M 6.0 or a regional M 9.0 earthquake is likely to cause substantial structural damage to bridges, buildings, utilities, and communications systems, as well as the following impacts to infrastructures and the environment:

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

[3] State of Oregon Natural Hazards Mitigation Plan, Region 2: Northern Willamette Valley/Portland Metro Regional Profile, 2012.

Table 2.2: Class A and B Faults Located in Clackamas County

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

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

A number of seismic vulnerability assessments conducted by the Oregon Department of Geology and Mineral Industries have highlighted the need for seismic retrofits to critical facilities. As a result, the county has recently completed several structural and non-structural seismic upgrades in key facilities and is in the process of identifying additional facilities for upgrades.

Flood

Flooding of rivers, streams, and tributaries may occur during periods of heavy rain and/or rapid snow melt. The rapid rise of water in a number of rivers and streams present severe risks to life and property, and any impending flood may require the evacuation of significant numbers of people and animals. Landslides are an associated problem that may occur as a result of flooding. Table 2.3 identifies specific locations and river drainages that are of particular concern for the county.

Table 2.3: Locations of Identified Flooding Problems

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

Source: Clackamas County Emergency Management

Landslide

Landslides can include the down slope movement of rock, soil, or other debris or the opening of sinkholes. These hazards are often triggered by other natural hazard incidents such as floods, earthquake, or volcanic eruptions. Because of the moderate to high relief characteristics of the county's riverbeds, along with hilly and mountainous terrain, the chance of landslides occurring in Clackamas County is high, but not deemed to present a serious threat to large numbers of people.

Severe Weather

Clackamas County identifies several categories of severe weather as follows:

Extreme Heat

Although rare, Clackamas County is subject to heat extremes when temperatures climb to 100 degrees or more. Many residences lack air conditioning or cooling systems, creating an environment especially hazardous to the elderly, children, and others with certain medical conditions.[4]

Windstorm

Windstorms, including the possibility of tornadoes, may occur suddenly, leaving little time for people to react and move to safety. Even with ample warning that a windstorm or tornado is likely, its path may be difficult to predict. Damage from these incidents may be extensive and severe, or confined to a narrow path of destruction, but they pose serious risks to life, infrastructure, and property whenever weather conditions make them likely.

Winter Storm

Winter storms are among the most common weather incidents impacting the county. These events often involve heavy accumulations of snow and ice that make travel dangerous or impossible, disrupt transportation of goods and services, damage trees and power lines, and cause widespread power outages. Dangerous road conditions make emergency response

[4] Clackamas County Emergency Operations Plan, *Situation and Planning Assumptions*, 2011.

more difficult and complicate the evacuation of people from areas at risk and the delivery of personnel, equipment and supplies to damaged areas. Avalanche risk is generally confined to the higher elevations surrounding Mount Hood.

Volcanic Event

The last known major eruptions of Mount Hood, located on Clackamas County's eastern border, occurred in the middle of the 19th century. Such recent eruptions, as well as the thermal activity that continues to be present, suggest that molten rock is still located within or beneath Mount Hood. Risks associated with a volcanic eruption include pyroclastic flows (incendiary avalanches) and lahars (mud flows), river flooding, destruction of property and woodlands, risk to the Bull Run watershed, and volcanic ash fall. Heavy ash fall in Clackamas County can cause health problems for individuals with certain medical conditions, create havoc with transportation, and pose a significant risk to the public.

Wildfire

Over half of Clackamas County's land mass is forested and wildfires are a natural part of the forest ecosystem in Clackamas County. In fact, wildfires have shaped the forests and rangelands valued by county residents and visitors. However, decades of timber harvest and aggressive fire suppression have significantly altered forest composition and structure. The result is an increase in the wildfire hazard as forest vegetation has accumulated to create a more closed, tighter forest environment that tends to burn more intensely than in the past. The exposure to wildfire hazards is also increasing, as recent population growth has spurred more residential interface (WUI). As development encroaches upon forests with altered fire regimes that are more conducive to larger, more intense fires, the risk to life, property, and natural resources continues to escalate.

FEMA Disaster Declarations

President Dwight D. Eisenhower approved the first federal disaster declaration in May 1953 following a tornado in Georgia. Since then, federally declared disasters have been approved within every state. As of March 2012, FEMA has approved a total of 28 federal disaster declarations, two emergency declarations and 49 fire management assistance declarations in Oregon.[5] When requesting a presidential declaration for a major disaster or emergency, governors provide detailed information about the amount of value of public and private property damage resulting from the event. FEMA uses these damage assessments to determine if the event meets the disaster declaration threshold. In addition, FEMA uses the information to determine the amount of federal public and private assistance being made available as well as the specific counties being included in the declaration.

Disaster declarations can help inform hazard mitigation project priorities, by demonstrating and documenting which hazards historically have caused the most significant damage to the county. Table 2.4 summarizes the major disasters declared for Clackamas County by FEMA since 1953. Since the 2007 Natural Hazards Mitigation Plan (NHMP), there have been two FEMA disaster declarations impacting Clackamas County. The table shows that all but one of the disaster declarations for the county are a result of severe winter storms with some

[5] FEMA. Declared Disasters by Year or State. http://www.fema.gov/news/disaster_totals_annual.fema#markS. Accessed 05 March 2012.

degree of flooding, mudslides, landslides, or debris flow. Since 1953, there have been a total of nine disaster declarations for the county; four of those occurred in the past ten years.

Table 2.4: FEMA Major Disaster Declarations – Clackamas County

Declaration Date:	Incident(s):	Incident(s) Period:
17-Feb-11	Severe Winter Storm, Flooding, Mudslides, Landslides, and Debris Flows	13-Jan-11 to 21-Jan-11
2-Mar-09	Severe Winter Storm, Record and Near Record Snow, Landslides, and Mudslides	13-Dec-08 to 26-Dec-08
20-Mar-06	Severe Storms, Flooding, Landslides, and Mudslides	18-Dec-05 to 21-Jan-06
19-Feb-04	Severe Winter Storms	26-Dec-03 to 14-Jan-04
9-Feb-96	Severe Storms/Flooding	4-Feb-96 to 21-Feb-96
26-Apr-93	Earthquake	25-Mar-93
25-Jan-74	Severe Storms, Snowmelt, Flooding	25-Jan-74
21-Jan-72	Severe Storms, Flooding	21-Jan-72
24-Dec-64	Heavy Rains & Flooding	24-Dec-64

Source: FEMA, Oregon Disaster History, Major Disaster Declarations

Hazard Probability

Probability is the likelihood of future natural hazard events within a specified period of time. Clackamas County evaluated the best available probability data to develop the probability scores presented below. For the purposes of this plan, the county utilized the Oregon Emergency Management Hazard Analysis Methodology probability definitions to determine hazard probability. The definitions are:

LOW = one incident likely within 75 to 100 years scores between 1 and 3 points

MEDIUM = one incident likely within 35 to 75 years scores between 4 and 7 points

HIGH = one incident likely within 10 to 35 years scores between 8 and 10 points

Table 2.5 presents the probability scores for ten natural hazards that consistently affect or threaten Clackamas County. As shown in the table, individual natural hazard events in the county have varying levels of probability. Flood, landslide/debris flow, and winter storms have a high probability of occurrence. Wildfire, earthquake, and windstorm events have a

medium probability of occurrence, while volcanic events have a low probability of occurrence.

Table 2.5: Natural Hazard Probability Assessment Summary – Clackamas County

Threat Event/Hazard	Severity	Weight Factor	Subtotal	Probability
Flood	9	7	63	High
Landslide/Debris Flow	9	7	63	High
Winter Storm	8	7	56	High
Wildfire	7	7	49	Medium
Earthquake - Cascadia	6	7	42	Medium
Earthquake - Crustal	6	7	42	Medium
Windstorm	6	7	42	Medium
Drought	4	7	28	Medium
Extreme Heat	2	7	14	Low
Volcanic Event	2	7	14	Low

Source: Clackamas County HMAC, OEM Hazard Analysis, updated April 25, 2012

Community Vulnerability

Natural disasters occur as a predictable interaction among three broad systems: natural environment (e.g., climate, rivers systems, geology, forest ecosystems, etc.), the built environment (e.g., cities, buildings, roads, utilities, etc.), and societal systems (cultural institutions, community organization, business climate, service provision, etc.). A natural disaster occurs when a hazard impacts the built environment or societal systems and creates adverse conditions within a community.

It is not always possible to predict exactly when a natural disaster will occur or the extent to which they may impact the community. However, communities can minimize losses from disaster events through deliberate planning and mitigation.[6]

Populations[7]

Natural disasters do not have boundaries, and they affect a variety of people. It is important to consider different types of vulnerable populations that will be affected in a natural disaster event. Below, Table 2.6 lists specific populations that are most vulnerable in a hazard event, along with the accompanied hazards likely to affect those populations.

Child care facilities, schools, and adult care homes are important and current mitigation measures include the seismic retrofitting of some schools. Hospitals become an issue if they are threatened by a natural disaster. Hospitals are an essential facility, but in this case can also be a critical facility. It is important for the county to focus on ensuring that hospitals remain a safe haven for its occupants.

[6] State of Oregon Natural Hazards Mitigation Plan, Region 2: Northern Willamette Valley/Portland Metro Regional Profile, 2012.

[7] Clackamas County NHMP Community Profile, Socio Demographic Capacity

Low Income

Low-income populations may require additional assistance following a disaster because they may not have the savings to withstand economic setbacks, and if work is interrupted, housing, food, and necessities become a greater burden. Additionally, low-income households are more reliant upon public transportation, public food assistance, public housing, and other public programs, all which can be impacted in the event of a natural disaster. According to the 2010 Census Estimates, 10.2% of the county's population is below poverty.

Age

Age is a very important factor which has a direct impact on what actions are prioritized for mitigation and how responses to hazard incidents are carried out. Young people represent a potentially vulnerable segment of the population. During the natural hazard mitigation process, special considerations should be given to young populations and schools, where children spend much of their time. Likewise, the elderly population may require special consideration due to increased sensitivities to heat and cold, possible reliance upon transportation for medications, and comparative difficulty in making home modifications that reduce risk to hazards. According to the 2010 Census Data, 26.2% of the county's population is under the age of 20, and 20.2% is over the age of 60. These two percentages show that significant outreach to these age groups is important. Residents in these age groups were taken into consideration when the HMAC developed the population asset chart.

Non-English speaking

Special consideration should be given to populations who do not speak English as their primary language. Non-English speaking populations can be harder to reach with preparedness and mitigation information and materials. According to the 2010 Census, 11% of the county's population speaks a language other than English. In addition to language barriers, cultural differences need to be considered when assessing vulnerability and developing mitigation strategies. Resiliency efforts need to be tailored to the specific needs of non-English speaking segments of the population.

Disabled

Individual and community health play an integral role in community resiliency. Members of the population with a disability may face increased vulnerability depending on the type and extent of their disability and the specific resources available to them at the time of the disaster. A primary consideration for disabled and alter-abled members of the population is mobility and response effort in a time of disaster. Notably, of the 12.6% of the population with a disability, about 37% are over the age of 65.

Table 2.6: Clackamas County Population Issues

Clackamas County Asset Identification	Drought	Earthquake	Extreme Heat	Flood	Landslide	Volcano	Wildfire	Windstorm	Winter storm
Schools (particularly those not up to code)		X							
Child Care Facilities		X	X	X		X	X		
Adult Care Homes/Assisted Living Facilities		X	X	X			X		
Homeowners in WUI							X		
Hospitals		X		X			X	X	X
Mass Transit		X		X				X	X
Clackamas County Jail		X							

Source: Clackamas County HMAC

Economy

Clackamas County's economy is highly susceptible to economic disturbance from Natural Hazards. Table 2.7 identifies they county's economic assets that, if disrupted could significantly impact the local economy. A majority of the community assets listed, such as the Clackamas Town Center and the Fred Meyer Distribution Center, are most affected by earthquakes, and other assets are affected by wildfire and severe storms, including agriculture and forestry. The HMAC matched specific community economic assets with the hazards that are most likely to impact them as outlined in Table 2.7 below.

Table 2.7: Clackamas County Economic Issues

Clackamas County Asset Identification	Drought	Earthquake	Extreme Heat	Flood	Landslide	Volcano	Wildfire	Windstorm	Winter storm
Clackamas Town Center		X							
Precision Cast Parts		X							
Fred Meyer Distribution Center		X							
Agriculture (feed procedurement, seasonal worker procurement, harvest delivery, refrigeration, etc)	X		X				X	X	X
Forestry							X	X	X
Tourism (Hotels and Restaurants)		X		X			X	X	X
City water supply	X	X		X	X				
Transportation Cooridors/Bridges		X			X				

Source: Clackamas County HMAC

Land-use and Development

To accommodate rapid growth, communities engaged in mitigation planning should address the vulnerability of the community's housing stock and development patterns. Eliminating or limiting development in hazard prone areas, such as floodplains, can reduce vulnerability to hazards, and the potential loss of life and injury and property damage. Communities in the process of developing land for housing and industry need to ensure that these goals are being met to prevent future risks.[8]

[8] State of Oregon Natural Hazards Mitigation Plan, Region 2: Northern Willamette Valley/Portland Metro Regional Profile, 2012.

The county's HMAC identified land use and development assets that are susceptible to natural hazards. The Forest Edge Apartments is an apartment complex located on hill in Oregon City. This location has a history of severe landslides near the homes, and action needs to take place to ensure the safety of the residents. Development along established floodplains is another land use issue that can affect homeowners after natural disasters including earthquake, flood, landslide, and volcano. Table 2.8 below outlines county land use and development issues identified by the county's HMAC, and lists the hazards that are most likely to impact them.

Table 2.8: Clackamas County Land Use and Development Issues

Clackamas County Asset Identification	Drought	Earthquake	Extreme Heat	Flood	Landslide	Volcano	Wildfire	Windstorm	Winter storm
Homeowners in Forest Edge Apartments		X			X				
Carver Mobile Home Ranch				X					X
Development on established floodplains, historic and pre-historic debris flow plains		X		X	X	X			
Decentrilized water and sewage systems	X	X		X	X				
Increased development in the wildland-urban interface							X	X	X

Source: Clackamas County HMAC

Environment

River corridors, farm fields, marshes, scenic outlooks, wildflowers, spawning beds for salmon, deer and elk wintering areas, gravel quarries, magnificent stands of trees along Oatfield Ridge, or reservoirs of hot water beneath the slopes of Mt. Hood are all part of the wealth of Clackamas County's environment.[9] The HMAC identified environmental issues and are outlined below in Table 2.9 along with the hazards associated with each issue.

[9] Clackamas County Comprehensive Plan, Chapter 3 - Natural Resources and Energy, III-1.

Table 2.9: Clackamas County Environmental Issues

Clackamas County Asset Identification	Drought	Earthquake	Extreme Heat	Flood	Landslide	Volcano	Wildfire	Windstorm	Winter storm
Forest/woodland areas							X		
Streams/Riparian zones (property damage, bridges/culverts)	X			X					
County/City Parks				X			X	X	X
General groundwater issues	X			X		X	X		
Groundwater and surface water contamination from industrial area disruption		X		X	X				

Source: Clackamas County HMAC

Critical Facilities and Infrastructure

Transportation networks, systems for power transmission, and critical facilities such as hospitals and police stations are all vital to the functioning of the region. Due to the fundamental role that infrastructure plays both pre- and post-disaster it deserves special attention in the context of creating more resilient communities.[10] Daily, transportation infrastructure capacity and the condition of bridges are factors that affect risk from natural hazards. Natural hazards can further disrupt automobile traffic and create gridlock, while incapacitated bridges can disrupt traffic and exacerbate economic losses because of the inability of industries to transport services and products to clients.[11] Table 2.10 displays critical facilities and infrastructure identified by the county's HMAC; the associated hazards are also listed.

[10] State of Oregon Natural Hazards Mitigation Plan, Region 2: Northern Willamette Valley/Portland Metro Regional Profile, 2012.

[11] State of Oregon Natural Hazards Mitigation Plan, Region 2: Northern Willamette Valley/Portland Metro Regional Profile, 2012.

Table 2.10: Clackamas County Critical Infrastructure and Services Issues

Clackamas County Asset Identification	Drought	Earthquake	Extreme Heat	Flood	Landslide	Volcano	Wildfire	Windstorm	Winter storm
Electrical grid		X	X	X	X			X	X
All highways and bridges		X		X	X			X	X
City Halls		X							
Cellular communications infrastructure		X						X	X
Fiber optics lines		X						X	X
Water intake facilities		X		X	X				
Emergency Services (fire department, police department, hospitals, EOC's)		X		X	X		X	X	X
Water sewer treatment plants		X		X					

Source: Clackamas County HMAC

National Flood Insurance Program (NFIP)

Clackamas County's Flood Insurance Rate Maps are current as of June 17, 2008. Table 2.11 shows that as of November 21, 2011, there were a total of 1,374 National Flood Insurance Program (NFIP) policies in force throughout unincorporated Clackamas County with a total coverage of nearly $348 million. Between 1978 and July 25, 2011, there were a total of 442 NFIP claims which paid just over $9 million in claims. Unincorporated Clackamas County has 55 repetitive flood loss properties. Clackamas County's last Community Assistance Visit was in February of 2011. Clackamas County is an active member of the Community Rating System (CRS), with a current class ranking of 5.

The table also displays information about each of the jurisdictions. All 15 jurisdictions within the county have Flood Insurance Rate Maps that are current as of June 17, 2008. The only city that is not a participant in the National Flood Insurance Program is Johnson City. Oregon

City is the only city that is an active member of the CRS with a class ranking of 7. The cities of Lake Oswego and West Linn have the two highest numbers of NFIP policies with 302 and 121 policies, respectively. Although the city of Milwaukie only has 52 NFIP policies, they have the highest number of repetitive loss properties at 19.

Table 2.11 NFIP Summary Table

Jurisdiction	FIRM Status	FIRM Date	NFIP Status	# NFIP Policies	Ttl Coverage	# NFIP Claims	Ttl Paid	# Repetitive Loss Properties	CRS Status
Clackamas County	**REVISED**	**Jun-08**	**P**	**1,374**	**$347,876,500**	**442**	**$9,305,431**	**55**	**5**
Barlow	REVISED	Jun-08	P	0	$0	0	$0	0	NA
Canby	REVISED	Jun-08	P	23	$5,513,800	2	$67,371	0	NA
Damascus	REVISED	Jun-08	P	10	$2,115,700	0	$0	2	NA
Estacada	ALL ZONE C&X PUBLISHED FIRM	Jun-08	P	3	$775,000	0	$0	0	NA
Gladstone	REVISED	Jun-08	P	46	$11,050,600	10	$137,427	0	NA
Happy Valley	REVISED	Jun-08	P	7	$2,450,000	0	$0	0	NA
Johnson City	ALL ZONE C&X PUBLISHED FIRM	Jun-08	NP	0	$0	0	$0	0	NA
Lake Oswego*	REVISED	Jun-08	P	302	$88,571,900	64	$3,583,026	0	NA
Milwaukie*	REVISED	Jun-08	P	52	$14,563,200	57	$1,904,200	19	NA
Molalla	ALL ZONE C&X PUBLISHED FIRM	Jun-08	P	8	$2,419,700	5	$110,943	2	NA
Oregon City	REVISED	Jun-08	P	64	$21,061,200	24	$1,467,600	2	7
Rivergrove	REVISED	Jun-08	P	45	$12,200,700	22	$590,751	9	NA
Sandy	REVISED	Jun-08	P	21	$5,075,100	2	$574	0	NA
West Linn	REVISED	Jun-08	P	121	$34,665,200	51	$1,872,689	2	NA
Wilsonville*	REVISED	Jun-08	P	29	$9,217,800	5	$73,826	0	NA

*Portions of jurisdiction not in Clackamas County
Source: State NFIP Coordinator; p=participating, np=not participating

Vulnerability Summary

Vulnerability is a measure of the exposure of the built environment to hazards. The exposure of community assets to hazards is critical in assessing the degree of risk a community has to each hazard. Identifying the facilities and infrastructure at risk from various hazards can assist the county in prioritizing resources for mitigation, and can assist in directing damage assessment efforts after a hazard event has occurred. The exposure of county assets to each hazard and potential implications are explained in each hazard section.

Table 2.12 summarizes the exposure of county land, critical facilities, and infrastructure assets to natural hazards. This table shows the amount of acres and number of parcels that are located in the hazard zones for earthquake, flooding, wildfire, landslide, and volcano. The table also lists potentially impacted locations and infrastructure in each hazard zone. Please note that Winter Storm and Windstorm are not included, as there is insufficient data to perform an analysis on these hazards. The full vulnerability analysis table is provided in Appendix F: Vulnerability Analysis Table.

Table 2.12 Vulnerability Analysis Table

	Potentially Impacted Parcels		Potentially Impacted Locations			Infrastructure				
Hazard	# of Parcels	% of Total Parcels	Ctritical Facilities	Essential Facilities	Vulnerable Populations	Miles of Road	Miles of Sewer Lines	Bridges	Cell Towers	Dams
County Total	151,520	Not Applicable	237	52	576	4902	324	520	17	58
Relative Earthquake Hazard										
High	12,494	8%	19	9	48	577	30	100	1	12
Flooding										
100 year Floodplain	4,615	3%	7	1	13	73	17	90	0	4
Overall Wildfire Risk										
High	204	< 1%	0	0	2	239	1	1	4	0
Landslide Hazard										
High	197	<1%	1	0	0	44	1	0	0	0
Volcano										
Exposed	7,634	5%	7	2	2	273	21	55	1	1

Source: Clackamas County GIS

The table illustrates that only 8% of the total parcels in the county are located in the relative high earthquake hazard zone. Likewise, only 3% are located within the 100-year floodplain, less than 1% in each of the overall high wildfire risk and landslide hazard zones, and only 8% are exposed to the volcano hazard. There are also 19 critical facilities and 100 bridges located in the high earthquake zone. There are only seven critical facilities located within the 100 year floodplain. While there aren't any critical or essential facilities located in the high wildfire risk zone, there are 82 critical facilities and 139 vulnerable populations located in the moderate risk zone. This assessment provides the HMAC an outlook on which types of potentially impacted locations, infrastructure, and economic locations are at risk, and outlines which areas can seek mitigation improvements.

Vulnerability is the percentage of population and property likely to be affected under an "average" occurrence of the hazard. Clackamas County evaluated the best available vulnerability data to develop the vulnerability scores presented below. For the purposes of this plan, the county utilized the Oregon Emergency Management Hazard Analysis Methodology vulnerability definitions to determine hazard probability. The definitions are:

LOW = less than 1-percent affected scores between 1 and 3 points

MEDIUM = between 1 and 10-percent affected scores between 4 and 7 points

HIGH = more than 10-percent affected scores between 8 and 10 points

Table 2.13 displays the vulnerability scores for each of the natural hazards present in Clackamas County. The county is highly vulnerable to earthquake events, and moderately vulnerable to volcanic, winter storm, wildfire, and flood events. There is a low vulnerability to landslide/debris flow and windstorm events in Clackamas County.

Table 2.13 Community Vulnerability Assessment Summary – Clackamas County

Threat Event/Hazard	Severity	Weight Factor	Subtotal	Vulnerability
Earthquake - Cascadia	10	5	50	High
Earthquake - Crustal	9	5	45	High
Volcanic Event	7	5	35	Medium
Winter Storm	6	5	30	Medium
Wildfire	5	5	25	Medium
Extreme Heat	4	5	20	Medium
Flood	4	5	20	Medium
Landslide/Debris Flow	3	5	15	Low
Windstorm	3	5	15	Low
Drought	2	5	10	Low

Source: Clackamas County HMAC, OEM Hazard Analysis, updated April 25, 2012

Risk Assessment

Clackamas County evaluated natural hazard risk using several tools, an updated vulnerability analysis and an up-to-date history of hazard events occurring in the past 100 year. The vulnerability analysis table (Table 2.12) outlines the amount of parcels, acres, facilities and infrastructure located in hazard prone areas; the table is explained in more detail in the above section. The list of hazard events described in detail the number of events, magnitude, and damage that has occurred in the county within the past 100 years. Both of these tools provided useful information to assist in the county's risk assessment update.

In order to develop a more comprehensive understanding of the natural hazard risks present in Clackamas County, the Hazard Mitigation Advisory Committee collaboratively worked through and discussed the hazard analysis to update the scoring system. In conjunction with this hazard analysis, the hazard evaluation tools described above provided support and background information to illustrate the level of impact each hazard has on the county.

At the HMAC's Risk Assessment Steering Committee Meeting on February 14, 2012, the committee developed severity impact scores to represent the potential impact of various natural hazards, through a relative risk questionnaire. The questionnaire, created by the Oregon Partnership for Disaster Resilience in collaboration with University of Oregon Emergency Management, intends to show how the likelihood of each hazard event, combined with the severity and magnitude of the impacts determines the overall relative risk Clackamas County residents face. This questionnaire focused on topics regarding general health and safety (by potential deaths and injuries), facilities (by physical damage and costs), and community (by expected economic, ecologic and social interruption). Each hazard received an overall severity impact score by averaging each hazard's specific responses to the ten question survey. Below, Table 2.14 illustrates that earthquake ranked number one for overall impact, with volcano following closely; extreme heat received the lowest impact score overall. A copy of the relative risk questionnaire can be found in Appendix B: Planning and Public Process.

The probability score (described in Table 2.5) and vulnerability score (described in Table 2.13) along with two other variables, event history and maximum threat, established a total threat score for each individual hazard. On April 25, 2012, a HMAC sub-committee made up of county department and special district staff updated the total threat scores. These scores are used by the HMAC to identify the level of priority for addressing the action items outlined in Section 4.

Below, Table 2.14 presents the overall risk assessment for Clackamas County including both the county's hazard analysis and relative risk. The hazards are listed in rank order from high to low, taking consideration for past historical events, vulnerability to populations, the maximum threat, and the probability, or likelihood of a particular hazard event occurring. The data shows that flood is the highest ranked hazard in the county, followed by winter storm and wildfire events. Landslide/debris flow, windstorm, Cascadia earthquakes, and drought events are ranked in the middle, with volcanic events, crustal earthquakes and extreme heat at the bottom with significantly lower relative risk scores than any of the other prevalent hazards in the county. The hazards are listed in rank order based on the relative risk scores from high to low, taking consideration for past historical events, vulnerability to populations, the maximum threat, and the probability, or likelihood of a particular hazard event occurring. Note that the total threat rankings may differ from the relative risk ranking. The top three hazards based on total threat are (1) Cascadia Subduction Earthquake, (2) Winter Storm, and (3) Crustal Earthquake.

Table 2.14: Risk Assessment Summary – Clackamas County

Hazard	Probability Total	Vulnerability Total	Total Threat Score	Severity Impact Score	Relative Probability	Relative Risk	Hazard Ranking
Flood	63	20	139	2.80	4.5	12.60	1
Winter Storm	56	30	160	2.80	4.0	11.20	2
Wildfire	49	25	130	3.00	3.5	10.50	3
Landslide/Debris Flow	63	15	112	2.20	4.5	9.90	4
Windstorm	42	15	121	2.95	3.0	8.85	5
Earthquake - Cascadia	14	50	164	4.50	1.0	4.50	6
Drought	28	10	60	2.00	2.0	4.00	7
Volcano	14	35	101	3.15	1.0	3.15	8
Earthquake - Crustal	7	45	146	4.50	0.5	2.25	9
Extreme Heat	14	20	90	1.50	1.0	1.50	10

Source: Clackamas County Hazard Mitigation Advisory Committee: Risk Assessment Steering Committee Meeting, February 14, 2012 and OEM Hazard Analysis Update Meeting, April 25, 2012

The table shows that, Cascadia and Crustal earthquake events rank the highest in terms of overall impact. However, note that because the relative probability of both earthquake events is lower than most of the other hazards, Cascadia and Crustal earthquakes rank #6 and #9, respectively, in terms of the overall hazard risk. This is because this risk assessment summary takes into consideration several factors that include: the total threat score, the overall impact of a hazard event, and the relative risk associated with that hazard. With low relative probabilities for both earthquake events, the relative risk scores drop as well.

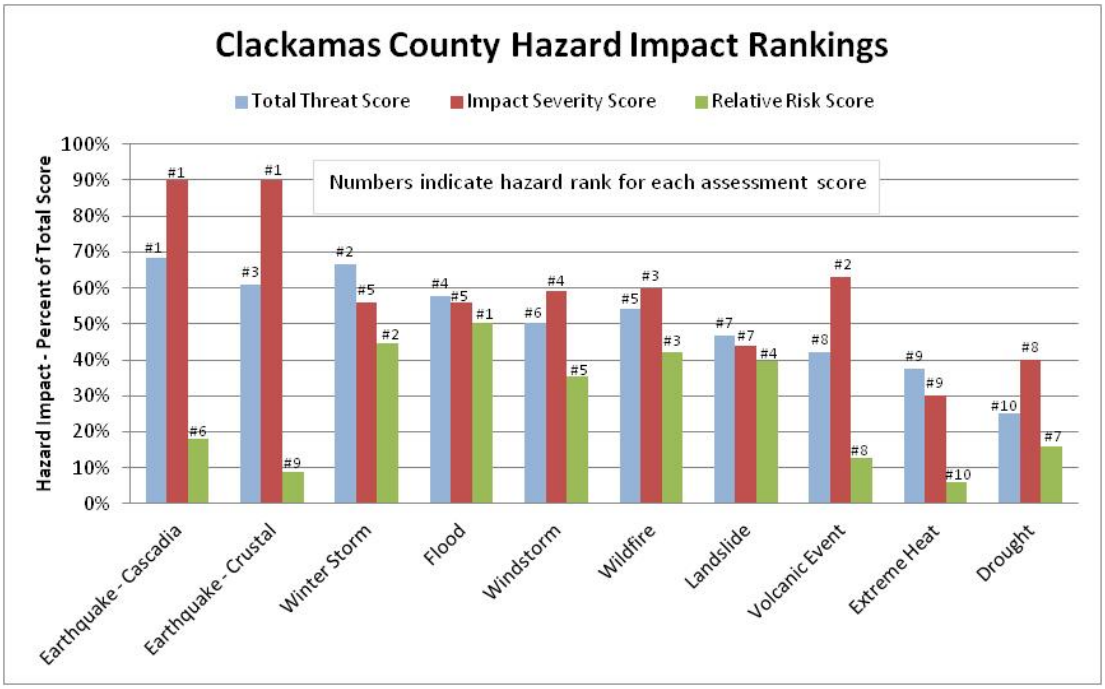
Volcanic event is ranked second when it comes to impact severity with a low probability of volcanic events occurring. Since there would be moderate impacts to all of Clackamas

County if it were to happen, the overall impact is high, but the probability of an event occurring lowers the overall hazard ranking.

Lastly, there is a high probability of a flood event occurring, and if it did happen, it would most likely to be an isolated event; therefore the overall impact is low. However, a generally high total threat score combined with the relative risk and overall impact makes flood events the #1 relative risk hazard, making it the most significant hazard threat to the county.

Figure 2.2 below provides additional analysis for the total threat, impact severity and relative risk scores from Table 2.8. The scores are presented as a percentage of the overall scoring potential for each hazard, and then assigned a rank based on their placement among the other hazard scores. In other words, the figure helps illustrate how each component of the hazard's overall relative risk is weighted.

Figure 2.2: Hazard Impact Rankings – Clackamas County



Source: Clackamas County Hazard Mitigation Advisory Committee: Risk Assessment Steering Committee Meeting, February 14, 2012 and OEM Hazard Analysis Update Meeting, April 25, 2012

The figure shows the relationship between each of the three scoring factors, and how each hazard varies in terms of their total threat, impact severity, and the overall relative risk. For example, crustal earthquake events have a very low relative risk score, yet they rank #1 in terms of impact severity. Conversely, flood events are ranked #1 in terms of relative risk, yet it is ranked #4 and #5 in terms of total threat and impact severity, respectively.

The hazard impact rankings isolate and target specific hazards that have a higher risk of impacting the county allowing the county's HMAC to easily identify potential areas of focus for future mitigation projects.

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