

*Lewis County*

**Hazard Identification  
And  
Vulnerability Analysis  
  
(HIVA)**

**~ 2003 ~**

**Revised August 31, 2018**

**Prepared by**

**Lewis County  
Division of Emergency Management**



## PREFACE

The Lewis County Hazard Identification and Vulnerability Assessment (HIVA) is an identification and assessment process of the local threats. This HIVA identifies the natural and technological hazards in Lewis County and assesses the vulnerabilities to such hazards. Hazards have the potential of becoming disasters or emergencies that can adversely affect the people, property, and environment of Lewis County. The assessment is the initial step in the emergency management process that leads to mitigation, preparedness, response, and recovery.

Hazard assessment helps government and emergency management rate the risks, determine the vulnerability and predict the adverse impact of disasters and emergencies. This assessment is a critical component of effective resource organization and development of comprehensive emergency management plans.

This HIVA contains information from state, local and public sources. The Lewis County Division of Emergency Management (DEM), Department of Emergency Services, publishes the document.

Of all the natural hazards in Lewis County, floods are the most common and cause the most property damage. Lewis County is affected on an annual basis by river, creek, and surface water events. Attachment B and C in this document relate the response and preliminary damages to the floods of record for both East and West Lewis County.

Recommendations on how this document can be improved should be addressed to DEM at:

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*Lewis County*  
*Hazard Identification and Vulnerability Analysis*

**HIVA**

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## INTRODUCTION

Disasters are difficult problems for governments to address. When people and property are not present, hazards are merely natural processes that modify the landscape as they have throughout the earth's history. It is not until humans encroach into vulnerable areas that damage to homes, infrastructure, and threat to human life, creates the potential for "disaster."

Disasters are inevitably complex events characterized by high levels of emotion and uncertainty. They typically involve low probabilities and severe consequences, making them difficult to prepare for and analyze. Fortunately, the most serious events are the least likely to happen, but this also means that data about their causes and effects are often scarce or unreliable. Because of their potential to affect large numbers of people, the amount of time and money expended on the preparation for such events is often a source of conflict.

A variety of natural and technological hazards continue to threaten the life and property of Lewis County residents. Some of the events produced by these hazards are episodic, as is the case with severe earthquakes; others such as river flooding are chronic problems for our county. The impacts of these hazards are becoming increasingly devastating, both in human terms and with regard to property damage. As the county continues to grow, development alters the land's ability to recover from disastrous natural events. In many cases, the conditions that cause today's natural catastrophes have existed for hundreds, thousands, or even tens of thousands of years.

Hazard identification is the systematic use of all available information to determine what types of disasters may affect a jurisdiction, how often these events can occur, and the potential magnitude of their consequences. Vulnerability analysis refers to the process used to determine the impact these events and their collateral effects (for example, landslides after an earthquake) may have on the people, environment, economy and lands of a region.

Communities own their own hazard risks, and a community-centered approach is essential in the management of those risks and the development of local, integrated plans and programs. The processes of **hazard identification** and **vulnerability analysis** serve as a foundation for development of strategies to deal with particular emergencies, for allocating resources, and for helping set priorities and standards in ensuring the safety of the public.

The hazards identified herein are not the only potential threats to Lewis County. Conditions may periodically change, or new information may become available that could require modification of the HIVA. Unique hazards may exist in certain specific locales which should be considered in the development of local plans, but which need not be included at the county level.

The hazard phenomena that are most likely to affect Lewis County can be divided into three broad categories based on their origin:

- 1. Natural**
- 2. Technological**
- 3. Social**

This HIVA includes natural and technological hazards. Social hazards will be added in a later addition. It contains an introduction that includes a purpose, scope, geography characteristics, economics and demographic descriptions of Lewis County, followed by a listing of potential natural and technological hazards. The following sections are included for each hazard:

1. **Definition of Hazard:** Provides a general definition of the hazard
2. **Hazard Identification:** Identifies the hazard as it pertains to areas throughout Lewis County
3. **History:** Provides history of the hazard occurrences in Lewis County or other areas. (Note: consideration is given to hazards not only within a jurisdictional boundary, but which can cause damage or population movement beyond jurisdictional lines)
4. **Vulnerability:** Identifies the probable vulnerability of a hazard to Lewis County
5. **Effects:** Describes the primary results that could be expected from the particular disaster
6. **Mitigation:** Describes some of the mitigation efforts that have been and can be taken in the future to mitigate the affects of the hazard

The HIVA is not a detailed study, but rather a general overview of hazards that can cause emergencies and disasters. This document will be periodically reviewed for content and revised as necessary. It will be reviewed following receipt of each revision to the State of Washington Hazard Identification and Vulnerability Analysis.

For quick reference to hazards and their potentials, the following charts are provided:

- 1. Risk Calendar:** Identifies the time of year (seasons/months) that the community is most at risk for a particular type of hazard (next page).
- 2. Hazard Risk Rating Chart:** Identifies the risk of a particular hazard based on probability of/and vulnerability to the hazard (next page).

Lewis County  
Hazard Identification and Vulnerability Analysis

<b>HAZARD RISK CALENDAR</b>												
<b>Natural Hazards</b>	January	February	March	April	May	June	July	August	September	October	November	December
Avalanche	←	→									←	→
Drought					←					→		
Earthquakes	←											→
Fires, Urban/Wildland interface					←					→		
Flood	←	→								←	→	
Severe Storms	←	→								←	→	
Mass Land Movement	←	→									←	→
Volcano	←											→

<b>*HAZARD RISK RATING (Probability, Vulnerability and Risk)</b>			
<b>Natural Hazards:</b>	<b>Probability of Occurrence</b>	<b>Vulnerability</b>	<b>Risk Rating</b>
<b>Avalanche</b>	Low	Low	Low
<b>Drought</b>	Medium	Low	Medium
<b>Earthquakes</b>	Low	High	High
<b>Fire- Urban/Wildland Interface</b>	Medium	Low	Medium
<b>Flood</b>	High	High	High
<b>Severe Storms</b>	High	Medium	High
<b>Mass Land Movement</b>	Medium	Low	Medium
<b>Volcano</b>	Low	High	Medium
<b>Technological Hazards:</b>			
<b>Civil Disturbance</b>	Low	Low	Low
<b>Dam and Reservoir Failure</b>	Low	High	Medium
<b>Epidemic</b>	Low	High	Medium
<b>Pipeline</b>	High	Medium	Medium
<b>Hazardous Materials</b>	High	High	High
<b>Terrorism</b>	Low	Low	Low
<b>Transportation</b>	High	Medium	Medium
<i>*See Attachment A: Hazard Risk Rating Criteria, page 93-94.</i>			

## A. PURPOSE

The purpose of this **Hazard Identification and Vulnerability Analysis (HIVA)** is to identify significant natural and technological hazards that have the potential to affect large areas or populations within Lewis County. It is intended to serve as a basis for county emergency management plans and programs and to assist municipal jurisdictions, school districts and private businesses in the development of similar documents focused on local hazards.

The HIVA is the foundation of effective emergency management and identifies the hazards that organizations must mitigate, prepare, respond, and recover from in order to minimize the effects of disasters and emergencies.

In addition to identifying the major hazards in Lewis County, the HIVA assesses the vulnerability of people, property and the environment to those hazards. The goal of the vulnerability assessment is to:

1. Develop methodologies to allow emergency managers and elected officials to estimate social-economic impacts of disaster
2. Form a basis for the advancement of mitigation, emergency preparedness and risk management strategies
3. Direct mitigation efforts to address the effects of disasters

## B. SCOPE

The scope of this document covers the identification of the hazards that Lewis County is susceptible to and describes them in terms of definition, identification, history, vulnerability, effects and mitigation.

The HIVA is applicable to all areas and political subdivisions within Lewis County. Chapter 118-30 Washington Administrative Code requires that emergency management plans be based on a written assessment and listing of the hazards to which the political subdivision is vulnerable. This document fulfills that requirement and is the basis for the Lewis County Comprehensive Emergency Management Plan (CEMP).

## COUNTY PROFILE

### A. HISTORY

The first economic activity in what is now Lewis County was trade. The Cowlitz and Chehalis Indians had developed an extensive trading system between the many sub-tribes that they consisted of, and with other peoples. Both tribes were river-dependent. They relied upon the rivers for the mainstay of their diet, salmon. Although the number of Native Americans in Lewis County is hard to determine, one report indicates that a gathering of the Upper Chehalis Tribe at Ford's Prairie in 1855 was 5,000 strong. Twenty years later disease had decimated the once thriving river communities. By 1864, the majority of the Native American population had moved to the Chehalis Reservation in adjacent Grays Harbor County.

The first European settlers in Lewis County were fur trappers. With outposts at Vancouver and Nisqually, fur trappers scoured much of Lewis County in the early-1800's searching for salable pelts, and were firmly entrenched when Americans started arriving in the 1840's to farm and settle the area. One of the first recorded white settlers in the county was Simon Plomondon in 1820.

In 1845 the Oregon territorial government created Lewis County, naming it after Meriwether Lewis, an explorer from the Lewis and Clark expedition. What they created resembles the present-day county only in name: the original borders extended from the Columbia River to the southern boundary of then Russian Alaska; from the Pacific Ocean to the Cascades. After a border dispute with the British, the borders were redrawn in 1851, and again in 1861, to those in effect today. Meanwhile, the Washington Territory was established and Lewis County became a part of Washington rather than the Oregon Territory.

Among the earliest settlers were Schuyler and Eliza Saunders (1851). They founded the town of Saundersville. Eliza Saunders later platted the land that became the city of Chehalis. Another early settler was George Washington, who platted the land that became Centerville, later renamed Centralia.

These early settlers were predominantly fishermen and subsistence farmers. Over time, logging and agriculture became the dominant industries in Lewis County. Mining also assumed some importance with the discovery of fairly high-grade coal deposits.

Until the railroad arrived in the Twin Cities (Centralia and Chehalis) in 1872, the primary means of transportation was by riverboat. The completion of the railroad spurred immigration and opened the markets of the East to the logging industry of Lewis County.

From the late 1800's until World War II, Lewis County followed a boom-bust cycle typical of an economy dependent on resource based, extractive industries. World War II revived the timber and agricultural industries.

Presently, Lewis County's economy can best be viewed as one in transition. While much of the county is still dedicated to agriculture, the significance of the timber industry has been declining. On the other hand, there have been increases in light industry and retail trade. The county is making the transition between a largely resource based economy to one with a greater emphasis on light manufacturing and commerce.

## **B. GEOGRAPHY CHARACTERISTICS**

Lewis County, formed in 1845, is the oldest county in the State of Washington. It once included all of western Washington and part of what is today British Columbia, Canada. The County has 2,449 square miles of land area and encompasses a portion of the Puget Sound/Willamette Depression, bordered on the east by the Cascade Range and on the west by the Coast Range. The County occupies that portion of the depression bounded on the south by Skamania and Cowlitz Counties; the west by Pacific County; the northwest by Gray's Harbor County; the north by Thurston and Pierce Counties; and the east by Yakima County.

The County is 95 miles wide from its western border in the Willapa hills to its eastern border at the Cascade Mountain Range crest. From north to south it is 25 miles long.

The county is mostly forestlands; the eastern half is mountainous with the eastern border being the summit of the Cascade Mountain Range. Portions of the central and eastern areas of the county are also quite rugged and mountainous, with elevations up to 3,000 feet.

Major rivers in Lewis County are:

- 1. The Cowlitz River** (with headwaters at the Cowlitz glacier on Mt. Rainier) traverses the County from the northeast corner to the southwest, exiting just south of the city of Vader into Cowlitz County. The Cowlitz River extends from the Cascade Crest westward into the southwestern portion of Lewis County. The river flows west / southwest prior to turning south near the town of Vader, where it flows toward the Columbia River. The Cowlitz River basin encompasses a large part of the eastern and southern portions of Lewis County. Three dams are located on the Cowlitz River in central Lewis County: Mossyrock Dam, which forms Riffe Lake, and Mayfield Dam, located downstream of Mossyrock Dam and the Cowlitz Dam. The dams (Cowlitz provides only limited flood control) provide flood control for the lower Cowlitz drainage; therefore, flood-prone areas within the Cowlitz basin tend to occur in the upper reaches near the towns of Randle and Packwood.

2. **The Chehalis River** (with headwaters in western Lewis County) winds into the Chehalis-Centralia areas and exits the county just north of the Galvin area into Thurston County.
3. **The Skookumchuck River** flows from the north through Centralia where it joins the Chehalis River.
4. **The Nisqually River** (with headwaters located in the northeast portion of Lewis County. The Nisqually River originates from the Nisqually Glacier on Mount Rainier and flows westerly to form a section of the north Lewis County border before turning northeast into Pierce County. The upper Nisqually River is very active. Its steep slope, high water velocities, and alluvial river valley provide conditions for frequent bank erosion and channel migration.

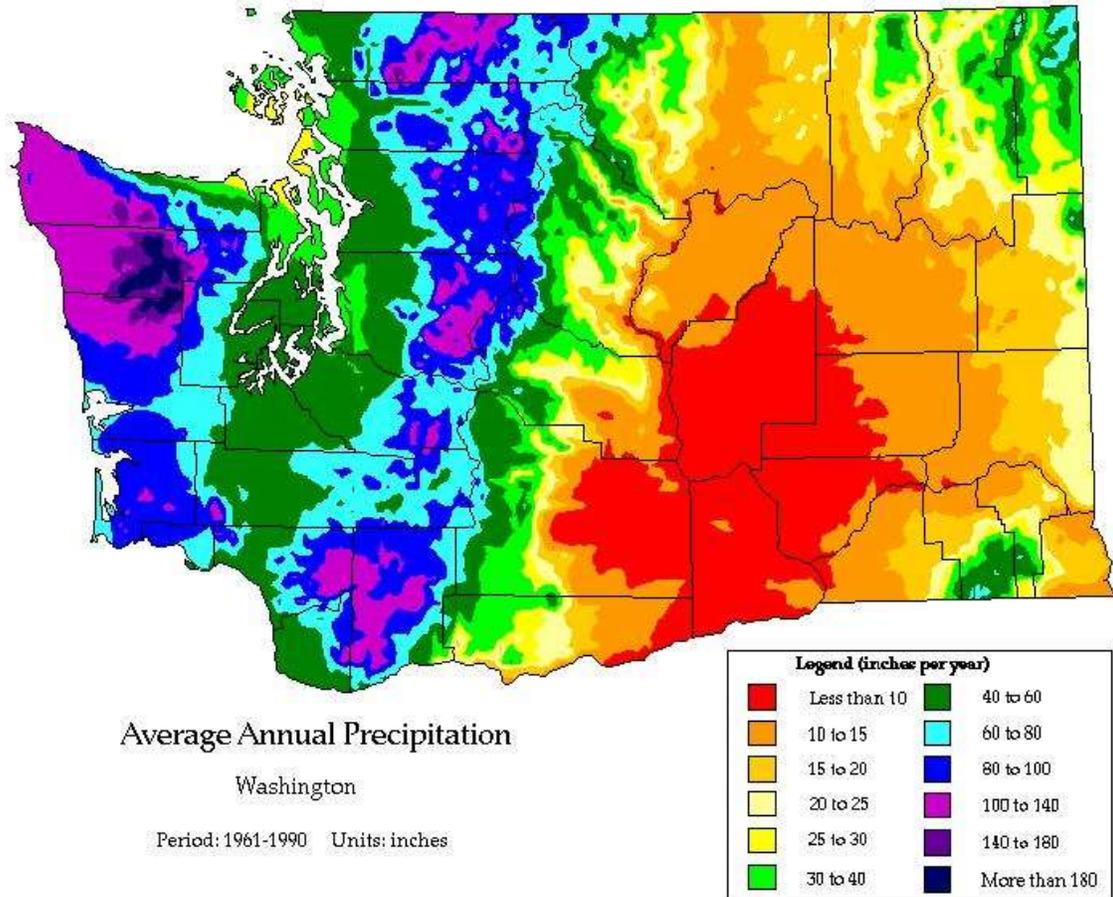
Other tributary rivers in the county are the Newaukum, Cispus, and Tilton. There are also several small creeks, one of which is China Creek that flows through the city of Centralia. Additional tributary creeks include Salzer, Dillenbaugh, Coffee, Stillman, Salmon, and Elkhorn.

## C. CLIMATE

Lewis County has a relatively mild marine climate characterized by warm, dry summers and cool, wet winters. Moist air masses reaching the county originate over the Pacific Ocean. This maritime air has a moderating influence on both winter and summer. Temperatures are moderate, averaging 50-55 degrees for the year. Summer average is in the 70's and winter average is in the 40's. In 2010, the annual rainfall average established by the National Weather Service is 47.04 inches per year.

The prevailing winds are from the south or southwest in fall and winter, shifting to the north or northwest in late spring and summer.

During the winter, rainfall is generally of a light or moderate intensity, though intense rain events are common enough to make flooding the most frequent cause of local disasters. Nearly half the annual rainfall occurs between November and February. July has the least mean annual precipitation. Most of the winter precipitation falls as rain below about 1,500 feet; as snow above about 2,500 feet; and as a mixture in between.



## D. DEMOGRAPHICS

### Population

Since 1970, Lewis County's population has shown relatively large fluctuations in its growth. The decade of the 1970's averaged an annual growth of 2.1 percent. Through the 1980's the county only averaged 0.6 percent annual growth. From 1990 through 1996, growth averaged 2.0 percent annually.

The decade of the 1980's gave Lewis County a net gain of only 55 people due to migration, though the general population grew by 3,333. The county would have had a loss in net migration were it not for the addition of 244 immigrants age 65 and older.

In 1996, the county had a population of 25,662 living in incorporated areas and 41,038 living in unincorporated areas. From 1990 to 1996 the incorporated population grew 9 percent; the unincorporated population grew 15 percent. The overall population grew 12 percent.

From the 1990 census, Lewis County’s population increased 9,242. From 2000 to 2010, it grew another 6,855. From 2010 to 2017, the Lewis County population increased 8,840.

The following are the April 1, 2017 U. S. Census Bureau population figures for Lewis County:

<u>Incorporated Cities</u>	<u>Population</u>
Centralia	16,940
Chehalis	7,500
Morton	1,120
Mossyrock	760
Napavine	1,900
Pe Ell	645
Toledo	720
Vader	610
Winlock	1,335
Totals: Incorporated areas - 31,530	
Unincorporated areas - 45,910	
<b>Total Lewis County Population 77,440</b>	

In December, 2017, Lewis County had the largest proportion of people 70 years of age or older in the State at 13.3%. There is an additional 13.5% of people in their 60s, which totals 26.8% of the Lewis County population is over the age of 60. This compares to a Washington State average of 11.1 % in their 60s and 9.1% in their 70s (total of 20.2% over 60).

**Ethnicity**

Racially, Lewis County is one of the least diverse counties in the state. Washington State is 87 percent white; Lewis County is 97 percent white. However, according to Census Bureau Statistics the non-white population increased at a 28 percent rate in the 1980’s, while the white population increase by only 7 percent.

Between 2000 and 2010, Washington’s population grew by 14.1%, the Hispanic population increased 71.2%, the largest of any minority group. Hispanics represented 11.2% of the population in 2010, up from 7.5 % in 2000. The white population was the second largest numeric increase of any race group; however, the 2010 72.7% was a decline from the 2000 figure of 79.4%.

Year	*White	Black	Hispanic
2000	68,600	283	3,684
2010	70,730	434	6,527
2017	68,941	456	8,043

\*This category includes all white and others not black or Hispanic

## **Age**

As the population of the county changes, so too does the age structure of the population. The age structure has significant bearing on the future population of the county. Most public services and facilities are designed for a specific age group. For this reason, it is important to examine changes in the age structure as they relate to future needs. Between the 1980 and 1990, the county experienced a decrease in persons in their late teens and twenties. During the 1980's, the overall population increase was primarily due to a net increase in persons between the ages of 35 and 50 and persons age 65 and over.

Between 2000 and 2010, Lewis County's median age increased from 38 years to 41.5 years. By 2016, it grew to 43.1 years. This trend is expected to continue.

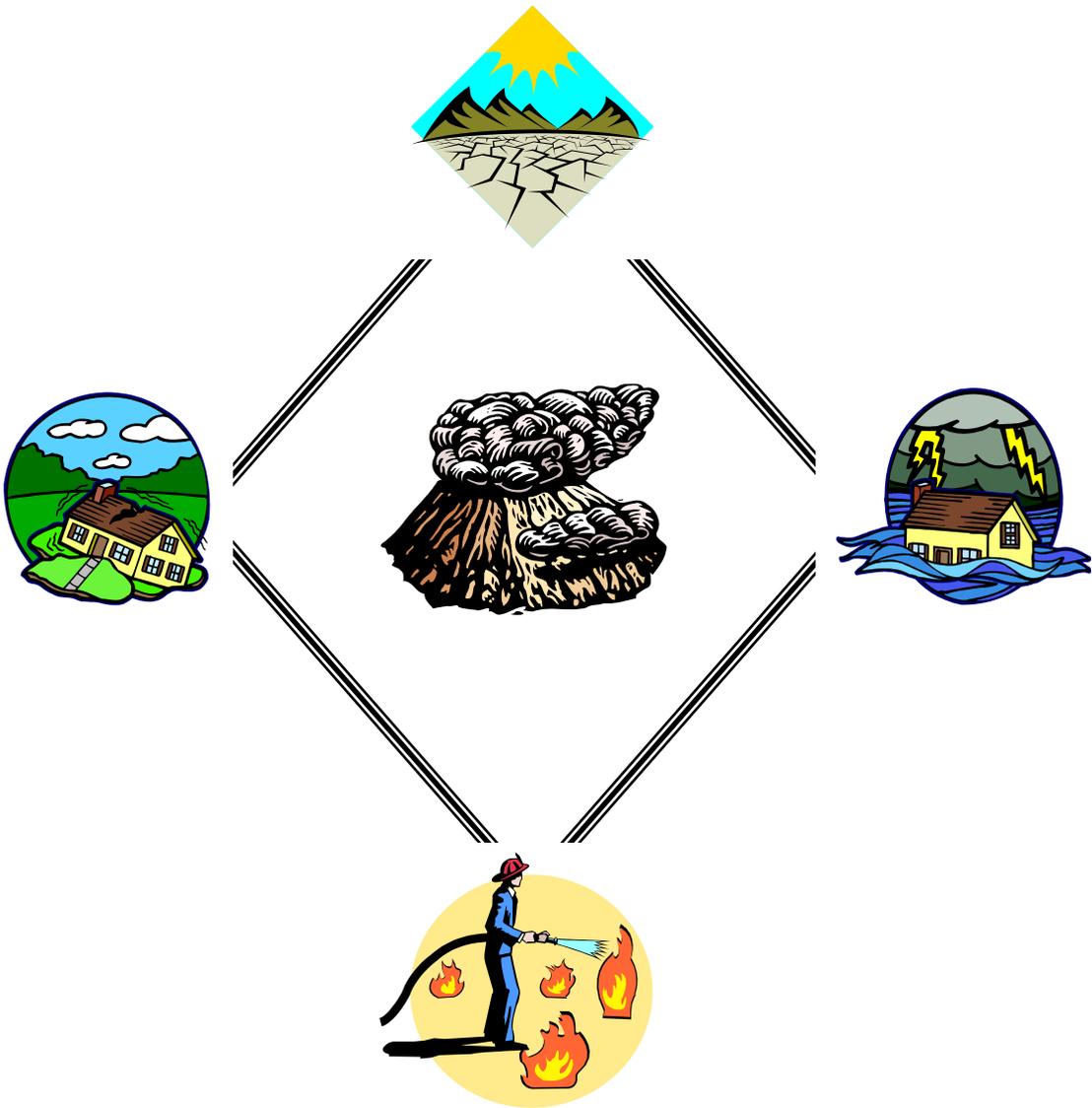
## **Household Size**

Between 1980 and 1990, Lewis County experienced a decrease in average household size decreasing approximately 2 percent from 2.66 to 2.61 persons per household. This reflected the national trend of people living longer, parents having fewer children, and a rise in single-parent households.

In 1990 approximately 23 percent of the Lewis County population lived alone. As the county's population ages, single elderly households have become even more common.

In the 2010 census, the Lewis County household size for the Hispanic population was 3.97 compared to the white population of 2.46 persons. The Lewis County population in the 2010 census was 75,455; the 2017 population was estimated at 77,440. In 2017, Washington State's population grew by 1.76%, with Lewis County experiencing a .72% increase over the previous year.

# Natural Hazards



# AVALANCHE

## **DEFINITION:**

An avalanche is a mass of sliding snow, ice, earth, and rock that grows and collects additional material as it descends.

The following are the types of avalanche most likely encountered in the Cascade Range:

### **Slab Avalanches**

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

### **Climax Avalanches**

Climax avalanches involve multiple layers of snow.

### **Loose Snow Avalanches**

Loose snow avalanches occur when loose, dry snow becomes unstable and begins to slide. Loose snow avalanches start from a point and gather more snow as they descend, fanning out to fill the topography.

### **Powder Snow Avalanches**

Powder snow avalanches occur when sliding snow has been pulverized into powder. They can be caused by either a rapid motion of low-density snow or by a vigorous movement over rugged terrain.

### **Surface Avalanches**

Surface avalanches occur only in the uppermost layers of snow.

### **Wet Snow Avalanche (also wet loose avalanche; wet slab avalanche)**

Wet snow avalanche refers to a type of avalanches in wet snow.

**HAZARD IDENTIFICATION:**

The Cascade Range, oriented perpendicular to the prevailing westerly flow of Pacific marine air into the Northwest, receives extensive precipitation as both rain and snow. The winter snow pack of the Cascades is the deepest recorded in the continental United States.

Areas in Lewis County that have potential for avalanches include White Pass and other slopes of the Cascade Mountain Range. Lewis County's avalanche season begins in November and continues until the last remnants of snow have melted, normally in the early summer. The low elevations of the majority of the county's mountainous terrain and dense forestation preclude a high probability of avalanches in most areas.

**HISTORY:**

In Eastern Lewis County, avalanches on the White Pass Highway have resulted in road closures, but no injuries. However, similar terrain and mountain pass avalanches in the Washington Cascade Mountain Range resulted in the following statistics:

<b>Washington Cascade Mountain Range Avalanche History</b>	
1910 Wellington, Stevens Pass: 96 dead, 2 trains derailed	1971 Yodelin: 4 dead, several buried
1917 Monte Cristo: 2 dead	1971 Snoqualmie Pass: 1 dead
1939 Mt. Baker: 6 dead	1974 Source Lake: 2 dead
1953 Source Lake: 1 dead	1981 Mt. Rainier: 19 dead
1958 Silver Creek: 4 buried	1988 Mt. Rainier: 3 dead
1962 Granite Mountain: 2 dead	1992 Mt. Rainier: 2 dead
1962 Stevens Pass: 2 buried	1996 Mount Index: 3 dead
1966 Mt. Baker: 1 dead	1998 Mt. Rainier: 1 dead, 7 injured
1966 Snoqualmie Pass: 1 buried	2004 Mt. Rainier: 2 climbers dead

From 1985 to March 14, 2012, avalanches have killed 56 people in Washington State. The Northwest Avalanche Center reports that Washington State has averaged 2.6 avalanche deaths each year over the past 30 years.

**VULNERABILITY:**

The Cascade Mountain Range traverses the eastern-most portion of Lewis County, with a large recreational area located at the White Pass Summit (SR-12). Frequently during winter and spring, there is avalanche danger to those recreationalists that venture outside of the designated areas.

More and more people work, build, and engage in recreation in the high mountain avalanche prone areas of the Cascade Mountain Range. This increased brings added exposure to the access routes and people entering the area. The risk to life and property is greatest at those times of the year when rapid warming follows heavy, wet snowfall.

Mountain passes and highways in Washington State that WSDOT has identified as being at risk to avalanche problems or have the potential for problems in the worst conditions included Lewis County and White Pass US 12.

In most winters, snow slides can close the White Pass highway between western and eastern Washington and result in a negative economic impact on Lewis County's transportation infrastructure. Although costs associated with removing avalanches from SR-12 are borne by the Washington State Department of Transportation, the county's road network and substantial commercial activity are also dependent on this main highway. There is also a financial impact to Lewis County's economy. The timber industry, power companies, recreational resorts, homeowners and various recreational groups depend upon relatively unlimited access to these Cascade Mountain Range passes.

### **EFFECTS:**

The effects of avalanches include, but are not limited to:

- Injury or loss of life
- Damage to building, roads, vehicles, and rail cars
- Damage and disruption to water, fuel supplies, and forests and logging equipment

Incurred damage may result in the temporary closure or loss of service, which may cause economic damage due to loss of goods or business.

### **MITIGATION:**

Mitigation efforts include, but are not limited to:

- Closing areas with high avalanche hazard
- Training the public in avalanche awareness
- Preventing construction in avalanche prone areas
- Development of snow sheds and rail lines crossing avalanche slopes
- Anchoring the snow to the slopes in the most prevalent avalanche zones
- Berming in high impact areas

Two measures that have been used to reduce avalanche threat are:

1. Monitoring timber harvest practices in slide prone areas
2. Encouraging reforestation near highways, buildings, and power lines

The Northwest Avalanche Center (NWAC) provides winter mountain weather forecasts, avalanche hazard warnings, avalanche safety education and research on the Cascade Mountain Range. The U.S. Forest Service, U.S. National Park Service, NOAA's National Weather Service and Washington State's Department of Transportation currently have programs to monitor avalanche zones and forecast avalanche danger.

Even during times of high risk, it is very difficult to keep the public out of avalanche-prone areas. A coordinated effort between state, county and local jurisdictions is needed to provide winter snow pack and avalanche risk data to the public.

<b>UNITED STATES AVALANCHE DANGER DESCRIPTORS</b>			
<b>Danger Level</b>	<b>Avalanche Probability and Avalanche Trigger</b>	<b>Degree and Distribution of Avalanche Danger</b>	<b>Recommended Action in the Back Country</b>
<b>Low</b>	Natural avalanches very unlikely. Human triggered avalanches <u>unlikely</u> .	Generally stable snow; isolated areas of instability.	Travel is generally safe. Normal caution is advised.
<b>Moderate</b>	Natural avalanches unlikely. Human triggered avalanches <u>possible</u> .	Unstable slabs <u>possible</u> on steep terrain.	Use caution in steeper terrain on certain aspects.
<b>Considerable</b>	Natural avalanches possible. Human triggered avalanches <u>probable</u> .	Unstable slabs <u>probable</u> on steep terrain.	Be increasingly cautious in steeper terrain.
<b>High</b>	Natural and human triggered avalanches <u>likely</u> .	Unstable slabs <u>likely</u> on a variety of aspects and slope angles.	Travel in avalanche terrain is not recommended. Safest travel on windward ridges of lower angle slopes without steeper terrain above.
<b>Extreme</b>	Widespread natural or human triggered avalanches <u>certain</u> .	Extremely unstable slabs <u>certain</u> on most aspects and slope angles. Large destructive avalanches possible.	Travel in avalanche terrain should be avoided and travel confined to low angle terrain well away from avalanche path run-outs.

### **REFERENCES:**

WAC 296-59-100 describes ski area avalanche control methods legally required

The NWAC Avalanche hotline: (206) 526-6677

## DROUGHT

### **DEFINITION:**

Drought is a condition of climatic dryness that is severe enough to reduce soil moisture, water and snow levels below the minimum necessary for sustaining plant, animal, and economic systems.

Drought is a normal, recurrent feature of climate. It is not a rare and random event. It occurs in virtually all the world's climatic zones. However, the drought characteristics vary significantly from one region to another. Drought is a temporary aberration (particularly in the Pacific Northwest) and differs from "aridity" since the latter is restricted to low rainfall regions and is a permanent feature of climate.

The statutory criteria for a drought includes the following:

- Water supply below 75 percent of normal
- Shortage expected to create undue hardship for some water users

There are four different ways that drought can be defined:

### **Meteorological**

Meteorological is a measure of the precipitation departure from normal. Due to climate differences, what is considered a drought in one location may not be a drought in another.

### **Agricultural**

Agricultural refers to a situation when the amount of moisture in the soil no longer meets the needs of a particular crop.

### **Hydrological**

Hydrological occurs when surface and subsurface water supplies are below normal.

### **Socioeconomic**

Socioeconomic refers to the situation that occurs when physical water shortage begins to impact people's jobs, incomes, recreational capabilities, and other such factors.

<b>Drought Severity Classification</b>			
<i>Category</i>	<i>Description</i>	<i>% of Normal Precipitation.</i>	<i>Possible Impacts</i>
<b>D0</b>	Abnormally Dry	<75% for 3 months	Short-term dryness slowing planting, growth of crops or pastures; fire risk above average.
<b>D1</b>	Moderate Drought	<70% for 3 months	Damage to crops, pastures; fire risk high; streams, reservoirs, or wells low, some water shortages developing or imminent.
<b>D2</b>	Severe Drought	<65% for 6 months	Crop or pasture losses likely; fire risk very high; water shortages common
<b>D3</b>	Extreme Drought	<60% for 6 months	Major crop/pasture losses; extreme fire danger; widespread water shortages.
<b>D4</b>	Exceptional Drought	<65% for 12 months	Exceptional and widespread crop/pasture losses; exceptional fire risk; shortages of water in reservoirs, streams, and wells, creating water emergencies.

**HAZARD IDENTIFICATION:**

In spite of the marine climate of Western Washington, Lewis County has experienced drought periodically for at least the last 100 years. The entire county has the potential for future droughts. Washington State usually experiences drought during a regional climate event, i.e. as part of a much larger region affected by dry conditions.

**Ground Water and Wells**

Five percent of the water on the earth is drinkable. Ninety-five percent of that is in the ground. In Washington much of the drinking water comes from the ground. In total, about 16,000 ground water systems in Washington get water from this source. The effects of drought on ground water supplies are usually not felt as quickly as they are for surface water supplies. However, reduced precipitation during a drought means that ground water supplies are not being replenished at a normal rate. This can lead to a reduction in ground water levels and problems such as reduced pumping capacity or worse yet – wells going dry. Shallow wells are more vulnerable than deep wells. In Lewis County, the total population serviced by a public water supply is 37,172 (54%); private wells service a population of 31,828 (46%).

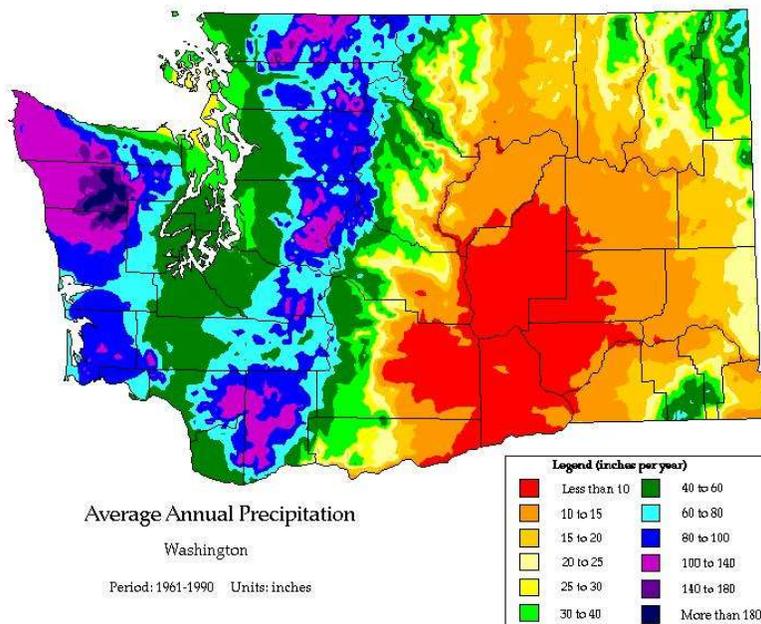
Most water utilities are aware of this problem and continuously monitor ground water levels, implementing water conservation measures as necessary. For private homeowner wells, the Washington State Department of Ecology, Division of Drinking Water Quality, advises water conservation practices. The Washington State Department of Ecology also can provide information on deepening or re-drilling wells if this action becomes necessary.

## Ground Water and Streams

Reduction of ground water also affects streams. Streams are not fed entirely by runoff from precipitation and melting of the snow pack. Much of the flow in streams comes from ground water, especially in the summer when there is less precipitation.

Reduced ground water levels mean that less water will enter streams. Combined with a reduced snow pack, the outlook for stream flows is not good. Some users of ground water will be affected by low stream flows – meaning they might legally have to cease withdrawing water.

### Average Annual Precipitation for Washington 1961-1990 (National Weather Service)



### HISTORY:

Some of the major droughts that have affected Lewis County are briefly described below (from the History of Drought in Washington, Dec., 1977, publication of the Governor's Ad Hoc Executive Water Emergency Committee):

- **1922** (June – August) – Crop production was below average. There were a number of forest fires. The first Governor's proclamation prohibiting campfires in the forests was issued.
- **1934** (April 1934 – March) The longest drought in the region's history. The Legislature declared fire season to be from April 15 to October 15.

- **1938** (May – September) It was the driest growing season ever recorded with less than half the normal amount of precipitation. The fire season was the most hazardous since 1922.
- **1952** – Extremely dry year with precipitation below normal in every month except June.
- **1964** (January – May) Dry with considerable wind and blowing dust.
- **1967** (June – August) State and National forests were closed, prohibiting logging, mining and recreation.
- **1976-77** (October 1976 – September 1977) – Stream flows averaged between 30 to 70 percent of normal.
- **2000-01** (October - August) The 2000-01 season was one of the five driest in the past 100 years. Rainfall was approximately 30% below normal. Federal agencies provided more than \$10.1 million in disaster aid to growers.
- **2005** (March – December) Water supply forecast was 66 percent of normal with a project of \$300 million drought impact. Governor Christine Gregorie request an agricultural disaster designation for crop damage in 15 counties. Unanticipated late spring precipitation lessened the impacts and reservoirs filled to 95 of capacity in most areas.
- **2015** (June-October) The entire Pacific Northwest experienced varying degrees of water shortages in 2015. Municipal agencies and private wells experienced a declining water table as the summer months proceeded. Executives received a grant to monitor the water tables monthly as some private homes experienced dry wells. In June, the Governor proclaimed a state of emergency and small business loans were made available to small farmers. By the end of July, 93 farmers with “junior” water rights were ordered to stop taking water from the local rivers due to fish run concerns.

The two worst droughts in Washington’s history (1977 and 2001) resulted in thousands of job losses to the power and agricultural industries as well as job losses in the mining, recreation, and fishing industries. In addition, the estimated losses to the state’s economy due to these two drought events were close to \$500 million.

During the 2005 drought, the State Department of Agriculture made a preliminary estimate of the potential impact on Washington’s agriculture industry. Assuming a worst-case scenario of below average precipitation throughout the growing season, WSDA anticipated that crop losses would be between \$195 and \$299 million, or 5 to 8% of the Washington harvest.

**VULNERABILITY:**

Unlike most natural hazards, drought cannot be viewed as purely a physical phenomenon or natural event. Its impacts on a region's weather, agriculture, hydrology, and society result from the interplay between a natural event (less precipitation than expected resulting from natural climatic variability) and the demand people and technology place on a region's water supply.

Human beings often exacerbate (or may ameliorate) the impact of drought. Recent droughts in both developing and developed countries illustrate the impacts on citizens and the environment.

In order to define Lewis County's vulnerability to a severe drought, it is important to examine the effects of prolonged dry weather on the four separate impact areas of droughts.

- 1. Meteorological Impact** – Drought's impact is seen first in relation to the day-to-day weather of a region, usually in the degree of dryness (in comparison to some "normal" or average amount of rainfall), and in duration of the dry period.

Meteorological drought is region-specific, since the atmospheric conditions that result in deficiencies of precipitation are highly variable from one part of the country to another.

Probably the most significant vulnerability in Lewis County from a prolonged period of dry weather is the elevation of the wild land fire threat in the Cascade foothills and western slopes. Warm, dry weather often exacerbates late afternoon thunderstorm-induced lightning, the most relevant cause of wild fire in Western Washington.

- 2. Agricultural Impact** – Agricultural drought impacts focus on precipitation shortages, differences between actual and potential evapotranspiration, soil water deficit, reduced ground water and/or reservoir levels.

Agricultural water demand depends on prevailing weather conditions, biological characteristics of specific crops, stages of growth, and the physical and biological properties of the soil.

The vulnerability of Lewis County agriculture to drought is dependent upon the variable susceptibility of crops during the different stages of crop development. Deficient topsoil moisture at planting may hinder germination, leading to low plant populations per hectare and reduction of final yield. However, if the topsoil moisture is sufficient for early growth requirements, deficiencies in subsoil moisture at this early stage may not affect final yield should subsoil moisture be replenished as the growing season progresses or if rainfall (or irrigation) can meet plant water needs.

A significant part of Lewis County's remaining agricultural industry involves dairy herds, beef cattle, poultry, and other animal husbandry. Livestock drought concerns

relate primarily to large animal needs for substantial quantities of drinking-quality water daily – 15-20 GPD for horses and up to 50 GPD for dairy cattle.

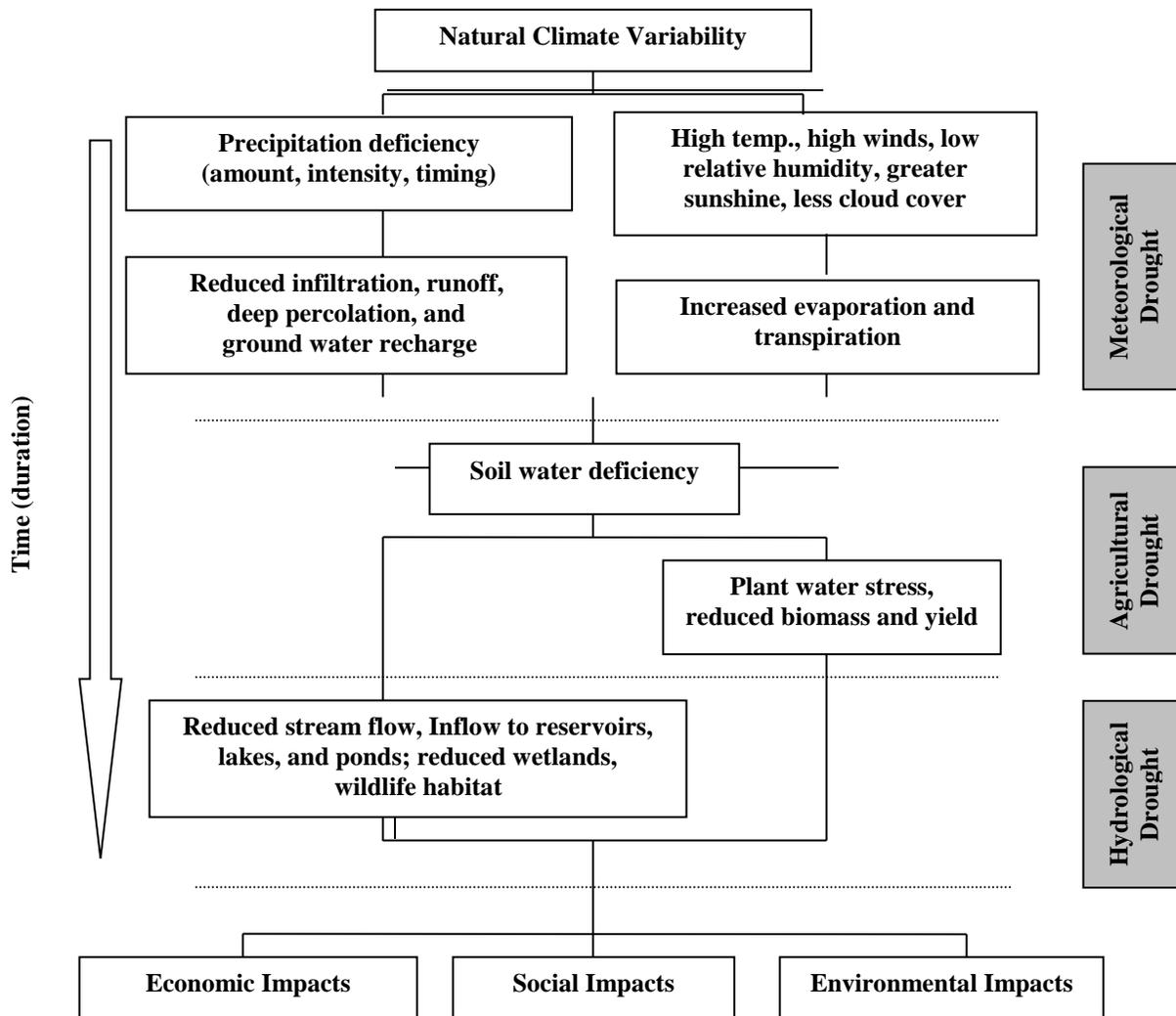
This particular agricultural effect bridges the gap into hydrological drought because it is more dependent on river flow and ground water than poor soil, water, and rainfall.

- 3. Hydrological Impact** – The hydrological effects of droughts are associated with the shortfalls of surface or subsurface water supplies (i.e., stream flow, reservoir and lake levels, ground water). The frequency and severity of *hydrological drought* are often defined on a watershed or river basin scale. Although drought originates with precipitation deficiency, hydrologists are more concerned with how this deficiency plays out through the rivers, streams and groundwater system.

It takes longer for precipitation deficiencies to show up in components of the hydrological system such as soil moisture, stream flow, and ground water and reservoir levels (See: Relationship Between Meteorological, Agricultural and Hydrological Drought, next page). As a result, the impacts are out of phase with those in other economic sectors because different water use sectors depend on these sources for their water supply. For example, a precipitation deficiency may result in a rapid depletion of soil moisture that is almost immediately discernible to agricultural users, but the impact of this deficiency on reservoir levels may not affect hydroelectric power production or drinking water supplies for many months.

Also, water in Lewis County's hydrologic storage system (e.g., lakes reservoirs, and drivers) is often used for multiple and competing purposes (e.g., flood control, irrigation, recreation, navigation, hydropower, wildlife habitat), further complicating the sequence and quantification of effects. Competition for water in these storage systems escalates during drought and conflicts between water users may increase significantly.

- 4. Socioeconomic** - Lewis County is likely to feel few direct effects from an agricultural drought, although the ripple effect could cause some economic hardships.



### Relationship Between Meteorological, Agricultural and Hydrological Drought

#### **EFFECTS:**

Drought affects water levels for use by industry, agriculture, and individual consumers. It also affects power production from hydroelectric dams. Water shortages affect firefighting capabilities through reduced flows and pressures. Other effects may include, but are not limited to:

- Loss of agricultural products
- Forest fires and the resulting erosion that causes damage to aquatic life, irrigation, and power generation through the silting streams, reservoirs and rivers
- Loss of jobs in agricultural and forestry related industries
- The loss of fish, their spawning beds and the related fisheries
- Possible salt-water intrusion into the water table along Puget Sound, affecting local wells

In addition, drought has forced the closure of ski resorts and limited the use of other recreational facilities such as the wilderness areas for hiking, camping, boating, and recreational fishing.

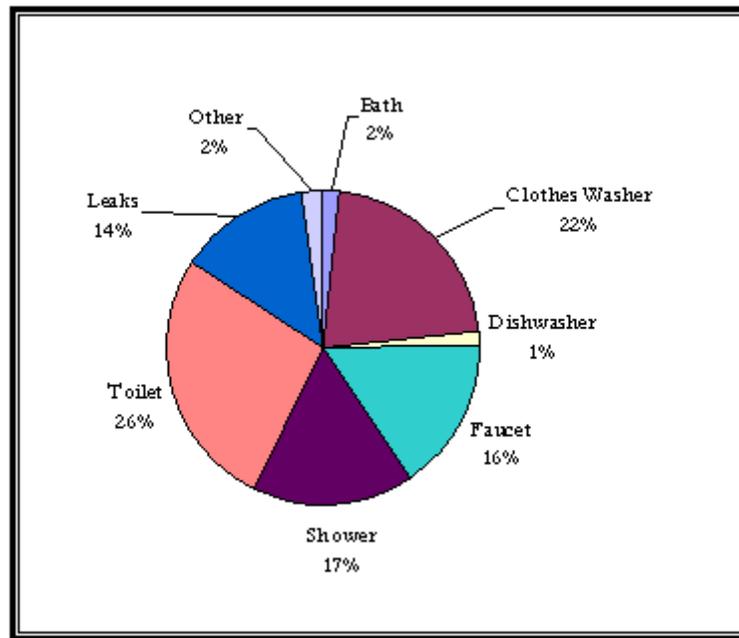
**MITIGATION:**

Drought mitigation can take many short-term forms including, but not limited to:

- Implementing energy and water conservation programs aimed at convincing the public to use less electricity and water
- Increasing energy efficiency for homes and other buildings
- Creating new pipelines to tap into unutilized watersheds
- Developing stricter irrigation methods such as drip irrigation

**Water Conservation**

**Home residents:** Residents need to do their part to lessen the effects of limited water supplies during summer months. They can start by conserving water use today. Landscape watering and toilets use the largest amount of water in the home (see: Typical Domestic Water Use chart on next page).



**Typical Domestic Water Use**

Mitigation recommendations for homeowners:

- Converting to low water landscaping
- Selecting plants, shrubs, and trees that need minimal water
- Water lawns early in the morning and/or late in the evening

- Limit water use to approximately one inch per week, including rainfall.
- Encourage growth of a deep root structure that is more drought resistant by watering less frequently
- Consider not watering the lawn for the summer months
- Convert to water efficient toilets (1.6 gallons per flush), faucets and showerheads (2.5 gallons per minute)
- Take shorter showers
- Conserve water by not letting the faucet run when shaving, brushing teeth, or hand washing dishes
- Use faucets at less than full pressure
- Operate washing machines or dishwashers at full capacity loads

Technical assistance during a current drought emergency is focused on water systems most vulnerable to drought impact. Washington State Department of Health sponsored activities include:

- Educating system operators about water conservation
- Promoting water audits and leak detection
- Supporting the development of water shortage response plans
- Helping identify alternate water sources
- Helping develop drought ordinances
- Ensuring the safe use of emergency sources of water

The Washington State Department of Health is working with the Department of Ecology and other agencies on the emergency funding available for drought response. Water systems most at risk to water shortages will be given priority for financial assistance.

### **REFERENCES:**

#### **National Weather Service Seattle**

<http://www.wrh.noaa.gov/Seattle/>

#### **NOAA Northwest River Forecast Center**

[http://www.nwrfc.noaa.gov/cgi-bin/r\\_fcst](http://www.nwrfc.noaa.gov/cgi-bin/r_fcst)

# EARTHQUAKES

## **DEFINITION:**

An earthquake is a naturally induced shaking of the ground. It is caused by an abrupt shift of rock along a fracture in the earth's crust, called a fault. The earth's surface, called the crust, is divided into eight major pieces (or plates). These plates are constantly moving, very slowly, over the buoyant portion of the upper mantle (layer of earth between the crust and the core). As these plates move, stresses/pressure builds up in areas where the plates come into contact with each other. When this stress/pressure releases, it causes an earthquake.

When evaluating earthquakes, some of the more important characteristics to consider are:

### **Amplification**

Amplification is an increase in strength of shaking that selectively affects some frequencies of wave energy. In a large earthquake, some of the energy released may be amplified by the kind of rock materials through which they pass.

### **Intensity**

The intensity of a quake is obviously one of the major factors in determining the effects encountered. Intensity is a measure of the quake's ability to do damage to the structures humans have built.

### **Magnitude**

Magnitude is the measurement of the energy released in the earth's crust by a quake. A distinction is made between intensity and magnitude. A shallow earthquake may be less powerful in terms of crustal energy released, but can do greater damage in the immediate vicinity of the epicenter because of more intense ground movement. Generally, the less intense and the shorter the duration of a quake, the less damage and casualties it causes.

The variable magnitude works in close conjunction with intensity and amplification. A small earthquake occurring during peak traffic hours near a populated area could cause more damage than a large one occurring at night in a remote part of the county. A moderate shallow earthquake that causes some local structural damage may be more destructive in the long run than a larger, deeper quake because of the possibility of subsequent damages from aftershocks.

## Depth

A quake with a focus of energy at or near the surface will normally cause more damage than one of equal size occurring at a significant depth. It is believed that absorption of the quake's energy by the thick layer of rock above is the reason for this damping effect.

The modern (major) earthquake history of the Western Washington area is one of fairly frequent deep events. However, much shallower ones are also possible. They can occur along faults located in and near Lewis County. There is a scientific chance that a great subduction zone earthquake could trigger large shallow intraplate tremors. Therefore the possibility needs to be considered in planning.

The two primary methods to measure earthquake intensity are the Richter scale and Mercalli scale. The Richter scale evaluates the quantity of freed energy (magnitude). The Mercalli scale assigns a degree according to the effects on the environment. The following tables compares the two scales:

<b>*Comparison of Earthquake Measurements – Mercalli and Richter</b>		
<b>Magnitude Richter</b>	<b>Degree Mercalli</b>	<b>Description</b>
< 3.5	I	People do not feel any earth movement.
3.5	II	Few people notice movement if they are at rest or on the upper floors of tall buildings.
4.2	III	Many People indoors feel movement. Hanging objects swing back and forth.
4.5	IV	Most people indoors feel movement. Hanging objects swing. Dishes, windows, and doors rattle. The earthquake feels like a heavy truck hitting the walls. A few people outdoors may feel movement. Parked cars rock.
4.8	V	Almost everyone feels movement. Sleeping people are awakened. Doors swing open or close. Dishes are broken. Pictures on the wall move. Small objects move or are turned over. Trees might shake. Liquids might spill.
5.4	VI	Everyone feels movement. People have trouble walking. Objects fall from shelves, off walls. Furniture moves. Plaster walls might crack. Trees and bushes shake. Slight damage in poorly built buildings.
6.1	VII	People have difficulty standing. Drivers feel cars shaking. Some furniture breaks. Loose bricks fall from buildings. Considerable damage in poorly built buildings, slight to moderate in well-built buildings.
6.5	VIII	Drivers have trouble steering. Houses that are not bolted down may shift on their foundations. Towers and chimneys may twist and fall. Poorly built structures suffer severe damage, well built suffer slight damage. Tree branches break. Wet ground hillsides may crack. Water levels in wells may change.
6.9	IX	Well-built buildings suffer considerable damage. Houses that are not bolted down move off their foundations. Some underground pipes are broken. The ground cracks. Reservoirs suffer serious damage.
7.3	X	Most buildings and foundations are destroyed. Some bridges are destroyed. Dams are seriously damaged. Large landslides occur. Water is thrown on the banks of canals, rivers, and lakes. The ground cracks in large areas. Railroad tracks are bent slightly.
8.1	XI	Most buildings collapse, some bridges are destroyed. Large cracks appear in the ground. Underground pipelines are destroyed. Railroad tracks are badly bent.
> 8.1	XII	Almost everything is destroyed. Objects are thrown into the air. The ground moves in waves or ripples. Large amounts of rock may move.

## **HAZARD IDENTIFICATION:**

In the past 100 years, a large area of the state has experienced earthquake damage. The risk is greatest in Western Washington. Most of the largest earthquakes felt in Washington have occurred in the Puget Sound Cascade Mountains region between Olympia and the Canadian border and along the Washington-Oregon border.

Within the past decade scientists have greatly expanded their knowledge concerning the seismic vulnerability of the Puget Sound region. Seismologists have identified three distinct sources of earthquakes in the Pacific Northwest.

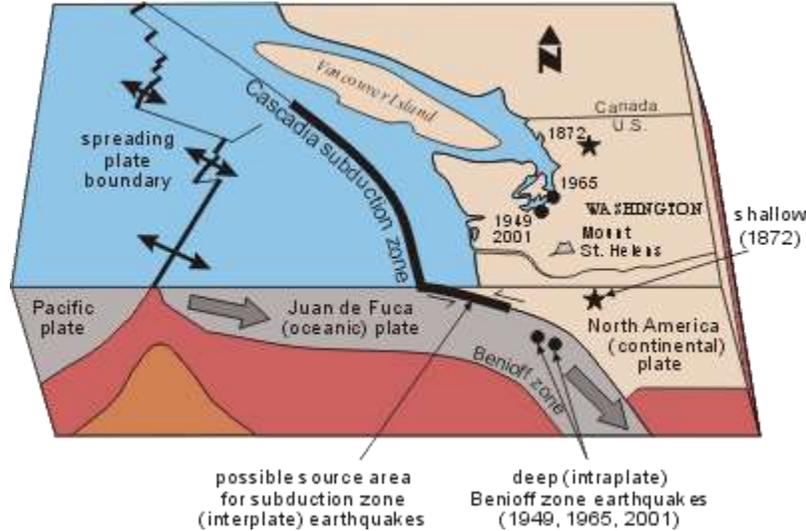
1. **Deep, intraplate earthquakes** 80-112 miles beneath the earth's surface occurring as faulting within the subduction Juan de Fuca plate
2. **Shallow, or crustal earthquakes** that occur along near-surface faults and fractures within the earth's crust at depths less than 48 miles
3. **Earthquakes along the Cascadia Subduction Zone** off the Washington-Oregon coast occurring at relatively shallow depths, and reaching magnitudes of R8 to R9.5

Washington's earthquake hazards reflect its tectonic setting. The Pacific Northwest is at a convergent margin between two tectonic plates of the Earth's crust. The Cascadia Subduction Zone (CSZ) is the long fault boundary between the continental North American plate and the oceanic Juan de Fuca plate that lies offshore from northern California to southern British Columbia. The two plates are converging at a rate of about 2 inches per year.

The interaction between these two plates creates a complicated system of three distinct earthquake source zones. The earthquakes produced by each source zone are responsible for the earthquake hazards across Washington (Cascadia Subduction Zone, Juan de Fuca Plate deep zone, and the earth's shallow crust zone).

IN 2015, geologists discovered a fault line that stretches from Centralia to Chehalis and crosses Interstate 5. They named this the "Doty Fault Line". More study needs to take place to determine if this is an active fault line (if so, it would be capable of a 6.5 or 7.0 earthquake).

**Figure 1: Seismic Source Zones for Pacific Northwest Earthquakes**



Several secondary hazards that exist from an earthquake are:

### 1. Liquefaction

Soil liquefaction occurs when water-saturated sands, silts or (less commonly) gravels are shaken so violently that the grains rearrange and the sediment loses strength and begins to flow or spread. Soft soils or human-made fills can subside or experience liquefaction in an earthquake. Liquefaction commonly causes ground failures, such as ground cracking or lateral spreading above liquefied layers. Lateral spreads are landslides that can occur on very shallow slopes. Noteworthy liquefaction took place in Puyallup during the 1949 earthquake. The sands that failed in many cases were sand deposits from Mount Rainier lahars. (see: Volcanoes section.)

### 2. Landslides

Landslides and rock falls can be triggered on steep slopes. Earthquakes have caused large and disastrous landslides, including debris flows from volcanoes. Accelerations from earthquakes can produce additional down slope force, causing otherwise stable or marginally stable slopes to fail. Deltaic and coastal water-laden areas are vulnerable to slope failure. Loss of strength in sensitive, clay-rich soils can also cause landslides and other ground failures. Strong shaking can cause cohesive sediments to lose strength. Strong earthquakes can trigger soil collapse or settlement over abandoned coalmines.

### 3. Dam Failure

Dam failure is also a possibility during an earthquake. Likely causes are either a fracture of the retention wall or the failure of the soils under the structure.

Each of these secondary hazards gives rise to additional hazards. These additional hazards are covered separately throughout the HIVA.

**HISTORY:**

Since the 19<sup>th</sup> century, Washington State has had over 1,000 earthquakes large enough to be felt. Although a majority of these earthquakes were not generated within Lewis County, many still affected the area (see: Notable Earthquakes Felt in Lewis County table on the following page).

Large magnitude earthquakes (greater than 6.0) have occurred repeatedly in the Puget Sound region. In 1909, an event estimated to be of magnitude 6.0 struck the San Juan Islands. Other large events followed in 1939, 1946, 1949, 1965 and 2001.

The large earthquakes of 1946 (R 6.3), 1949 (R 7.1), and 1965 (R 6.5) killed 17 people and caused more than \$200 million (1984 dollars) in property damage. The Nisqually earthquake (R 6.8) on February 28, 2001, was centered very near the location of the 1949 event. This event caused extensive non-structural damage throughout the region. Although estimates were still being totaled in 2003, losses from this event are greater than \$350 million.

In addition to these historical earthquakes, research indicates that the subduction Juan de Fuca plate has generated great subduction earthquakes in the past. These infrequent earthquakes (estimated at R 8 to 9), appear to have occurred at unequal intervals over the past several thousand years.

At least 13 great subduction earthquakes appear to have occurred in the Pacific Northwest over the past 7,000 years. Current research is attempting to understand their recurrence patterns, size, precursors and effects. At this time it appears that the mean recurrence rate is about 500 to 600 years. The actual recurrence rate is highly variable with the shortest period between them being around 150 years and the longest time span around 1,150 years. Our most recent great subduction earthquake in Washington State was over 300 years ago on January 26, 1700.

<b>NOTABLE EARTHQUAKES FELT IN LEWIS COUNTY</b>			
<b>Date</b>	<b>Location of the Epicenter</b>	<b>Magnitude</b>	<b>Costs</b>
Dec. 14, 1872	North Cascades	7.3	
Jan. 03, 1896	Decatur Island, San Juans	5.7	
Jan. 11, 1909	Orcas Island, San Juans	6.0	
Dec. 6, 1918	Vancouver Island	7.0	
Jan. 23, 1920	Orcas Island, San Juans	5.5	
July 17, 1932	East of Duvall, Central Cascades	5.2	
Nov. 12, 1939	South Fork of Snoqualmie River	5.75	
April 29, 1945	Chester Morris Lake, Central Cascades	5.5 – 6.0	
Feb. 14, 1946	Hartstene Island, South Puget Sound	6.3	
Feb. 15, 1946	44.5 mi N. of Olympia	5.8	

<b>NOTABLE EARTHQUAKES FELT IN LEWIS COUNTY</b>			
Feb. 23, 1946	0.0 mi SE of Olympia	5.0	
<b>April 13, 1949</b>	<b>19.6 mi ENE of Olympia</b>	<b>7.1</b>	<b>\$25 million</b>
Nov. 05, 1962	Portland, OR	5.5	
<b>April 29, 1965</b>	<b>29.3 mi N. of Tacoma</b>	<b>6.5</b>	<b>\$12.5 million</b>
Feb. 13, 1981	Elk Lake, North of Spirit Lake	5.5	
Dec. 24, 1989	Storm King Mt., Northeast of Morton	5.1	
April 14, 1990	Deming	5.2	
<b>Jan. 29, 1995</b>	<b>28 mi NNE of Tacoma</b>	<b>5.0</b>	
May 2, 1997	Duvall	5.3	
June 23, 1997	Southwestern Bainbridge Island	4.9	
July 10, 1997	4 mi ENE of Bremerton	3.6	
Jan. 4, 1999	7.5 mi SE Tacoma	3.2	
July 1, 1999	9.5 mi N of Tacoma	3.0	
<b>July 2, 1999</b>	<b>4.2 mi N. of Satsop</b>	<b>5.1</b>	<b>\$8.1 million</b>
Dec. 12, 1999	48.0 mi NW of Forks, WA	3.8	
<b>Feb. 28, 2001</b>	<b>28 mi NE of Olympia (Nisqually)</b>	<b>6.8</b>	<b>\$1-4 billion</b>
<b>June 10, 2001</b>	<b>30 mi NE of Aberdeen (Satsop)</b>	<b>5.0</b>	
July 22, 2001	Nisqually Delta	4.3	
Nov. 29, 2002	27 mi N of Friday Harbor (Georgia, WA)	3.8	
Nov 16, 2010	Silver Creek, WA	4.2	

<b>Largest Recorded Earthquakes in the World and Washington State</b>			
Worldwide	Magnitude	Washington	Magnitude
1960 Chile	9.5	1872	*6.8
1964 Prince William Sound, Alaska	9.2	1949 Olympia	6.8
2004 Sumatra, Indonesia	9.1	2001 Nisqually	6.8
2011 Japan	9.0	1965 Tacoma	6.7
1952 Kamchatka, Russia	9.0	1939 Bremerton	6.2
2010 Chile	8.8	1936 Walla Walla	6.1
1906 Ecuador	8.8	1909 Friday Harbor	6.0

\*Estimated magnitude

**VULNERABILITY:**

The effects of an earthquake upon Lewis County are difficult to predict because of the many uncertainties that are involved. The variables that cannot yet be predicted but have the greatest impact are:

- Time
- Location
- Depth
- Intensity
- Occurrence or absence of aftershocks

Vulnerability to soil liquefaction and mass movement (landslides and mudslides) is controllable to a degree by

- Mapping
- Zoning
- Restricting construction in high-risk areas

Other manageable factors include:

- Age of structures
- Construction materials
- Construction quality and design
- Adherence to seismic codes

The time that an earthquake occurs significantly determines the impact of the quake. The most significant effect of time relates to the potential for human casualties. Experts believe that casualties would be greatest during hours of heavy vehicular traffic and when large numbers of people are in concentrated areas, such as business and government districts, hospitals, universities, and schools.

The highest potential for human casualties resulting from an earthquake exists during the 12-hour period from 6 a.m. to 6 p.m.

The location of the quake's epicenter will have a substantial impact on its ability to damage the "built environment" (man-made structures). Most earthquake damage is caused by strong ground motion that results from the energy released by the quake. The strength of this ground shaking usually decreases with distance from the earthquake source. Locally it can be much higher due to amplification of energy waves, which pass from bedrock into softer geological materials such as river sediment. Generally, the closer the epicenter is to a populated area, the more severe the damage will be.

The greater the distance from the epicenter, the better the chance of survival and the lower the probability of major property damage. Since earthquakes are still not predictable with respect to either time or focus, it is not possible to choose the most advantageous building location.

The recent Nisqually earthquake (February 28, 2001) graphically demonstrated that structures built with solid rock underfoot are much less likely to sustain damage than those constructed on clay, alluvium, artificial fill (non-compacted), sandy soil or unstable slopes.

Secondary effects such as land failure (subsidence, liquefaction) and mass movement (landslides, mudslides) are also common during and after a major quake. Lewis County is particularly susceptible to these effects during those times of the year that the ground is already saturated (November to April).

The county's vulnerability to collateral hazards that occur subsequent to a major earthquake (building collapse, damage to transportation systems, dam failure, rupture of underground utility lines, hazardous material spills, fire) is also deserving of attention. These types of events may add substantially to the amount of damage caused by ground movement.

In terms of threat to human life, perhaps the most serious of these is urban fire. Given the scenario of a severely damaged transportation system following a great quake, fire can spread uncontrolled in densely built city areas.

Most community earthquake preparedness tends to focus on potential damage to major structures – buildings, bridges, highways, water and power infrastructure, etc. Experience with most modern quakes in the U.S. has taught us that the greatest dollar damage to most buildings and homes caused by a catastrophic earthquake (and the greatest threat to human safety) is from damage to the following non-structural elements of homes and workplaces:

**Equipment and furnishings:**

Tables, desks, chairs, computer equipment, TVs, stereos, file cabinets, bookshelves, china, display and other storage cabinets, refrigerators and freezers, vending machines, free-standing industrial equipment in manufacturing plants, even such decorative items such as aquariums and potted plants

**Glass:**

Non-safety glass windows, pictures, mirrors, skylights

**Hazardous materials:**

Gas cylinders, laboratory and household chemicals petroleum distillates, paints, thinners, natural gas heating and plumbing

**Overhead elements:**

Suspended and decorative ceiling panels, chandeliers and pendant lights, fluorescent light fixtures, heater and air conditioner ducting, fire sprinkler system plumbing and valves, hanging plants

**Electrical systems:**

Emergency power systems and cabling, battery equipment and UPS, generator fuel tanks, power panels, transformers, telecommunications and radio racks, exit and emergency lighting

**Mechanical equipment:**

Furnaces and boilers, water heaters, fans, chillers, heat pumps and other heating/cooling equipment, piping and ducting, manufacturing equipment, elevators, wood stoves

**Architectural elements:**

Partition walls, drywall, stairways, veneer, parapets and cornices, cladding, fences, statuary

**DAMAGE COMPARISONS:**

Damages and costs related to natural disasters are often difficult to assess as there is no one agency that has responsibility to consistently gather this type of information. However, some commonalities exist in disaster events and therefore, comparison pictures can be of value for planning purposes. The following chart shows Lewis County damage estimates from the 2001 Nisqually earthquake and some statistics from the 2010 Haiti and Chile earthquakes.

<b>Nisqually Earthquake</b>	<b>Haiti Earthquake</b>	<b>Chile Earthquake</b>
February 28, 2001 10:54 17.6 km NE of Olympia <b>6.8</b> – Depth 52.40 km 40 seconds 5 aftershocks	January 12, 2010 4:53 p.m. 10 mi west Port-au-Prince <b>7.0</b> – Depth 13 km 35 seconds 33 aftershocks (4.2 to 6.0)	February 27, 2010 3:34 a.m. 70 mi from Concepcion <b>8.8</b> – Depth 35 km 90 seconds 90 aftershocks (4.9 to 6.9)
Deaths: 1 Injuries: Unknown	Deaths: 230,000 Injuries: 300,000	Deaths: 800 Injuries: Unknown
State-wide damages: <b>\$2 billion</b> Lewis County Damages: Public agencies: \$7.5 million FEMA 1,221 claims: \$4 million <b>LC Total: \$ 11.5 million</b>	700,000 displaced 3 million needing emergency aid	1.5 million without power 2 million affected 500,000 buildings severely damaged Tsunami alert issued

**EFFECTS:**

Lewis County’s vulnerability to collateral hazards that occur subsequent to a major earthquake (building collapse, damage to transportation systems, dam failure, rupture of underground utility lines, hazardous material spills, fires) is also deserving of attention. These types of events may add substantially to the amount of damage caused by ground movement.

Effects of a major earthquake in the Puget Sound basin could be catastrophic, providing the worst-case disaster short of war. Thousands of persons could be killed and many tens of thousands injured or left homeless.

The effects of an earthquake may vary from not even being felt by the local citizens to near total destruction of the physical and economic infrastructure of the area. The effects are highly variable depending on the magnitude, proximity to the population centers, depth, types of soil on which structures are located, local building codes, age and type of structures, time of day and a host of other factors.

Secondary effects such as land failure (subsidence, liquefaction) and mass movement (landslides, mudslides) are also common during and after a major quake. Lewis County is particularly susceptible to these effects during those times of the year that the ground is already saturated (November to April).

The actual movement of the ground in an earthquake is seldom the direct cause of injury or death. Most casualties result from falling materials. Other effects include, but are not limited to:

- Broken water and sewer mains
- Downed electric lines
- Downed or damaged bridges
- Cracked and partially displaced roadbeds and rail lines
- Loss of telephone or other telecommunications services
- Houses knocked off their foundations
- Partial or complete collapse of buildings, building facades, cornices, or chimneys
- Fires including urban conflagration
- Chemical spills
- Ruptured gas and oil pipelines
- River beds disrupted
- Broken or cracked dams with possible flooding
- Injury and death
- Psychological trauma
- Economic disruption
- Large numbers of displaced persons

**MITIGATION:**

Mitigation activities such as the following should be instituted and maintained to lessen the potential problems.

- Evaluation, revision, and examination of building and zoning codes and enforcement of seismic provisions

- Identification of Growth Management Act geological hazards and adoption of land use policies to lessen risk
- Dissemination of public information on what to do before, during and after an earthquake
- Development of response procedures by local and state governments
- Identification and removal of potential threats in the non-structural elements in homes and businesses

In summary, local governments must take appropriate actions to mitigate against earthquake severity with conscientious enforcement of codes, improved building standards, and educating our citizens to be ready for a great quake. Public awareness programs, “Drop, Cover and Hold” drills, Community Emergency Response Team (CERT) education and training, neighborhood outreach, and informational meetings on what to do before, during and after an earthquake are just part of the answer.

The county’s leadership must continuously reassess the threat. The threat assessment needs to anticipate future population increases and urban development planning. At the individual level, each citizen must accept his or her responsibility to prepare self, home and family for the day the ground shakes.

For more mitigation strategies see the Lewis County Hazard Mitigation Plan.

**REFERENCES:**

For more information on mitigation measures in Lewis County, see the Lewis County Hazard Mitigation Plan.

Washington State Department of Transportation  
<http://www.wsdot.wa.gov/>

Uniform Building Code  
[http://www.sbcc.wa.gov/pages/code.html#viewing\\_online](http://www.sbcc.wa.gov/pages/code.html#viewing_online)

USGS  
<http://earthquake.usgs.gov/>

Washington State Department of Natural Resources, Geology and Earth Resources Division  
<http://www.wa.gov/dnr/htdocs/ger/>

## **FIRES**

### **URBAN/WILDLAND INTERFACE**

#### **DEFINITION:**

An urban/wildland interface fire is a fire located in a geographical area where structures and other human development meets or intermingles with wildland or vegetative fuels.

There are numerous locations within Lewis County where structural developments meet and intermingle with the wildland areas. This condition gives rise to the possibility of urban/wildland interface fires, especially when weather conditions are dry and fuels are abundant.

The major types of fires that have the potential to adversely affect Lewis County are:

#### **Wildland Fire**

Wildland fires are the uncontrolled destruction of forested lands caused by natural or human-initiated events. Wildfires occur primarily in undeveloped areas. These natural lands contain dense vegetation such as forests, grasslands, or agricultural croplands. Because of their distance from firefighting resources and manpower, these fires can be difficult to contain and can cause a great deal of destruction.

#### **Conflagration**

A conflagration is a fire that grows beyond its original source area to engulf adjoining regions. The elements of wildfire conflagration are:

- Wind
- Extremely dry or hazardous weather conditions
- Excessive fuel buildup
- Explosions

#### **Firestorm**

A Firestorm is a fire that expands to cover a large areas, often more than a square mile. A firestorm usually occurs when many individual fires grow together to make one huge conflagration. The involved area becomes so hot that all combustible materials ignite, even if they are not exposed to direct flame. Superheated air and hot gasses of combustion may rise upward over the fire zone, reaching velocities of 50 mph and temperatures in excess of 1000° .

**HAZARD IDENTIFICATION:**

Urban/wildland interface fires occur naturally (lightning strikes) or by carelessness. People's carelessness and lack of fire knowledge are the most common causes of interface fires. Naturally occurring interface fires, especially those caused by lightning, are rare in Western Washington.

Controlled burns are not considered hazards unless they get out of control. Controlled burns are conducted because the fire cycle is an important aspect of management for all ecosystems.

Washington State's fire season usually runs from mid-May through October, although large fires can occur during the winter. The probability of an interface fire in any one locality on a particular day depends on any of the following activities and events:

- Fuel conditions
- Topography
- Time of year
- Past and present weather conditions
- Activities (debris burning, land clearing, camping)

Any prolonged period of lack of precipitation presents a potentially dangerous problem. Prolonged periods of strong winds can also create dry conditions.

**HISTORY:**

Fires historically burn on a fairly regular cycle, recycling carbon and nutrients stored in the ecosystem and strongly affecting the species within the ecosystem. They are a normal part of most forest and range ecosystems and not generally considered a hazard. The burning cycle in western Washington is every 100 – 150 years.

As communities expand farther and farther into forested lands, and the desire to maintain the wilderness ambiance, interface fires are becoming a significant hazard, having the potential for loss of life and destruction of property.

<b>Lewis County Wildland Fires</b>		
<b>Year</b>	<b>Total Fires</b>	<b>Acres Burned</b>
2004	48	85.50 Acres
2005	39	80.24 Acres
2006	16	4.20 Acres
2007	16	4.20 Acres
2008	19	37.74 Acres
2009	29	15.00 Acres
2010	11	7.46 Acres
2011	15	7.22 Acres
2012	34	41.11 Acres
2013	25	305.45 Acres

Dog Mountain Fire began May 4, 2013 burned approximately 200 acres. 100 firefighters and 2 helicopters fought the blaze until July 3, 2013.

**VULNERABILITY:**

Factors affecting the degree of risk of urban/wildland interface fires include the following:

- Amount of rainfall
- Type and amount of vegetation
- Population density
- Proximity to firefighting agencies

The urban/wildland interface fire vulnerability can be created from the actions and decisions of people or by the area's vegetation and topography.

Home building in and near forested lands creates the interface and therefore increases the risk of interface fires. Many homes are built with an effort to maintain the scenic aspects of the surrounding area. Often structures are built with minimal consideration given to the need for protection from exterior fire starts or the need to minimize interior fires from spreading to forested lands. Frequently there is little clearance of vegetation resulting in a lack of defensible space.

Narrow access roads frequently found in these areas interfere with fire suppression efforts. Frequently roads are so narrow that standard sized fire apparatus cannot adequately turn around. More diverse fire apparatus such as brush rigs and smaller engines are needed. Rural communities may not be able to financially support these additional requirements. More isolated homes may not have any fire services available.

Available fuels (vegetation and other combustible materials), winds and slope gradient are contributors to the speed that a fire spreads.

The heavy and dense vegetation that grows on the west side of the Cascade Mountain Range is different than that which grows on the east side and has the potential for tremendous energy release when it burns.

Winds exacerbate the speed in which fire spreads. The topography of the Cascade foothills creates a seasonal event commonly called the "east winds". These "east" winds result as an attempt to equalize off-coast low pressures with the higher pressured air funneling off the mountains. The Packwood and Randle areas of Lewis County are prone to these "east" winds.

Slope also affects the spread of fire. A slope of 55% enables fire to spread four times faster than flat terrain.

**EFFECTS:**

The effects of urban/wildland interface fires vary with intensity, area, and time of year. The potential for loss is the partial or complete destruction of valuable resources such as:

- Ground cover
- Forests and reduced amounts of timber for commercial purposes
- Fish and wildlife habitat
- Recreation areas and activities
- Reduction of travel in the affected area
- Watersheds
- Loss of life and property

Other secondary hazards may include the closure of highways or roads near the affected area.

There is an immediate increase in vulnerability to flooding due to the destruction of all or parts of the watershed. Severe fires producing high soil temperatures create a water-repellant layer below the soil surface. The soil above this layer becomes highly prone to erosion, often resulting in mudslides.

### **MITIGATION:**

Fire safety education, awareness, and outdoor skills are the key to mitigation. Most of the urban/wildland interface fires start from a careless or uniformed act. An educated public is more likely to embrace and possibly insist upon mitigation and awareness education.

Methods to mitigate urban/wildland fire risk include the following:

- Adopting stricter land use and building codes
- Mandating sprinkler system installation
- Management of vegetation
- Requiring the use of survivable materials in construction of homes
- Training and equipping fire services to deal with urban/wildland fires
- Providing access and accessibility for fire fighting equipment

### **REFERENCES:**

Some websites of interest:

State of Washington Department of Natural Resources

<http://www.wadnr.gov>

<http://www.firewise.gov>

USDA Forest Service

<http://www.fs.fed.us>

## FLOOD

### **DEFINITION:**

A flood is an inundation of dry land with water. Types of floods in Washington State are primarily:

- River and Creek
- Surface water
- Flash
- Tidal

Of all the natural hazards in Lewis County, floods are the most common and cause the most property damage. Lewis County is affected on an annual basis by river, creek, and surface water events. Flash or tidal floods rarely affect Lewis County.

### **River and Creek Flooding**

River and creek flooding results from heavy and prolonged rainfall. Flooding of this type can last several days after the storm. It may include substantial snowmelt if there is rise in freezing levels after a measurable snowfall.

Surface Water – two types of surface water floods impact Lewis County:

#### **1. Closed Depression Flooding**

Closed depression flooding occurs where water collects in low-lying areas with little to no drainage capacity. Once flooding occurs, it lasts until evaporation or slow infiltration lowers the water level, which may be for the remainder of the wet season.

#### **2. Groundwater flooding**

Groundwater flooding is associated with a large amount of cumulative rain over several storms or consecutive rainy season. High groundwater may occur weeks after the last significant rainfall and can also shift locations as groundwater levels change throughout the region. This type of flooding may last for several weeks or even months.

### **HAZARD IDENTIFICATION:**

The major Lewis County river systems flood at irregular intervals, but mostly in response to long periods of warm rainfall and mild temperatures following fairly heavy low-level snow.

These storm patterns, typically given the name “Pineapple Express” (from the tropical origins of their warm/moist air) usually occur between early November and late February. Affected basins include those of the Skookumchuck, Chehalis, Cowlitz and Newaukum Rivers and their associated tributaries.

Flood prone rivers of Lewis County are the Upper Cowlitz above Riffe Lake and the Nisqually in the east county; the Chehalis, Newaukum, Skookumchuck and Lower Cowlitz in western Lewis County.

One of the elements leading to a potential flood is fresh, heavy snow in the mountains. If a weather front with warm winds (usually from the southeast) and heavy rainfall follows the snow before it has a chance to settle and solidify, the potential for flooding is high.

It is rare for rain to cause flooding without the other elements being present. An example is that high tides may be responsible for flooding conditions by restricting the normal discharge of the Chehalis River; low tides facilitate the discharge from the Chehalis River system.

**HISTORY:**

Throughout recorded history, flooding has been a natural characteristic of the climate, topography, and hydrology of Lewis County. Low lying areas, especially river valleys, have flooded regularly for hundreds of years. As population and urbanization grow within the county so does the consequence of flooding.

Lewis County experienced 16 federally declared disasters between 1971 and 1997. Of these, 13 were either caused or exacerbated by flooding. The following is a listing of Lewis County floods during the past 30 years that resulted in a Presidential Declaration of Disaster:

<b>Lewis County Presidentially Declared Flood Disaster History 1971-1997</b>		
<b>Dates</b>	<b>River/Area</b>	<b>Total Damage (in Dollars)</b>
January 1971	Chehalis/Skookumchuck	\$446,571
January 1972	Chehalis	\$2,060,245
January 1974		
December 1975		
December 1977	Cowlitz River/East Lewis County	\$1,359,800
November 1986	Chehalis/Skookumchuck	\$3,926,250
January 1990	Chehalis/Skookumchuck	\$1,439,378
February 1990	Chehalis/Skookumchuck	\$200,000
November 1990	Chehalis/Skookumchuck/Cowlitz	\$1,050,000
December 1990	Nisqually (Hidden Valley)	\$700,000
December 1994	Chehalis River	\$40,000
November – December 1995	Cowlitz River/East Lewis Co.	\$12 Million
February 1996	Chehalis/Skookumchuck/Cowlitz	\$30 Million
Dec. 1996 – January 1997	Chehalis/Skookumchuck/Cowlitz	\$3,255,903
March 1997	Cowlitz Flood	

During the 1986 flood, one of the local industrial buildings in a flood prone area of Chehalis was inundated. The result of this inundation was a large chemical contamination that affected an entire neighborhood.

The November 1990 flood affected the Centralia/Chehalis area and eastern Lewis County. A complete subdivision, Hidden Valley, on the Wold Road near Ashford was inundated when the Nisqually River changed its course and affected 121 property owners.

The January and February, 1990 floods and winter storms resulted in the following types of damages:

- Three fatalities (2 Centralia, 1 Chehalis)
- Livestock losses - 42,000 fryers (\$115,000); 75 dairy cattle (\$25,000)
- Damages to 82 aircraft
- SWW Fairgrounds building/dike damages (\$1,058,000)
- Lewis County Public Works - \$872,577 (estimated road damages)
- Residential building damages - \$15 million (insured only)
- The Red Cross housed 499 people in 14 shelters, serving 4,049 meals

The winter months of 1995-96 broke all records for river levels and damages incurred from flood. Individual Assistance (uninsured) damages for November and December were placed at \$314,700. Events early in January 1996 caused damages to 553 Lewis County homes with FEMA Individual Assistance totaling \$1.83 million.

The total public and private damage estimates for February 1996 were placed at \$30 million. FEMA Individual Assistance applications for Lewis County totaled 1,967 claims. The Red Cross sheltered over 500 displaced Centralia residents. Some of the largest losses are listed in the table below:

Name/Businesses	Losses (estimates)
County Revetments	\$2,506,175
County Roads	613,860
Lewis & Clark State Park	\$1,500,000
IFA Nurseries, Toledo	2,938,000
Alpine Redi-Mix, Toledo	801,550
WA Outfitters & Guides Assoc.	485,319
Centralia School District	75,000
Vader	46,800

Flooding impacts from 1998 to the present include the following:

Lewis County Flood History - 1998 to Present		
Dates	River/Area	Total Damage (in Dollars)
January 15, 1998	Flood	
Nov 23-38, 1998	Flood	

<b>Lewis County Flood History - 1998 to Present</b>		
<b>Dates</b>	<b>River/Area</b>	<b>Total Damage (in Dollars)</b>
December 1-3, 1998	Flood	
Dec 28-31, 1998	Flood	
Feb 22-28, 1999	Flood	
Nov 24-27, 1999	Flood	
December 16, 1999	Flood	
January 7, 2001	Flood	
December 17, 2001	Flood	
January 25, 2002	Flood	
January 10-13, 2006	Chehalis, Skookumchuck/Newaukum	\$1,704,947
Jan 20-Feb 2, 2006	West County Flooding	\$293,362
Nov 6-10, 2006 (See Attachment B for details)	Flood East County – Cowlitz River East County Flood of Record	\$26,649,480
December 3, 2007 (See Attachment C for details)	West County, Chehalis River West County Flood of Record	\$166,163,520
November 12, 2008	Flood - East County	
January 7, 2009	Flood, Chehalis River	\$22,474,696
December 8-15, 2010	Flood	\$32,175
January 9-26, 2011	Flood - Cowlitz River, Randle affected	\$813,184
January 5, 2015	Flood – Newaukum, Skookumchuck	\$107,000
December 8-10, 2015	Flooding	\$3,504,935
<b>1998 to 2018 = 20 floods in 20 years</b>		

**VULNERABILITY:**

River and creek flooding cause extensive damage to productive croplands, dwellings, farm buildings, businesses, bridges, railroads, highways, and utilities, and interrupt transportation. Erosion and subsequent failure of levees presents a threat to human life. Recent history has shown that Lewis County can expect an average of one episode of minor river flooding each winter. The potential for major floods exists in any year and may occur at any time during the flood season. It is unusual for a flood to occur without warning due to the sequential pattern of meteorological conditions needed to cause serious flooding.

Some of the factors contributing to flood vulnerability are:

- Vegetation and wetland encroachment
- Sedimentation in the riverbeds (which reduces the flood carrying capacity)
- Disposal of yard waste into streams and rivers
- Continued growth into flood prone areas

Flood zones along Lewis County’s rivers were mapped decades ago. Since then, rapid population growth and urbanization have drastically changed land-use patterns, altering the ability of the land to absorb high amounts of precipitation and to extend the duration of runoff into the rivers and floodplains.

As open space is developed, runoff increases from 2 to 6 times over what would occur on natural terrain. Thus flood-zone maps do not accurately depict the present state of the hazard nor adequately evaluate increased risk in the areas bordering flood zones.

### **EFFECTS:**

Potential effects from flooding include but are not limited to:

- Physical injury/death, both to people and animals (companion and service animals, wildlife, and livestock)
- Damage to agriculture, including erosion
- Damage to flood control structures and public facilities (i.e. dikes, levees, bridges, dams, schools, etc.)
- Damage to homes, buildings, businesses, transportation corridors and other lifelines

It is important to remember that the dangers associated with a flood do not end when the rain stops and the rivers and creeks recede. Some secondary hazards associated with floods and flood cleanup are:

- Electrocutation
- Structural collapse
- Hazardous materials incidents
- Disease/health
- Fire

### **MITIGATION:**

In Lewis County, floods are a major threat to the environment, property, and the safety of humans and livestock living in the floodplains. Flood damages in the county have far exceeded losses due to all other natural hazards.

Mitigation methods include, but are not limited to:

#### **1. Stricter floodplain regulations**

Regulating construction in floodplain areas. Man-made developments within flood plains should be limited to non-structures such as parks, golf courses, farmland, etc. These facilities have the least potential for damage, but maximize land use. The move toward natural use of river bottomland for farming, parks, grazing, and other agricultural uses is commendable and should be conscientiously continued.

#### **2. Updated floodplain maps**

Conducting ongoing updates to the Chehalis Basin and Upper Cowlitz mapping programs to establish accurate data for floodplain management.

#### **3. Property acquisition**

Conducting federal, state, and local buyout programs to further reduce the number of people living in flood prone lowlands and gradually move the population into less susceptible areas.

#### 4. Warning and evacuation

Improving warnings and evacuation systems in flood-prone areas. These systems include:

- River and stream flow gauging systems operated by the U.S. Geological Survey and NOAA's National Weather Service
- Snow depth information from USDA's Natural Resources Conservation Service
- U.S. Army Corp of Engineers gauges
- NOAA's weather radar covering the Olympic/SW Washington region

All these tools improve NWS hydrological forecasts to local communities. The timeliness of these predictions and the local agencies familiarity with flood alerts significantly improves the county's preparedness for major flood conditions. Warning, evacuation, and shelter plans are in place for vulnerable areas. Every attempt is made to ensure the flood warning information is quickly disseminated.

Other mitigation efforts include but are not limited to:

- Increasing building elevation requirements
- Enhancing development of the Community Rating System (CRS) program and increased participation in the National Flood Insurance Program (NFIP)
- Development of the Comprehensive Flood Hazard Management Plan for Lewis County addressing Endangered Species Act (ESA) habitat
- Improvement of storage areas and pumping abilities
- Conducting public education on waste disposal
- Coordinate with the U.S. Army Corps of Engineers to reduce potential flood problems

For more mitigation strategies see the Lewis County Multi-jurisdictional Hazard Mitigation Plan.

#### **REFERENCES:**

Lewis County Department of Public Services, ***Comprehensive Flood Hazard Management Plan for Lewis county, Volume I, II, December 1994.***

Lewis County Department of Public Works, ***Comprehensive Flood Hazard Management Plan Amendment for the Upper Cowlitz River Basin, May 2001.***

***Flood Phase Guidelines Manual, Centralia, Chehalis, Lewis County, 1993.***

Additional Information:

The U.S. Army Corp of Engineers, under PL 84-99, has the authority to assist eligible public entities in flood fighting and rescue operations and to protect, repair and restore federally constructed flood control works, which are threatened, damaged or destroyed by a flood.

## **MASS LAND MOVEMENT**

### **DEFINITION:**

Mass land movement is the sliding movement of a mass of loosened rock and soil down a hillside or slope. The causes of mass land movement depend upon rock type, precipitation, seismic shaking, land development and zoning practices, soil composition, moisture and slope steepness.

The geological conditions of Western Washington are primarily the result of repeated glacial episodes of advance and retreat during the past 2 million years. The cool, rainy Pacific Northwest climate ensures that soil moisture levels remain high throughout most of the year, and are often at or near saturation during the wetter winter months.

The four types of mass land movement that have the ability to adversely affect Lewis County are:

### **Landslide**

Landslide is a mass of rock, earth, or debris moving down a slope. Landslides may be minor or very large, and can move at slow to very high speed. They can be initiated by storms, earthquakes, fires, volcanic eruptions, and by human modifications of the land.

### **Mudslides or mudflows (debris flows)**

Mudslides are rivers of rock, earth, organic matter and other soil materials saturated with water. They develop in the soil overlying bedrock on sloping surfaces when water rapidly accumulates in the ground. Water pressure in the pore spaces of the material increases to the point that the internal strength of the soil is drastically weakened. The soil's reduced resistance can then easily be overcome by gravity, changing the earth into a flowing river of mud or "**slurry**." A debris flow or mudflow can move rapidly down slopes or through channels and strike with little or no warning at avalanche speeds. The slurry can travel miles from its source, growing as it descends, picking up trees, boulders, cars, and anything else in its path. Although these slides behave as fluids, they pack many times the hydraulic force of water due to the mass of material. They can be some of the most destructive events in nature.

### **Sinkhole**

A sinkhole is a collapsed depression in the ground with no visible outlet. Its size is typically measured in meters or tens of meters. It is commonly vertical-sided or funnel-shaped and drainage is subterranean.

## **Lahars**

Lahars are a slurry of volcanic debris, rock, sediment, ash and water with the consistency of wet concrete. Lahars pour down stream channels and fill valleys at speed up to 190 miles per hour, destroying everything in their paths and traveling as far as 160 mph or more from the volcano source. They can be caused either by an actual eruption or by non-volcanic phenomena.

### **HAZARD IDENTIFICATION:**

There are two broad categories of mass land movements that commonly occur in Lewis County:

#### **1. Mudslides or Mudflows (Debris flows)**

Mudslides or mudflows (debris flows) are the most hazardous to life. They are fast moving, water-saturated masses of soil, rock, and debris (tree trunks, limbs, etc.) that move down steep slopes and channels. Mudslides (debris flows) are typically triggered by intense rainfall, and can run long distances when confined to a channel. This type of failure is most common to the mountainous portions of Lewis County.

#### **2. Landslides - Deep seated**

Deep-seated landslides can be as large as a few tens to a few hundreds of acres. They can occur on slopes with an average slope gradient as low as 15%. These landslides are usually reactivations of older pre-historic failures. They are typically slow moving.

The velocity of movement may range from a few feet per year to many feet per second, depending on slope angle, material and water content.

The recognition of ancient dormant mass movement sites is important in the identification of those areas most susceptible to this hazard, as they can be reactivated by earthquakes or by exceptionally wet weather. They also consist of broken materials and frequently involve disruption of ground water flow. These dormant sites are more vulnerable to construction-triggered sliding than adjacent undisturbed material.

### **HISTORY:**

Most of the mass land movement hazards and losses in Lewis County occur in the mountainous areas where highways and other roads cut through steep-sided banks or below a cliff. The majority of the slides occur during the flood or rainy season.

In November 1990, residents near the North Fork of the Newaukum River (Weyerhaeuser land) noticed muddy water at the site of a previous 1984 mudslide. The mudslide shut down the water supply intake to the reservoir for the cities of Centralia and Chehalis. Both cities were forced to use alternate sites for public water. Centralia changed over to an alternate well system and never returned to using their intake. Chehalis returned to use their intake after the slide damage was repaired.

It is possible that the Centralia Seminary Hill reservoir breach on October 5, 1991 was caused by a hillside collapse (cause undetermined, but probably to be a mass land movement). The tank and hillside gave way and pushed mud and silt into a ten block residential district. One house was completely taken off its foundation and pushed 10 feet. Debris removal included over one million yards of silt and mud. The cleanup of the district and sewer system continued for several weeks.

After heavy seasonal rains in November 1994, a mass land movement occurred approximately one-half mile west of Randle between Peters and Silverbrook roads. An entire portion of a hill near State Route #12 rolled down onto the highway, making it impassable. The slide, where it crossed the highway was about 30 feet high and more than 100 feet wide. Just the clean-up estimates were \$1.2 million. It resulted in the closure of State Route #12 from November 22<sup>nd</sup> to December 4<sup>th</sup>. A 25-mile detour route through Elbe and Ashford was the only access. Due to the massive amount of dirt, debris, trees, and the unstable condition of the hillside, a two-lane detour road 2,000 feet long was constructed around the slide area. It was more than two years before a re-alignment of Highway 12 was completed.

In neighboring Cowlitz County a large deep-seated landslide in 1998 destroyed about 120 residences. Losses exceeded over \$20 million.

The winter storms of January 29 through March 11, 1999 brought snow, heavy rains, high winds and landslides. Heavily saturated soils and unstable soil conditions on the hillside above Kresky Avenue (Chehalis) resulted in a large mass land movement. It caused severe damage (in excess of \$100,000) to the Elks Lodge and the eventual removal of over 20 mobile homes from the Golden West Mobile Home Park.

Pe Ell had a newly installed water line collapse from another mass land movement from this same storm series in early 1999. It was reported that the erosion could undermine the basin where the wastewater was treated, resulting in raw sewage running directly into the Chehalis River. Preliminary repair estimates were \$316,000. The total Pe Ell general fund budget for 1999 was \$209,306.

From December 2005 into January 2006 a prolonged rainfall caused numerous landslides throughout the state. Slides, slumps or settlement closed lanes of Interstate 5, US 101, SR 4 SR 9, SR 14, SR 107, SR 105, SR 112, SR 116, SR 166, SR 302 and SR 530 for various periods. Governor Christine Gregoire declared a state of emergency following unprecedented 13 inches of rain in 26 days and \$7.3 million in damages to infrastructure (primarily transportation) in Clallam, Grays Harbor, Jefferson, King, Kitsap, Lewis, Mason, Pacific, Pierce, Skagit, Spokane and Thurston counties. After more winter storms, Governor Christine Gregoire signed an Emergency Proclamation on February 3<sup>rd</sup> requesting federal fund for all 39 counties.

Later that year on November 5<sup>th</sup>, a heavy rain and high winds brought flooding and landslides. State Route 508, on the east side of Bear Canyon, failed and the road was closed for several months while repairs were made to the highway. The upper Cowlitz River valley

was particularly hard-hit with numerous slides and debris flows that destroyed houses and seriously impacted state and local transportation infrastructure.

The Hanukkah Eve Wind Storm of 2006 brought hurricane force wind gusts and heavy rains to Western Washington between December 14<sup>th</sup> and December 15<sup>th</sup>. The storm brought with it a small amount of landslides reported around Western Washington.

The storm event of December 1-3, 2007 was a truly historic event where snow, strong winds, and heavy rainfall battered western Washington, triggering landslides and causing major flooding on numerous rivers. The storm came in three parts, bringing winds and heavy snow on December 1<sup>st</sup>. Warm temperatures and heavy rain on December 2-3 caused rapidly melting snow. Hurricane force winds blew into the area on December 3<sup>rd</sup>. Just west of Pe Ell, a massive debris avalanche along with numerous smaller landslides, blocked State Route 6, from Pe Ell to Raymond, isolating 21 households without electricity and water. In addition, State Route 8, just west of the SR 101 interchange in the vicinity of MP 18, State Route 12 in the vicinity of MP 17 between Porter and Malone, and SR 508 near Onalaska were blocked by landslides.

In the Chehalis headwaters area, the hardest hit area from the storm, nearly 20 inches of rain was recorded within a 48-hour period, most of that falling within the first 24 hours. Intense flooding followed the heavy rain, primarily along the Chehalis River, occurred. Woody debris and sediment, including material from more than 1,000 landslides in the Chehalis headwaters basin, clogged channels at bridges, creating temporary dams and causing widespread deposition of logs and debris, especially across the Boistfort Valley. The flood waters reached Chehalis and Centralia on December 3<sup>rd</sup>, inundating Interstate 5 with as much as 14 feet of water and flooding numerous homes. The flood waters persisted and kept I-5 closed until December 6<sup>th</sup>, when flood waters finally receded enough to reopen the interstate highway.

January 7-8, 2009 Storm was a Pineapple Express storm, brought warm rains that originated from around Kauai (Hawaiian Islands) and caused rapidly melting snow in a rain-on-snow event. The rainfall followed lowland snow in the Puget Sound region from December 2008 into January 2009, resulted in high amounts of flooding and saturation of soils. The hardest hit areas included eastern Lewis County.

In Lewis County, hundreds of debris flows between Morton and Randle flowed into the valley, destroying houses and blocking Highway 12. The debris flows were very long reaching, often transforming into hyper-concentrated flows on the valley floor and moving for miles downstream. Many of the hyper-concentrated flows were channelized into roadways by plowed snow from earlier snow storm events. Over 500 landslides were recorded in Eastern Lewis County with an unknown number of houses damaged.

### **VULNERABILITY:**

As the demand for a “home with a view” and population continues to grow, the potential for damage or destruction and loss of life increases. The vulnerability to mass land movement is largely dependent on slope, material, and water saturation. Water saturation is most

prevalent during the rainy season of the winter and spring months. An unequivocal predictor of mass land movement vulnerability is the occurrence of previous episodes in the same area.

Characteristics that are indicative of mass land movement hazard areas include but are not limited to:

- Bluff retreat caused by sloughing of bluff sediments, resulting in a vertical bluff face with little vegetation
- Pre-existing mass land movement area
- Tension or ground cracks along or near the edge of the top of a bluff
- Structural damage caused by settling and cracking of building foundations and separation of steps from the main structure
- Toppling, bowed or jack-sawed trees
- Gullying and surface erosion
- Mid-slope ground water seepage from a bluff face

**EFFECTS:**

Typical effects include, but are not limited to damage or destruction to the following:

- Roads and railroads
- Sewer and water lines
- Homes and public buildings

Many of the losses due to mass land movement may go unrecorded for the following reasons:

- Claims are not made with insurance companies
- Lack of coverage by the press
- Mass land movements affecting transportation may be recorded as “maintenance” costs

Even small incidents of mass land movement are expensive. Clean up costs may include the following:

- Debris clearance from streets, drains, streams, and reservoirs
- Minor vehicle and building damage
- Personal injury or death
- Livestock losses
- Timber losses
- Crop losses
- Fencing losses
- Damaged utility systems

**MITIGATION:**

Some actions that home and property owners should be encouraged to take in order to reduce the damaging effects of mass movement include the following:

- Consult a geotechnical expert for evaluation of landslide/mudslide hazards
- Take corrective measures to reduce risk of slippage
- Divert, contain and safely discharge water away from unstable slopes and structures
- Use interrupter drains to redirect groundwater flow away from vulnerable areas
- Plant low growing ground cover vegetation to improve slope stability
- Install flexible fittings on pipe and conduit to avoid gas, water and sewer leaks or damage to underground electrical lines

Other mitigation efforts include but are not limited to:

- Obtain maps that provide a technically sound identification of mass land movement hazards
- Inventory historic mass land movements
- Strengthen and reinforce regulatory standards, particularly through the Growth Management Act Critical Areas requirements
- Provide consistent building and grading code enforcement
- Expand requirement and review of geotechnical assessments and reports

**REFERENCES:**

Some websites of interest:

USGS

<http://www.usgs.gov>

Washington State Department of Natural Resources

<http://www.wadnr.gov>

Coastal Zone Atlas

<http://www.ecy.wa.gov/programs/sea/femaweb/pierce.htm>

## SEVERE STORMS

### **DEFINITION:**

Severe storms are atmospheric disturbances usually characterized by strong winds frequently combined with rain, snow, sleet, hail, ice, and thunder and lightning. Any heavy fall of snow, rain, or hail might be considered a severe storm in its own right.

The major types of inclement weather that have the potential to adversely affect Lewis County include:

#### **Blizzard**

Winter storm condition with sustained winds greater than 35 mph that cause blowing and drifting snow resulting in reduced visibility of ¼ mile or less.

#### **Hail**

Hail is a ball or clump of ice produced by thunderstorms. Large hail (greater than ¾" diameter) can be produced by repeated trips up and down through thunderstorm updrafts before falling to the ground. Hail consists of alternating layers of opaque and clear ice. Clumps of hail are called hailstones.

Hailstorms occur when freezing water in thunderstorm type clouds accumulates in layers around an icy core. Hail causes damage by battering crops, structures, automobiles, and transportation systems. When hailstorms are large (especially when combined with high winds), damage can be extensive.

#### **Heavy Rain**

Heavy rain is a situation when precipitation is heavy enough to either cause flooding or aggravate an existing flooding condition. A more in depth review is provided in the FLOOD section of this plan.

#### **Heavy Snow**

Heavy snow generally means snowfall accumulating to 4" or more in depth in 12 hours or less, or snowfall accumulating to 6" or more in depth in 24 hours or less below 2000 feet. Above 2000 feet, it means snowfall accumulations to 12" or more in 12 hours or less, or 18" or more in 24 hours or less.

## **High Wind**

A high wind is sustained winds of 40 mph and/or gusts to 58 mph. Windstorms are high winds with sustained speeds of at least 40 mph and/or gusts to 58 mph or greater and lasting at least two hours. They are often accompanied with thunder and lightning. Localized geographic conditions can exacerbate weather conditions moving through the region and cause wind intensity to increase.

## **Ice Storms**

Ice storms occur when moisture falls from clouds and immediately freezes on contact with the cold ground and other surfaces. It accumulates on exposed surfaces such as trees, roads houses, power lines, etc. The accumulated weight of this ice, especially when accompanied by wind, can cause damage to trees and utility wires resulting in loss of power and communications. Ice storms make driving and even walking extremely hazardous. Ice storms are usually of short duration from several minutes to a few hours. However, the danger left behind will last until a rising temperature allows for thawing.

## **Lightning**

Lightning is a luminous flash or discharge of atmospheric electricity as a result of tremendous voltage differences created by charge-pumping thunderstorm updrafts.

## **Thunderstorm**

A local storm (accompanied by lightning and thunder) produced by a cumulonimbus cloud, usually accompanied by gusty winds, heavy rain, and sometimes hail.

Severe storms often include two or more of the inclement weather patterns.

## **HAZARD IDENTIFICATION:**

All areas of Lewis County are vulnerable to severe storms. Topography plays a role in producing the local microclimates. Due to the wide range of topography, some areas will experience a higher frequency of one type of storm from another. Factors contributing to storms in Eastern Lewis County are often different than in Western Lewis County.

## **HISTORY:**

Because of their relatively small size and short life cycle, severe local storms have not been well documented in Lewis County. The October 12, 1962 Columbus Day Storm was the strongest windstorm recorded in Lewis County and Washington State and has become the windstorm of which all others are compared. This storm was the strongest widespread non-tropical windstorm to hit the continental U.S. during the 20<sup>th</sup> century, with its effects felt from northern California to British Columbia. The storm claimed 46 lives and caused the

loss of power to over 1 million homes. More than 50,000 homes were damaged costing an estimated \$235 million (in 1962 dollars).

The Inauguration Day Windstorm on January 20, 1993 brought hurricane force winds to King, Mason, Lewis, Thurston, Snohomish, Pierce and Wahkiakum counties. Total damages for all counties were estimated at \$130 million.

The following events stand out as examples of damaging severe storm events in Lewis County:

<b>Lewis County Severe Storms</b>	
<b>Date</b>	<b>Event Description</b>
November 3, 1958	No data available at this time.
October 12, 1962 Duration: 2 hours	Columbus Day Storm Toledo Airport Barometric Pressure: 28.70 Max Wind Speed: 89 Miles/hour \$235 million in damages.
January 12, 1980	Toledo Airport Nothing available SeaTac Airport Barometric Pressure: 28.76 Max Wind speed: Not available
January 20, 1993 Duration: 30 minutes	Inaugural Day Storm Toledo Airport Sustained winds or gusts of 74 MPH \$130 million in damages.
December 12, 1995 Duration: 6 hours 40 MPH/gusts 69 mph	Wicked Wind Storm Toledo Airport Barometric Pressure: 28.65 Max Wind speed: 67 miles/hour
January 16, 2000 Duration - 2 hours Winds 40 mph, gusts to 60	Wind Storm Centralia's Hydroelectric facility (Yelm-Centralia) received over \$40,000 in damage. One Lacey man killed.
December 14-15, 2006	Sustained winds and gusts up to 70 MPH. \$50 million in damages for 39 counties, Lewis County preliminary damages \$2.8 million.
December 1-17, 2007	Severe Storm – Heavy snow, flooding. Lewis County  Strong winds lasting up to 36 hours made this storm very unique and was responsible for much of the damage. Flooding of the Chehalis River lead to widespread flooding throughout western Lewis County, including a stretch of I-5, forcing 20 miles of the interstate to be closed for 4 days. Lewis County Preliminary damages \$166 million, One year later rose to \$512 million.
January 6-11, 2009	Severe Storms. Snow-flood event. The State's primary north-south rail line was closed. Interstate 5 was closed from milepost 68 to 89 for 43 hours due to water over the

<b>Lewis County Severe Storms</b>	
	roadway around Chehalis. The economic impact of this closure was estimated at \$12 million per day. Lewis County Preliminary damages \$1.7 million.
January 9-26, 2011	Severe snow and freezing rain. Lewis County per capita losses at \$9.42, state-wide losses at \$8.7 million. Preliminary East county damages \$814,000.
January 14-23, 2012	Snow Mageddon, freezing rain. Eleven counties reports \$32 million in preliminary damages, Lewis County per capital estimate was \$13.86. Lewis County preliminary damages was \$1.1 million.
January 5, 2015	Flooding, Newaukum & Skookumchuck rivers. Preliminary damages \$107,000.
November 14, 2015	Winter storm – Windstorm. 4 agencies reported \$583,767 in preliminary damages.
December 8-10, 2015	Winter Storm, Flooding. Preliminary damages \$3,505,000.
February 9-10, 2017	Winter Storm. Preliminary Lewis County damages \$1,216,800.

**VULNERABILITY:**

All areas of Lewis County are vulnerable to severe local storms. History shows that the county will encounter an average of one major snowstorm every ten years. The frequency of a major snowstorm is variable and is not predictable on a seasonal basis.

Ice storms also occur infrequently, but probably have a higher degree of probability.

Eastern Lewis County receives snow annually during the winter season, which is considered normal for that area.

Windstorms also occur infrequently, but can usually be predicted more accurately than other local storms. Lewis County can expect to experience at least one windstorm each year.

**EFFECTS:**

The general effects of most severe storms are immobility and loss of utilities. Transportation routes can become blocked, travelers and commuters can get stranded, and families can be separated. Additionally, because electrical lines are damaged, other utilities such as telephones (cell and landlines), natural gas, water and sewer systems can become inoperable.

Physical damage to homes and facilities can occur from winds or the accumulation of snow, ice, or hail. Even a small accumulation of snow can adversely affect transportation systems.

Traffic accidents due to icy streets have the potential for injury or death. There is also the threat of hypothermia deaths, especially among the elderly.

The number of house fires will increase as people try to heat their homes or cook with non-traditional methods.

Frequently, there is an economic deprivation to businesses, not just from storm related damage, but also from loss of business.

The affects of severe storms can vary with the intensity of the storm, the level or preparation of local jurisdictions and residents, and the equipment and staff available to perform necessary tasks to lessen the effects.

### **MITIGATION:**

Mitigation measures involve:

1. Burying both electric and phone lines underground to avoid weather damage and reduce the long-term repair costs.
2. Incorporating procedures for early warning notification, evacuation, and sheltering in the local emergency response plans.
3. Creating prioritized plans for road/street clearance and provision of emergency services.
4. Establishing mutual aid agreements with neighboring jurisdictions.
5. Providing written procedures for requesting county, state or federal assistance.
6. Establishing community-sponsored programs that advocate emergency preparedness through:
  - Family preparedness plans
  - Disaster kits for homes and vehicles
  - Preparation of school and business preparedness plans
7. Utilizing the National Weather Service (NWS) weather-warning network for public warning and alert notification. The following message definitions are used in the weather bulletins:

- **Storm Watch**

Used to indicate when the risk of hazardous weather or a hydrological event increases, but its occurrence, location, and/or timing is uncertain. It is intended to provide enough lead-time (12-36 hours) so those who need to set plans in motion can do so.

- **Storm Warning**

Used to indicate when hazardous weather or a hydrologic event is occurring, imminent, or has a very high probability of occurrence. A warning is typically issued within 12 hours of conditions posing a threat to life or property.

**REFERENCES:**

For more information on mitigation measures in Lewis County, see the Lewis County Hazard Mitigation Plan.

Some websites of interest:

[www.wrh.noaa.gov/seattle](http://www.wrh.noaa.gov/seattle)

[www.cpc.ncep.noaa.gov/](http://www.cpc.ncep.noaa.gov/)

# VOLCANO

## **DEFINITION:**

A volcano is defined as a vent in the earth's crust through which magma-molten rock (lava), rock fragments, gases, ash, etc., are ejected from the earth's interior.

Volcanoes take many forms, according to the chemical composition of their magmas and the conditions under which the magmas are erupted. When magma is erupted, it is referred to as "lava." Some lava, like those of the Hawaiian volcanoes (basalts), are hot and fluid. Rhyolites are those that are too stiff to flow and erupt explosively or form steep domes.

About midway on the scale are the andesites, the most common lava of the Pacific Northwest volcanoes. These are thick, flow slowly, and are moderately explosive. Dacite, the lava forming the dome of Mt. St. Helens, has some characteristics of both andesite and rhyolite.

Volcanic hazards include:

### **Lahars**

Lahars, also called volcanic mudflows or debris flows, are slurries of volcanic rock, sediment, and ash mixed with water that rush down stream and river valleys leading away from a volcano. They can travel more than 160 mph downstream, commonly reaching speeds of between 50 and 80 mph (the highest speed measured on the slopes of Mount St. Helens was 200 mph, the lowest in the lower valleys, about 7 mph). Sometimes they contain so much rock debris (60-90% by weight) that they look like fast-moving rivers of wet concrete.

Close to a volcano, lahars have the power to move huge boulders or destroy entire forests and demolish large buildings and bridges. Further downstream they simply entomb everything in mud. They may attain depths hundreds of feet in the canyons near their point of origin but spread out over valleys and low ridges downstream.

Although they are normally generated during an eruption by mixing of ash and lava with snow melt waters and rain, lahars do not need an actual eruption in order to form. Rapid release of water from a glacial outburst or heavy runoff caused by excessive rain and snowmelt can produce lahars even during periods of volcanic quiescence. A large earthquake may also serve to release enough rock and debris to create a lahar.

### **Steam and gas explosions**

Explosions of steam and other gases, containing suspended, pulverized fragments of older rocks (from pea-size to hundred-ton blocks), newly erupted hot lava "bombs" or

blocks, and a shock wave that may extend for several miles, may occur any time hot material comes into contact with water, glacial ice or snow.

### **Volcanic gases**

Pockets or clouds of toxic gases kill with chemical poisons, internal or external burns, or asphyxiate by replacing oxygen. Carbon dioxide, is heavier than air, odorless and colorless and may collect in low areas on or near both active and inactive volcanoes. Gases mixed with ash makeup the eruptive cloud, the “smoke” of the volcano.

### **Pyroclastic flows**

High-speed avalanches of hot ash, rock fragments and gas move down the sides of a volcano during an explosive eruption or when the dome breaks apart and collapses. These pyroclastic flows can reach 1832° Fahrenheit and move at 160-250 mph and are capable of knocking down and burying everything in their paths.

### **Tephra and volcanic ash**

The fragments from such an eruption, ranging in size from microscopic ash to boulders three feet in diameter are collectively called tephra. Tephra forms a deposit that blankets broad areas downwind from the volcano, generally decreasing in thickness and particle size as distance from the source increases.

### **Volcanic landslides, debris avalanches, and glacial outburst floods**

Volcanic landslides and debris avalanches are glacial ice or rock debris that are set in motion by explosions, earthquakes, collapse of crumbling cliffs, or heat-induced melting of ice and snow. Heat melts glacial ice and/or snow cover and may begin a flood or mudflow. Earthquakes, heavy rains, or rapid snowmelt may release melt water (previously stored water) behind an ice dam or beneath a glacier. This type of outburst flooding can occur unrelated to any eruptive activity.

### **Volcanogenic earthquakes**

Volcanic earthquakes, centered within or beneath the volcano, are usually one of three kinds:

- Pre-eruption earthquakes caused by explosions of steam or underground magma movements
- Eruption earthquakes caused by explosions and collapse of walls inside the crater
- Post-eruption earthquakes, caused by magma retreat, and interior structural collapse

## **HAZARD IDENTIFICATION:**

The Cascade Range extends more than 1,000 miles from southern British Columbia into northern California and includes thirteen potentially active U.S. volcanic peaks. Many of these volcanoes have erupted in the recent past and will be active again in the future. Given an average rate of two eruptions per century during the past 12,000 years, these disasters are not part of our everyday experience; however, in the past hundred years, California's Lassen Peak and Washington's Mount St. Helens have erupted with terrifying results. The explosive disintegration of St. Helens' north flank in 1980 vividly demonstrated the power that the Cascade volcanoes can unleash.

Lewis County is vulnerable to the effects of volcanic activity from Mt. St. Helens, Mt. Rainier, and Mt. Adams. The Cowlitz Glacier on Mt. Rainier feeds the Cowlitz River headwaters. The river flows through eastern and southern Lewis County. It is susceptible to mudflows and flooding in the event of major volcanic activity at Mt. Rainier. A portion of the lower Cowlitz near Toledo could also be affected by extreme flooding from Mt. St. Helens and/or Mt. Rainier.

The degree of hazard depends on the type of eruption and proximity to the event. Most of the danger is in the immediate vicinity of the volcano. Other dangers, such as mudflows and ash fall, may exist many miles both downstream and downwind.

Fatalities, injuries, and property damage from tephra and volcanic ash occur where ash-sized fallout from the eruption accumulates on roofs and other man-made structures (especially when the ash is wet). A one-inch deep layer of ash weighs an average of ten pounds per square foot.

A combination of acidic gas and ash may cause lung damage to the very young, very old, or those already suffering from respiratory problems. When an ash cloud combines with rain, sulfur dioxide combines with water to form diluted sulfuric acid that may cause painful burns to skin, eyes, and mucous membranes, nose, throat, etc. Acid rains may affect water supplies, strip and burn foliage, strip paint, corrode machinery, and dissolve fabric.

Heavy ash falls blot out sunlight. Sudden heavy demand for electric light and air conditioning may cause a drain on power supplies, leading to a partial or full power failure. Ash clogs watercourses and machinery of all kinds. It causes electrical short circuits, drifts into roadways, railways, and runways. Its accumulative weight may cause structural failure. Ash remains a hazard to machinery and transportation for months after an eruption.

Hazards of steam and gas explosion blasts include suspensions of cold rock particles. They are sometimes accompanied by hot or cold mud, blocks of old rock, and shock.

A glacial outburst flood or volcanic landslide, even if it does not become a full-fledged mudflow, is a serious concern in the Cascade valleys near the volcanoes. These floods come without warning, travel rapidly, and carry large amounts of debris. Most Cascade outburst floods have occurred between August and November, but they can occur at any time of the year.

Lava flows from the Cascade volcanoes tend to be short and slow moving because of the thick, relatively low-temperature magma that feeds them. They may issue from the main volcanic vent or from nearby cinder cones formed at or near the base of the mountain. The heat of lava may start forest or grass fires. Flows may bury roads or other escape routes.

Volcanogenic earthquakes generally have a shallow focus, and although they may be felt strongly near the volcano, their effects are most often confined to a small area around the epicenter. There are some exceptions, as with the “St. Helens Fault Zone”, where a tectonic (earth’s crustal structure) fault is closely associated with the volcano. Volcanic earthquakes may cause large rock falls, snow avalanches and landslides. Since all Northwest volcanoes are in seismically active area, earthquakes should be evaluated for their volcanic potential by qualified geophysicist/seismologists.

### **HISTORY:**

Eruptions of Cascade volcanoes are infrequent events, occurring perhaps once or twice in a lifetime. As a result, the volcanic hazard is taken lightly, if considered at all.

Lewis County is close enough to be directly affected by eruptions from any one of three volcanoes (Mt. St. Helens, Mt. Rainier, and Mt. Adams). The explosive history of Mt. St. Helens and the geological evidence that shows major lahar and debris flows have affected areas of the county provides clear evidence that this danger is real. Mt. St. Helens is the youngest, most frequently active, and often the most explosive volcano in the Cascades. During the past 4,000 years, it has produced many lahars and a wide variety of eruptive activity, from relatively quiet outflows of lava to explosive eruptions much larger than the one on May 18, 1980. In recent historical times, Mt. St. Helens was active from 1831 to 1856, and “reawakened” in March 1980 with two eruptions and a series of earthquakes leading up to a major eruption on May 18, 1980. During the past 200 years, Mt. St. Helens has erupted three times, suggesting a reoccurrence interval of about 70 years. A summary of the Mt. St. Helens activity 1980-86 is shown in the Significant Eruptions in the History of Northwest Volcanoes table.

The May 18, 1980 eruption of Mount St. Helens generated a lateral pyroclastic blast that destroyed an area of 1600 square miles and is computed to have had a initial velocity in excess of 1300 mph. Trees 6 feet in diameter were snapped off at ground level as far as 40 miles from the mountain.

The eruption claimed 57 lives and caused nearly a billion dollars in property damage, transportation, and response costs. In addition to the direct damage and response cost was the economic loss due to road, highway, and forest closures. The effects were felt throughout the northwest.

Never before in Lewis County have emergency planners, response personnel, and the general public been so aware of and concerned with volcanic activity. Although the volcano is located in the neighboring Skamania County (to the southeast) Lewis County has been greatly affected.

While geologists can monitor and usually predict ensuing activity, they cannot predict future major eruptions or how long a volcano will remain active. At this time, geologists still consider Mt. St. Helens as an active volcano.

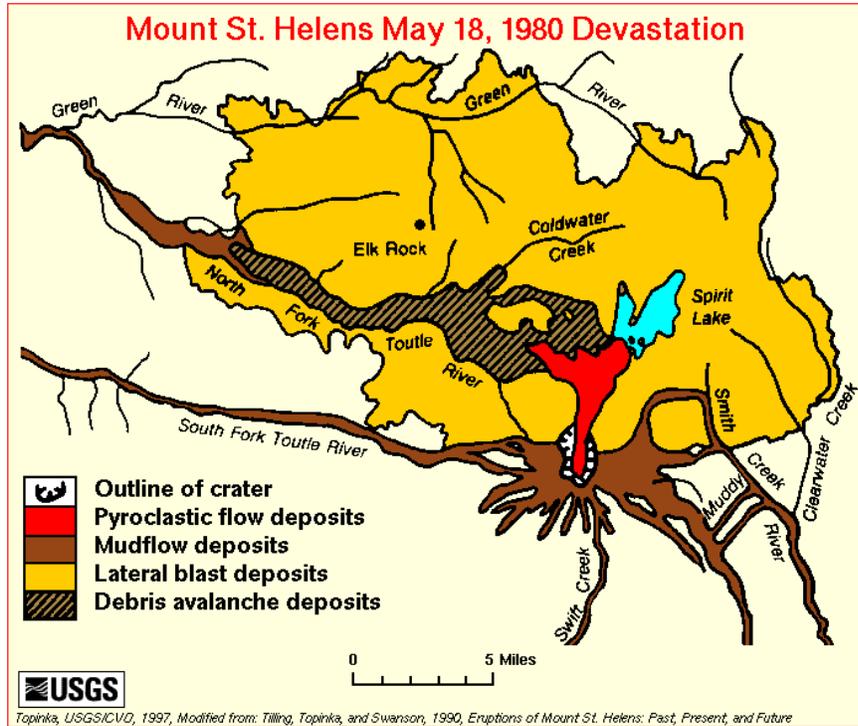
A history of significant eruptions of Northwest volcanoes is shown below.

<b>Summary of activity of Mt. St. Helens, 1980 – 1986</b>					
<b>Date*</b>	<b>Explosive Activity</b>	<b>Pyroclastic Flows</b>	<b>Lava Flows (dome)</b>	<b>Lahars</b>	<b>Erupted Volume** (million cubic yards)</b>
05/18/80	X	X		X	1.4 billion cubic yards
05/25/80	X	X			41.8
06/12/80	X	X	X		54.5
07/22/80	X	X			13.1
08/07/80	X	X	X		7.2
10/16/80	X	X	X		3.6
12/27/80			X		2.1
02/05/81			X		4.7
04/10/81			X		5.4
06/18/81			X		5.4
09/06/81			X		5.1
10/30/81			X		4.7
03/19/82	m		X	X	4.4
05/14/82			X		3.5
08/18/82			X		6.0
02/07/83**	m		X	X	29.3
* 03/29/84			X		1.4
06/17/84			X		1.2
09/10/84			X		4.8
05/24/85			X		5.6
05/08/86			X	m	7.6
10/21/86			X		8.0
m Minor * Explosive activity usually lasted hours and dome-building usually lasted days ** Volumes based on lava flows plus un-compacted air-fall ash and pyroclastic flows *** Dome growth continued for almost a year					

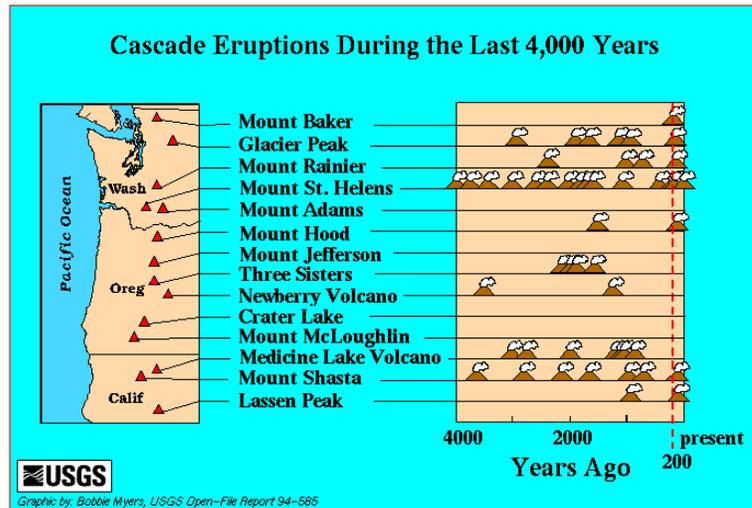
Jurisdictions at risk to lava flow and lahar are identified in the table below with annual probabilities. Once a volcano becomes restless or begins to erupt, the probability for lahars and other effects increase greatly over these long-term averages.

<b>Volcano</b>	<b>Lahar</b>	<b>Annual Probability</b>
Mount Adams	Reaches Trout Lake	1 in 100 to 1 in 1,000
Mount Rainier	Debris Flows within National Park	>1 in 100
	Inundates Nisqually River (National Lahar)	1 in 100 to 1 in 500
	Reaches Puget Sound lowlands (Electron Mudflow)	1 in 500 to 1 in 1,000
	Reaches Puget Sound (Osceola Mudflow)	<1 in 10,000
Mount St. Helens	Not calculated due to 1980 eruption	

<b>Significant Eruptions in the History of Northwest Volcanoes</b>		
<b>Volcano</b>	<b>Years ago of Eruption (Unless noted as A.D.)</b>	<b>Type of Eruption</b>
Mount Adams	6,600 – 10,000	Flank eruption of lava.
	3,500 – 6,600	Lava
	1,000 – 2,000	Flank eruption of lava.
Mount Baker	Postglacial – 10,350	Sulfur Creek mudflows and tephra.
	6,000 – 10,350	Tephra and pyroclastic flows. Bolder Creek lava flows. Sulphur Creek mudflow and lava flow. Park Creek mudflow. Middle Fork Nooksack River mudflow.
	300 – 6,000	Tephra. Middle Fork Nooksack River and Park Creek mudflow.
	Within last few centuries	Bolder Creek mudflow and tephra. Rainbow Creek avalanche.
	1843 A.D.	Ash fall.
	1958 A.D.	Bolder Glacier mudflow and avalanches.
	1975	Sherman Crater increased steam and gas activity.
Glacier Peak	11,000 – 13,000	Tephra, lahars, pyroclastic flows, and dome.
	5,100 – 6,600	Tephra, lahars, and pyroclastic flows.
	1,750 – 2,800	White Chuck dome.
	90 – 2,800	Tephra and ejecta.
	Before 8,750	Tephra
Mount Rainier	5,000 – 6,000	Tephra, debris flows, and avalanches. Paradise mudflow.
	2,200 – 4,700	Tephra
	2,000	Present summit cone lava flows and mudflows.
	1,000 – 2,000	Pyroclastic flow and lahars.
	600	Electron lahar.
	300-500	Debris and mudflows.
	125	Tephra
	1820 – 1894 A.D.	Minor tephra eruptions.
Mount Saint Helens	8,000 – 13,500	Tephra
	1,800 – 4,000	Tephra, pyroclastic flows, mudflows, domes, and lava.
	1,750	Cave basalt flow.
	1,650	Tephra and mudflows.
	1,100 – 1,200	Lateral explosions of east side dome.
	1480 – 1482 A.D.	Tephra, pyroclastic flows, and mudflows.
	1480 – late 1700s A.D.	Summit dome pyroclastic flows, mudflows, and tephra. Worm flows. Kalama eruptive period.
	1800 – 1857 A.D.	Tephra. Floating Island lava. Goat Rockdome and eruptive period.
1980 A.D.	Lateral explosion of north face. Extensive tephra fall, lahars, and pyroclastic flows.	



Devastation area from May 18, 1980 eruption



Cascade Eruptions

## **VULNERABILITY:**

The degree of volcanic hazard depends on the type and size of eruption and proximity to the eruption. The greatest threat to life is to people living in or near the vicinity of a volcano. Other dangers to life and property, such as ash fall, mudflows, and flooding may exist miles downstream or downwind.

The greatest volcanic threat to human life and property in Lewis County is from lahars or debris flows from Mt. Rainier or Mt. St. Helens. Lewis County could receive significant ash fall from Mt. St. Helens, Mt. Rainier, or Mt. Adams. Mt. St. Helens has a past history of violent eruptions accompanied by heavy ash fall. A future eruption would be expected to deposit significant ash fall across Lewis County.

Violently explosive eruptions are likely in the future, but the cumulative annual probability of experiencing such an event is very low.

## **EFFECTS:**

### **Tephra**

With proper wind conditions, tephra could be deposited in Lewis County from several of the Cascade volcanoes, including those in Oregon. The greatest impact on the Lewis County area would occur if Mt. Rainier erupted when there was a northeast wind. This would deposit the majority of ash in Western Washington and affect the populated areas of Lewis County. Depending on the size of the eruption and time of year, the ash could:

- Clog drainage channels
- Cause electrical short circuits
- Drift onto roadways, rail lines and airport runways causing accidents
- Collapse roofs of houses and other buildings
- Cause skin and eye irritation to the general population and or respiratory distress to the aged, the infirm, the very young, or those who already have decreased respiratory flow
- Clog engines and air filters and create acid rain, which may affect water supplies, strip paint, burn foliage, corrode machinery, and age fabric
- Disrupt radio, television, and telephone transmissions

Since the ash remains on the surface, it can be re-suspended in the atmosphere when disrupted by wind or human activities.

### **Pyroclastic flows**

Pyroclastic flows may cover miles; killing, burning, and burying most everything in their path. A pyroclastic flow descending a glacier can melt significant quantities of ice causing an eruption-associated lahar. If a pyroclastic flow were to enter a forest on the flanks of Mt. Rainier, it could start a forest fire.

## **Lahar flows**

Lahar Flows can:

- Overwhelm roads and railroad tracks
- Destroy bridges and other public and private property
- Kill both wildlife and the people caught in the path
- Destroy forest and other agricultural products grown

In addition, it can destroy the river's fisheries, which may take years to recover.

Lahars containing greater than 3% to 5% clay tend to be cohesive and are able to maintain their identity as debris flows that cause damage up to 160 mi downstream. For comparison, there is approximately 7 cubic mi of ice locked up in the glaciers of Mt. Rainier compared to the less than 0.3 cubic miles of ice that existed on Mt. St. Helens prior to the 1980 eruption. Therefore the ice on Mt. Rainier has the potential to produce debris flows many times greater than that which occurred on Mt. St. Helens.

## **Glacial outbursts**

Glacial outbursts, floods, and other small debris flows form suddenly without warning. Like lahars, they travel down valleys causing extensive damage to buildings, roads, vegetation, wildlife and people in their paths. In Lewis County, glacial outbursts should have a more limited volume than a lahar that melts large amounts of glacial ice and snow.

Due to the large amount of non-cohesive material in most debris flows of this sort, the flow volume should reduce rapidly in response to valley widening, slope reduction or confluence with other streams. The majority of damage should be confined to the relatively steep sloped upper few miles of the watersheds where there are few, if any, manmade objects.

## **Rock Avalanches**

Rock avalanches can cause extensive damage over limited areas directly adjacent to Mt. Rainier, Mt. St. Helens and Mt. Adams. The situation where people might be affected is when climbers and/or hikers are below a section that collapses. Threats to buildings and campgrounds are limited.

## **Lava**

Lava flows are not considered a problem except on the volcano. Due to the highly viscous nature of the lava, direct damage will primarily consist of the burying of roads or other escape routes, damage to a few park buildings, and the starting of forest fires or grass fires. The greatest threat of a lava flow comes from the affects that could produce a lahar.

**MITIGATION:**

In studying Mt. Rainier and Mt. St. Helen's eruptive history, volcanologists and geologists know that they will erupt again. Since the exact type and scale of the eruption(s) cannot be predicted, emergency planning and preparation must not be postponed.

Lewis County identifies this risk to be significant and has taken measures to lessen the negative impact on residents and business communities located in the river valleys. The county continues work on evacuation planning and route identification projects, maintaining a lahar warning system with Pierce County, and advocates the use of weather radios for communities in the upper valleys.

The best method of mitigating the threat of volcanic hazards to life and property is to prohibit development in areas of Lewis County endangered by these hazards. Land use planning for critical facilities and new development must follow the Washington State Growth Management Act's guidelines for high volcanic risk areas. Local jurisdictions' emergency plans must be adequate to provide for quick response to volcanic activity.

Experience at Mt. St. Helens showed the need for specialized protective equipment for both vehicles and people working in the shadow of a volcanic eruption. Breathing masks and other respiratory protection equipment are required for workers/emergency responders. Similarly, air filtration is mandatory for vehicles operating in heavy ash fall.

**REFERENCES:**

For more information on mitigation measures in Lewis County, see the Lewis County Hazard Mitigation Plan.

USGS:

<http://earthquake.usgs.gov/>

Washington State Department of Natural Resources, Geology and Earth Resources Division:

<http://www.wa.gov/dnr/hdocs/ger/>

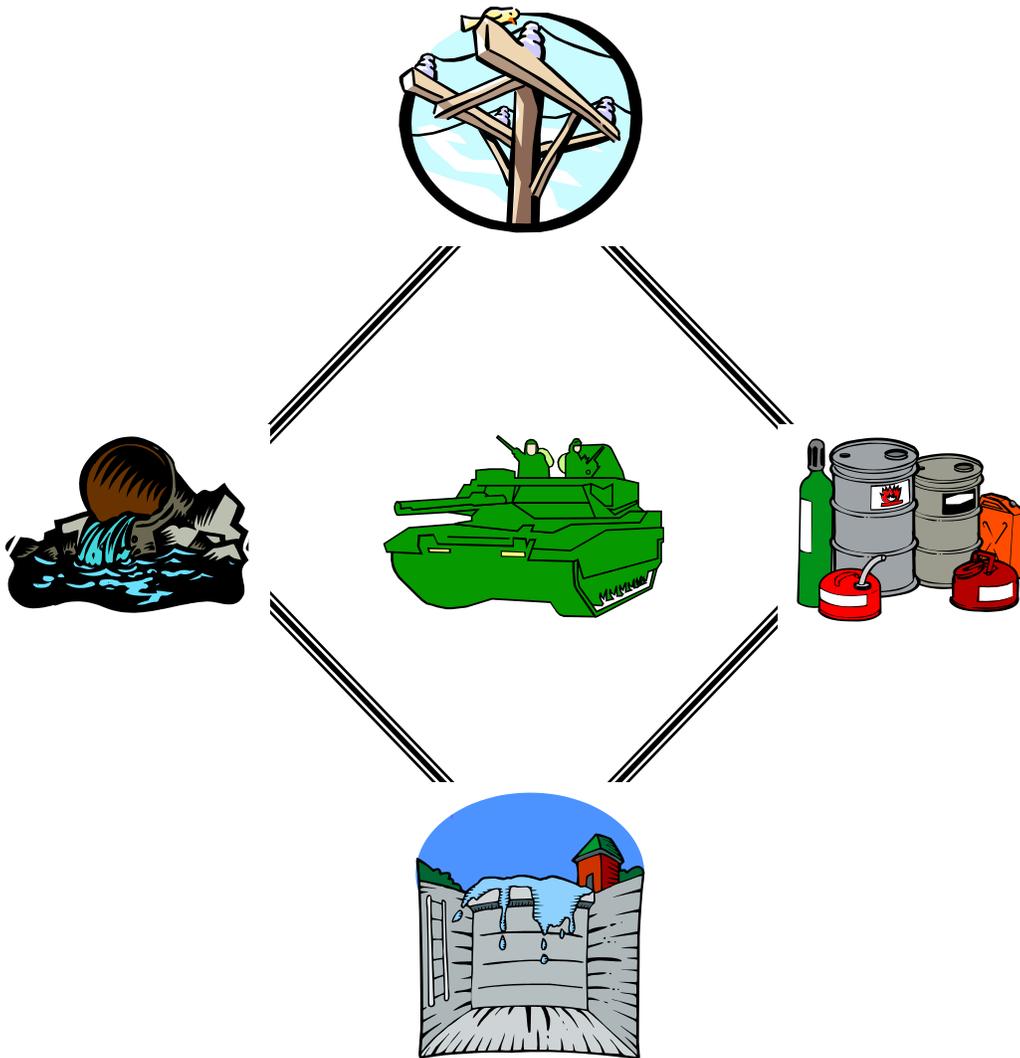
USFS:

<http://www.fs.fed.us/gpnf/>

National Weather Service:

<http://www.wrh.noaa.gov/seattle/>

# Technological Hazards



## **CIVIL DISTURBANCE**

### **DEFINITION:**

Civil disturbance is any incident that disrupts a community where intervention is required to maintain public safety. Civil disturbance spans a variety of actions including labor unrest, strikes, civil disobedience, demonstrations, riots and rebellion. Events that could trigger these actions include racial tension, unemployment, unpopular political actions, and decrease in the supply of essential goods or services.

### **HAZARD IDENTIFICATION:**

Today's "civil disturbance" has taken on a more deadly connotation than activists' demonstrations, riots or looting from earlier days; and is much more frightening to the general populace. It is the role of the pipe bomber, political terrorist, the hi-jacker, and the person who poisons items in a supermarket.

Although not restricted to urban areas, civil disturbances tend to occur more often in cities or congested areas. Looting may occur with riots, or be sparked by natural or technological disasters that engage the police force with other activities. Rural as well as urban areas are subject to rioting, looting, and acts of widespread violence.

Lewis County's electrical plants, gas pipelines power-generating stations, Planned Parenthood offices, dams and jails are vulnerable targets and potential sites for civil disturbance.

In areas of the county with a lower population density, there are continued complaints from citizens that their rights are being violated through land use regulations, that their needs are being ignored, and that the more urbanized areas get most of the benefits. While much of this discontent is unorganized, the potential for civil disturbance is there.

Acts of civil disorder are not always initiated by large groups, as evidenced by the 2002 sniper attacks across the United States that involved only two people. Bomb threats, poisoning, or hi-jacking may involve only one deranged or mentally unbalanced person. This type of person could also terrorize a neighborhood and possibly, be a resident, whose violence erupted from a domestic dispute.

### **HISTORY:**

Some examples of civil disturbance in Lewis County are "The 1919 Centralia Massacre", environmental demonstrations on US Forest Services lands, and labor demonstrations at local businesses.

On November 11, 1919, Centralia was celebrating Armistice Day with a parade of World War I Legionnaire veterans. There had been escalating hostilities between the veterans group and an organized labor union called the Industrial Workers of the World (IWW). No one knows for sure who started it, but the parade ended in a burst of gunfire that caused the deaths of four veterans and wounded three others. Martial law was declared and a curfew was enacted. Later one man was taken from jail and lynched by a band of unspecified citizens. There were subsequent arrests, trials, and jail time for eleven men. The incident caused years of bitterness in the community.

The November 1999 World Trade Organization (WTO) event in Seattle demonstrated how crowds of demonstrators could get out of control and cause harm to both property and citizens. Over 500 people were arrested in one day. Besides the physical violence that took place, there were numerous incidents of looting and vandalism. This incident drew upon fire, EMS, and law enforcement resources from within Lewis County.

### **VULNERABILITY:**

Large cities are the most highly vulnerable areas for civil unrest and civil disturbances. In Lewis County, this includes Centralia and Chehalis. However, as other cities grow, their vulnerability also increases.

Immediate vulnerability and dangers include injury and loss of life from gunfire, poison, explosions, and assault. Damages may also occur to highways and other portions of the infrastructure, buildings, property, and the environment from looting and fires associated with riots and demonstrations. Long-term damages result in economic loss to businesses and tourism.

Civil disturbances can lead to the elimination of services and utilities for several days because of damage to facilities or the refusal of workers to return to their jobs. Fear, itself, will interrupt the normal functioning of a community.

### **EFFECTS:**

Civil disturbance can, in extreme cases, cause extensive social disruption, loss of jobs, death, and property damage. These may result either from those involved in the action or initiated by those in higher authority in response to what they perceive as a threat to either the status quo or their own authority. In addition, the government may also curtail certain civil liberties even to the eventual imposition of martial law.

Looting and general vandalism are the most common activities associated with civil disturbance. Fire setting is also quite common and can quickly spread due to slow response times of overwhelmed fire departments. Transportation routes can become blocked making it difficult for non-rioters to leave the area and difficult for the emergency response personnel to arrive.

Long-term effects may include a local depressed economy, environmental damage, social disruption, and long lasting animosity between the contending groups.

**MITIGATION:**

The variable nature of civil unrest demands a cautious approach to the actual situation. In order for society at large to prevent or mitigate civil unrest it must be responsive to social problems inherent in the community. As conditions that could lead to widespread civil unrest arise, the prevailing authorities must monitor the situation and then plan and execute whatever actions are needed in order to lessen the tension and/or resolve the dispute.

The ability to respond quickly is a crucial mitigation act. Thus, emergency response agencies should plan and train for such events.

Local, state and federal law enforcement officials are on constant alert for information indicating the possible outbreak of civil disturbances.

The Federal Bureau of Investigation (FBI) monitors suspected terrorist activity and subversive activist groups.

Emergency Management maintains warning and alert systems that can be utilized to alert and inform the public. Usually a community will have a “warning period”, as unrest and violence build over a period of time. In the event that a potential incident is foreseen, the public will be alerted and instructed to stay clear of the disturbance.

## **DAM AND RESERVOIR FAILURE**

### **DEFINITION:**

Dam or reservoir failure is the uncontrolled release of impounded water resulting in downstream flooding, which can affect life, property, and economic viability.

Flooding, earthquakes, blockages, landslides, lack of maintenance, improper operation, poor construction, lahars, vandalism, and terrorism can cause dam or reservoir failure. While the affects may be total collapse of a dam, that is not always the case.

### **HAZARD IDENTIFICATION:**

The major dam projects in Lewis County are the Mayfield, Mossyrock and Cowlitz Falls dams. An earthen dam located in Thurston County that would affect Lewis County is located on the Skookumchuck River.

#### **Cowlitz Falls Dam**

Completed in 1994. It is a 145-foot high concrete structure. The drainage area takes in approximately 1,042 square miles. It provides a total storage of 11,000 acre-feet of water with a water level at normal reservoir elevation of 862 feet.

#### **Mossyrock Dam**

Completed in 1968. It is composed of a 605-foot high concrete arch dam. The drainage area above Mossyrock Dam is 1,042 square miles. It provides a total storage of 1,685,100 acre-feet at the maximum normal reservoir elevation of 778.5 feet.

#### **Mayfield Dam**

Completed in 1963. It is a 250-foot high concrete structure. The drainage area above Mayfield Dam is 1,400 square miles and provides a total storage of 133,718 acre-feet at the maximum normal reservoir elevation of 425 feet.

#### **Skookumchuck Dam**

It is composed of a rolled earth-filled embankment with a crest length of 1,320 ft. and a height above streambed of 160 ft. The drainage area covers approximately 62 square miles. It provides a total storage of 35,000 acre-feet at the maximum normal reservoir elevation.

### Reasons for Dam Failures:

#### **Overtopping** – 34% of all failures (nationally)

- Inadequate Spillway Design
- Debris Blockage of Spillway
- Settlement of Dam Crest

#### **Foundation Defects** – 30% of all failures

- Differential Settlement
- Sliding and Slope Instability
- High Uplift Pressures
- Uncontrolled Foundation

#### **Piping and Seepage** – 20%

- Internal Erosion Through Dam caused by Seepage – “Piping”
- Seepage and Erosion Along Hydraulic Structures Such as Outlet
- Conduits or Spillways, or Leakage Through Animal Burrows
- Cracks in Dam

### **HISTORY:**

In January 1971 the George Raatz Dam, a small dam on Sulphur Creek near Swofford in Lewis County overtopped due to an inadequate spillway. Complete failure of the dam was prevented by construction of an emergency spillway at the left abutment (ordered by the Department of Ecology). Later this dam was breached and never reconstructed.

On October 5, 1991 two water supply reservoirs for the City of Centralia failed. Reservoir #3, constructed in 1914, contained about 3.5 million gallons of water. Reservoir #4 was constructed in 1926, and contained about 5 million gallons. Both reservoirs were 20 feet deep and were constructed by cut and fill methods into the steep hillside. The reservoirs were lined with un-reinforced concrete, with copper strips at panel seams to minimize leakage. An under-drain system was provided beneath the reservoir floors to collect leakage.



**Centralia Reservoir failure in October 1991, which sent over 8.5 million gallons of water downhill into a residential area of the city of Centralia.**

The failure occurred without warning. Reportedly, Reservoir #3 was emptied in 3 minutes, with a peak channel discharge of 2500 cfs. Reservoir #3 failed first, causing the break of the service and drain lines for Reservoir #4. The 5 million gallons contained in Reservoir #4 drained for several hours after the failure. A massive landslide in the siltstone rock formation that underlies the reservoirs caused the reservoir failure. The cause of the landslide was likely due to increased seepage into the rock foundation through continued deterioration of concrete panel seams, and a 2-foot raise in the reservoir pool elevation from the previous year.

The reservoirs had been drained and cleaned in August, and apparently no unusual conditions were noted. However, the cleaning crews did not document their inspections of the seams. Further, the city did not routinely inspect the under-drain outfall (which was in a deep manhole) to see if seepage was increasing or decreasing. Judging from portions of the under-drain pipe exposed by the failure, the under-drains may have been clogged, significantly restricting their ability to discharge seepage. This, in turn, may have led to increased seepage into the siltstone foundation.

The reservoirs were located on Seminary Hill above the city of Centralia. The flood first passed through an uninhabited park in a ravine, then discharged into a crowded neighborhood causing appreciable damage. A Boy Scout Troop was clearing debris in the ravine at the time of the failure, but was able to scramble out of the way of the flood wave. Two homes were knocked off their foundations and destroyed. Several other homes were severely damaged by the water and mudflow. Many other homes had silt and mud deposited in their yards. No lives were lost in the failure. This may be attributed to the fact that the failure occurred at 10:15 a.m. on a Sunday morning and few people were outside.

Financial damages from the failure were significant. Damages to the neighborhood totaled over \$3 million. In addition, the city of Centralia lost much of its online storage for several months. The reservoirs were replaced with tanks.



**Home damaged by failure of Centralia Reservoir.**  
Source: Washington State Department of Ecology, Dam Safety

**VULNERABILITY:**

A dam located in a rural area with a limited number of acre-feet of storage capacity can fail and have little or no effect on those living in the county. However, an urban-based population continues to move into areas downstream from dams and increases the potential for a catastrophic incident.

Traditionally our valleys were the scenes of agricultural production. Where agricultural crops used to grow there are now houses, warehouses, and businesses of all types. This puts not only more lives at risk, but it also increases the potential for economic damage.

Several areas of Lewis County are vulnerable to dam failures. Were the Skookumchuck Dam to completely fail, the city of Centralia, located 12 miles downriver, would be inundated with several feet of water, resulting in serious flooding of the business and residential districts.

Failure of the Mossyrock Dam would cause a failure of the Mayfield Dam that would result in a catastrophic event. All developments, towns and cities along the lower Cowlitz River and tributaries would be severely inundated. In Lewis County, this would include Mossyrock, Silver Creek, Salkum, Toledo, Vader, recreation areas on the lakes, and roads, and many rural residences.

**EFFECTS:**

The effects of a reservoir or dam failure will be variable depending upon the amount of water released and the types of structures and terrain that would be affected.

General effects may include, but are not limited to:

- Loss of life
- Destruction of homes and other property
- Damage to roads, bridges, and other lifelines
- Destruction of agriculture
- Deposition of mud and other debris
- Economic disruption as well as economic losses that result from a lowered tax base and lack of utility profits
- Loss of flood control capabilities
- Loss of power generating capabilities
- Disruption of fish stocks and spawning beds
- Erosion of stream or river banks with the resulting loss of land

## **MITIGATION:**

To help minimize or mitigate the impact of dam failures, a variety of agencies monitor and inspect dams for safety, conduct maintenance operations, and facilitate local training. These agencies and duties include but are not limited to:

### **Dam Operators/Owners:**

- Conduct periodic inspections combined with follow-up engineering analysis. These inspections are to identify defects; evaluate operations and maintenance; assess structural integrity and stability; determine the ability of the spillways to accommodate floods; assess the structures stability under earthquake conditions
- Maintains and updates an Emergency Action Plan (EAP) that includes callout notification to Lewis County E911 Communications and Emergency Management
- Conducts training exercises with local emergency management and first responders

### **Department of Ecology (DOE):**

- Inspects at least once every six years
- Requires that dams located above populated areas have an emergency action plan (EAP) developed in conjunction with the local jurisdiction's emergency management agency. All four major dam structures effecting Lewis County have provided updated EAPs to Lewis County Emergency Management.

### **Federal Energy and Regulatory Commission (FERC):**

- Conducts annual dam safety inspections
- Monitors any cracks, dam movements, compliance with project minimum flow requirements, sediment buildup and foliage growth
- Requires five-year inspections and safety report. This can include in-dept stability analyses, site-specific earthquake studies, and maximum flood studies.
- Requires dams be in compliance with FERC regulations and recommendations

### **Emergency Management:**

- Maintains emergency alert and warning systems that can be utilized to alert and inform the public
- Maintains and updates the Lewis County Comprehensive Emergency Management Plan (CEMP)
- Maintains an Emergency Coordination Center (ECC) and liaison with first responders in Lewis County
- Participates in dam safety exercise and planning efforts and acts as the facilitator between the dam operators and first responders

## **EPIDEMIC**

### **DEFINITION:**

Epidemics are outbreaks of disease that affect, or threaten to affect, a significant portion of a population in a relatively short period of time. Although usually referring to human contagious disease, epidemics can also affect crops and domestic/wild animals. Epidemic diseases are usually introduced into an area from remote regions and inflict devastation because there is no natural or induced immunity.

### **HAZARD IDENTIFICATION:**

The entire population is vulnerable to an epidemic. Depending on the disease, there could be short or long term debilitation and massive loss of life. An epidemic can spread very rapidly among citizens in a community (schools, churches, meeting and work places).

Loss of productivity and efficiency could have a devastating impact on the economy and on the provision of essential public safety and health services. If large numbers of people are affected, it could overtax the local health department and hospitals, especially if those agencies are responding to another disaster.

There is growing concern that an epidemic, whether terrorist related, or natural, could affect large segments of the population due to the increased mobility of the public.

A number of diseases have had or have the potential to affect the population's health in the county. A few of these include:

- Acquired immune deficiency disorder (AIDS)
- Measles
- Hepatitis B
- Tuberculosis (TB)
- Standard winter/fall flu
- E-Coli
- Lyme Disease
- Hantavirus Pulmonary Syndrome (HPS)
- West Nile Virus

## **HISTORY:**

During World War I (1917-1918), Spanish influenza, which affected young adults, spread worldwide. Locally, long-time residents recall everyone wearing protective masks and “quarantine” signs placed on houses where families had contracted the influenza. In Lewis County a number of people died from the influenza. Nationwide it is estimated that 20 million people died due to the outbreak.

The 1957/58 Influenza Pandemic was on the whole much milder than that of the 1918 influenza, with the global death toll reaching 2 million. Due to advances in science from the 1918/19 influenza, worldwide vaccine production began shortly after the pandemic of 1957/58 and 1968/69, likely lessening the death rates for both of these events.

The 2009/10 novel influenza A (H1N1) is a new flu virus of swine origin that first caused illness in Mexico and the United States in March and April, 2009. By June 3, 2009, all 50 states in the United States and the District of Columbia and Puerto Rico were reporting cases of novel H1N1 infection. The nationwide U.S. influenza surveillance systems reported 41,821 hospitalizations and 2,117 deaths from H1N1 through April 16, 2010. The Washington State Department of Health reported 1,516 hospitalizations and 99 fatalities from laboratory confirmed influenza H1N1 cases.

West Nile Virus was first identified in the US in 1999. It can affect people, horses, certain types of birds, and other animals. Ongoing West Nile virus monitoring for infected dead birds and mosquitoes is limited to a few counties due to a lack of resources.

## **VULNERABILITY:**

Immediate vulnerability and dangers include widespread sickness, panic and loss of life. The possibility of catastrophic disease affecting animals and humans within the confines of Lewis County is very real, although seldom considered a threat. Epidemics, both animal and human, are usually introduced from outside the immediate area and in many cases by vectors from foreign countries.

The potential for an epidemic would increase dramatically in the event of a disaster such as an earthquake or major flood event. In such cases disease may reach a larger segment of the population due to the absence or breakdown of normal intervening services.

## **EFFECTS:**

### **Human Epidemic:**

The impacts could include loss of life of either short or long term debilitation for the victims. It could include economic hardship for the individuals or their families. Lost work time affects not only the employee, but also the employer. Loss of productivity due to individual illnesses is a major business problem today without taking into account the effects of a major

epidemic. In addition, a serious epidemic would likely cause a strain on current public health and medical resources.

If the current upward trend in AIDS cases continues for the foreseeable future, the impact will not only strain medical resources, but also those of charitable organizations who support patients without other resources. This could put a greater financial drain on the medical system that will have to either absorb some of the costs, or at least emergency room care if not long-term care, or begin refusing service to the indigent who cannot pay for treatment. Since refusing treatment to the poor has unacceptable moral and social overtones, medical facilities will have to absorb the costs in some other way or charge higher fees to offset the costs. The insurance companies who pay for AIDS related illnesses, may lose their profits. They may then refuse to pay for AIDS related illnesses, which passes the costs back to the patient, or dramatically increases premiums which spreads out and passes the costs back to the public.

### **Animal Epidemic:**

The effects of animal epidemics include such diverse problems as:

- Economic loss due to either the direct heath of livestock and/or the necessity of euthanasia of living, albeit infected or exposed, animals
- The need for disposal of the carcasses before they become a secondary health hazard
- Loss of primary food supplies, such as the possible loss of meat and/or dairy products and animal byproducts such as wool
- Loss of recreation such as has happened recently in Washington State with the death of most of the razor clam population on the Washington coast due to disease

Another effect is the possibility that an animal epidemic may not just be relegated to the animal population. Rather it might be Zoonotic, or transferable to the human population. Two examples of Zoonotic disease that have recently become prominent are Lyme disease and West Nile virus. Both of these diseases have their roots in animal populations and apparently were only recently transferred to human populations. Another example, rabies, is an obvious case of a Zoonotic disease that has been with us for centuries. It is also very possible that many of the epidemics that decimated portions of the world's population had their origin in animal populations.

### **MITIGATION:**

Mitigation efforts in Lewis County include a strong presence from the Department of Public Health and Social Services and public media awareness campaigns. Monitoring and planning for epidemic outbreaks is a priority of the Division of Public Health. Some of these mitigation efforts include but are not limited to:

- Conducting immunization programs for children and adults
- Providing public education in schools and on a community level
- Targeting the mechanisms for disease transmittal

- Maintaining strict health standards for food service employees and establishments
- Utilizing and recommending infection control practices at medical facilities
- Monitoring the community for outbreaks both actively and passively
- Monitoring sewage, waste disposal, and water sources

Public officials will keep abreast of an epidemic potential and ensure that accurate and timely information and instructions are provided in the public. They also do everything within their power to assure services to the public are maintained.

Emergency Management maintains the Comprehensive Emergency Management Plan (CEMP) for response planning and activation. It also maintains an emergency coordination center (ECC) that can be activated to assist the Department of Public Health and Social Services with:

- Warning and alert notification
- Coordination of county and state resources
- Media public information during times of epidemic outbreak

## PIPELINE

### **DEFINITION:**

Pipelines are transportation arteries carrying liquid and gaseous fuels. Pipelines can be above ground or buried underground.

### **HAZARD IDENTIFICATION:**

The main Williams Natural Gas (previously called Northwest) pipeline (consisting of two pipes, one 14", the other 10") runs north-south through Lewis County, with 'feeder lines' servicing the cities of Centralia, Chehalis, Toledo and Winlock. Natural gas is lighter than air and while there is always a potential for an accident where natural gas pipelines exist, it does not generally pose a threat to the extent that some of the other hazardous materials do.

Another pipeline company that runs through Lewis County is BP/Olympic Pipe Line Company. Olympic's pipeline annually transports 4.9 billion gallons of gasoline, diesel, and jet fuel from four refineries located in Watcom and Skagit Counties. It is the sole supplier of jet fuel to Seattle-Tacoma International Airport. The pipeline consists of a 400-mile system of pipe (constructed in 1965) running in a 299-mile corridor the entire length of Western Washington. Counties along the pipeline corridor include Watcom, Skagit, Snohomish, King, Pierce, Thurston, **Lewis**, Cowlitz, Clark and Multnomah (Oregon).

The BP/Olympic system has the capacity of 350,000 barrels per day, moves at four miles per hour, and has eight pump stations. It enters Northern Lewis County around the Big Hanaford Road just east of the Centralia Steam-Electric Plant and runs east of Centralia/Chehalis where it then runs parallel to Interstate-5 from Highway 508 to the south county line. It passes within 1.5 miles west of Toledo but no closer than 3 miles from Chehalis and Centralia.

### **HISTORY:**

In 1972 there was a break in the pipeline just south of SR 12 on Meier Road. The natural gas caught on fire and burned until the source was cut off. Damage was very localized and did not adversely affect the surrounding area.

In 1964 one of the wells at the underground gas storage facility on Zandecki Road did "explode" while it was being worked on. Although no fire was involved, experts had to be brought in from out of the area to shut the well down. Evacuation of nearby residences was carried out, and lasted for a couple of days.

### **VULNERABILITY:**

The 1999 Bellingham incident where an Olympic Pipeline spill of over 229,000 gallons of gasoline killed three people gives a good idea of the potential from a large spill. If the Bellingham spill had progressed further down the creek into the more populated portions of town before igniting, it would have burned down large portions of the downtown.

The pipelines were all originally located away from the major population centers. However, the continued expansion of the population base has located many people close to them, particularly in the Toledo area. A major break at the wrong spot could shut down major transportation routes for a short period of time and affect the larger Western Washington community.

Gas main and pipeline incidents may occur as a result of another hazard such as:

- An earthquake
- Construction
- Vandalism
- Terrorism

A good example of a potential situation for a natural gas explosion would be gas leaking in a vacant, closed-up building with an ignition source such as a spark from electrical wiring.

Natural gas can be very hazardous, if leaking into an enclosed unventilated area. It will cause death to person(s) trapped or confined with the leaking gas. Whenever gas is escaping into an enclosed area and there is an ignition source, there is a potential for an explosion.

Another type of effect would be a loss of service to customers if the gas lines were shut off due to an accident. This situation could be critical during the winter months.

### **EFFECTS:**

The major effects would revolve around explosions and major fires in not only the rural areas of the county but also the suburban areas and the small cities and towns lying along the paths of the pipelines. Other effects could include death, transportation disruption, major environmental degradation, both short and long-term loss of livestock, and economic disruption.

### **MITIGATION:**

In relationship to other forms of transportation, the transportation of liquid and gaseous fuels is safer than by any other transportation method. It is estimated that the Lewis County pipelines take 1,800 tankers off of Interstate 5.

The best way to reduce pipeline incidents is to fully comply with the safety measures enumerated in the Pipeline Safety Act. Regular checking of the pipeline for damage,

corrosion, land movement that might affect the ability of a pipeline to safely carry product can assist in preventing spills.

The local gas companies maintain emergency response plans and are able to quickly dispatch an emergency team to a natural gas or petroleum emergency. There is a 24-hour 1-800 emergency number available for reporting gas line incidents.

The gas companies have the ability to shut off or “clamp down” the pipelines to minimize impact in the effected area. In addition, local fire departments are trained on responding to pipeline incidents.

Emergency Management maintains warning and alert systems that can be utilized to alert and inform the public. In the event that an incident does occur the public will be alerted and instructed on the proper action to take.

Educating the public as to the hazards of pipelines and their location in the community would help them understand not only where the hazard is but also give them a realistic idea of the vulnerability of their neighborhood.

## HAZARDOUS MATERIALS

### **DEFINITION:**

Hazardous materials are materials that because of their chemical, physical, or biological nature pose a potential risk to life, health, or property when released. A release may occur by spilling, leaking, emitting toxic vapors or any other process that enables the material to escape its container, enter the environment, or create a potential hazard. The hazard can be explosive, flammable, combustible, corrosive, reactive, poisonous, toxic, a biological agent, or radioactive. They can be solid, liquid, or gaseous.

### **HAZARD IDENTIFICATION:**

The types of materials that can cause a hazardous materials spill are wide ranging in nature. Incidents involving these materials include materials such as chlorine, sodium hydroxide, sulfuric acid, radioactive isotopes, anhydrous ammonia, gasoline and other hydrocarbons. They may include medical/biological waste from hospitals or clinics. The lists are long and include many other items used in manufacturing, medicine, construction, etc.

While not totally inclusive, a good place to start when looking at what materials may be hazardous is to look at the lists developed for reporting under the Emergency Planning and Community Right-to-Know Act (EPCRA) also known as Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA).

There are four groups of chemicals subject to reporting under this act. They are:

**1. Extremely Hazardous Substances**

These chemicals have acutely toxic properties. Includes approximately 366 chemicals.

**2. Hazardous Substances**

Includes approximately 720 chemicals.

**3. Hazardous Chemicals**

Inventories of these chemicals and materials safety data sheets for each must be submitted if they are present at the chemical facility in certain amounts.

**4. Toxic Chemicals**

Chemicals or chemical categories that appear on the list because of their chronic or long-term toxicity include 325 chemicals.

In 2003, the Local Emergency Planning Committee (LEPC) reports they have received 93 Tier II reports listing quantities of these four types of hazardous materials at various facilities throughout Lewis County.

Uncontrolled release of hazardous materials can occur at any time in the county and impact water, air, life, land, or a combination of the four.

**HISTORY:**

There is an ever-increasing rate of occurrence of incidents involving hazardous substances within Lewis County. Past occurrences of hazardous materials releases have been caused by illegal dumping, drug labs, floods, storms and other natural phenomenon, human error, equipment failure, transportation accidents, and other unknown causes. Some samples of these incidents include the following:

<b>Selected Lewis County *Reported Toxin Release Incidents</b>		
<b>Date</b>	<b>Incident</b>	<b>Cause</b>
<b>1986</b>	Flooding at Chehalis Crossarms Factory caused containers of pentachlorophenol (“Penta” wood preservative) and diesel oil to contaminate a residential neighborhood of 15 homes and 4 businesses. Fifty homes were evacuated for several days. “Clean-up” continued for months.	Flooding
<b>1993-1999</b>	Contaminated shallow depth wells in the vicinity of S. C. Breen Construction Company, LaBree Road near Interstate 5. September 30, 1999 more than 60 barrels of industrial waste were unearthed.	Unspecified dumping
<b>06-05-95</b>	Jarvis Truck Sales, Toledo. Contaminated soil from oil drums dumped into exposed ground water in a pit.	Employee Dumping
<b>1998</b>	Lewis County Central Shop, 109 Forest Napavine Road, Chehalis. Well water and soil contamination from solvents.	Undetermined cause
<b>04-25-2000</b>	Waste oil spilled across a meadow and into a tributary of Lincoln Creek. Waste Oil pump left running, resulted in 2,000-5,000 gallons of Waste Oil overflow.	Operator Error
	<i>* Department of Ecology</i>	

Areas of Lewis County that have had some type of hazardous materials spill within 2003-2006 include: Centralia (52); Chehalis (37); Morton (9); Napavine (8); Toledo (8); Winlock

(5); Mineral (3); Mossyrock (3); Pe Ell (3); Glenoma (2); Onalaska (2); Packwood (2); Cinebar (1); Galvin (1); Kosmos (1); Randle (1); Silver Creek (1); and Vader (1).

In 2011, Lewis County reported 27 spill reports. Between 2012 and 2017, there were 246 incidents that occurred in Lewis County that were referred to State Ecology.

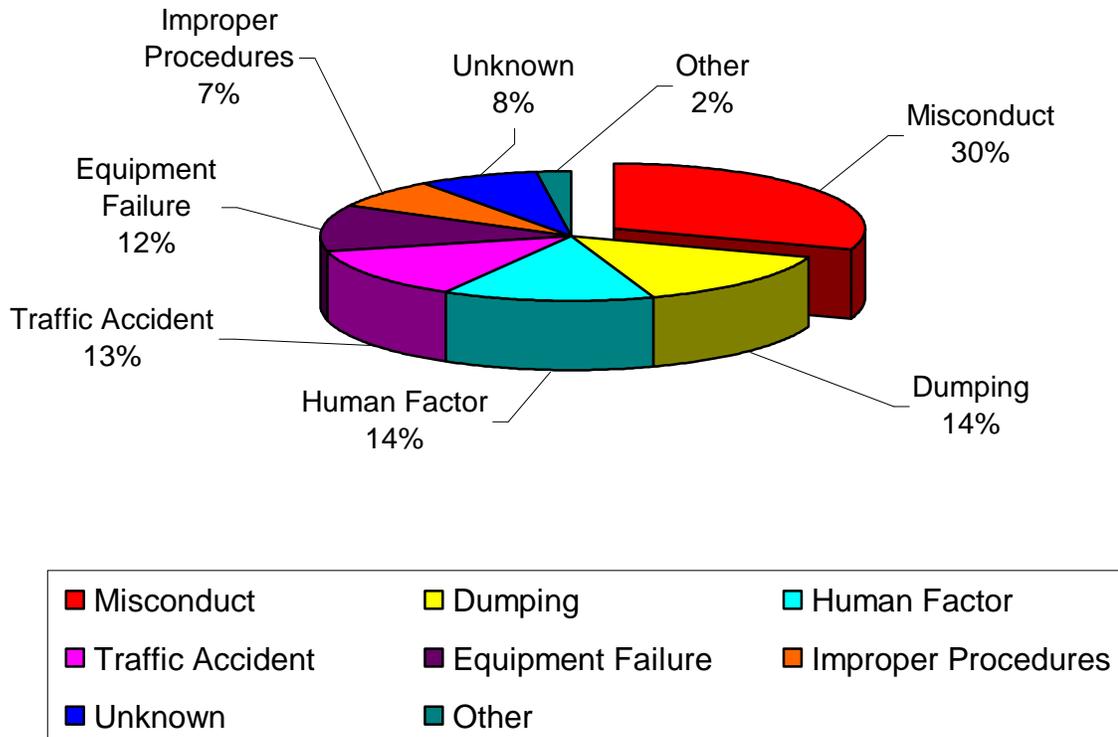
Materials involved in reported Lewis County spills include:

<b>Types of Spill Materials &amp; Number of Incidents</b>			
Chemical (64)	Other (4)	Debris (1)	Sewage/Sludge (1)
Diesel (14)	Gasoline (3)	Fertilizer (1)	Transformer Oil (1)
Oil (12)	Antifreeze (2)	Fuel (1)	Waste Oil (1)
Petroleum (7)	Dust (2)	Fuel Oil (1)	Waste Petroleum (1)
Dairy Waste (5)	Mud/Silt (2)	Herbicide (1)	Waste Water (1)
Hydraulic Fluid (5)	Unknown (2)	Insecticide (1)	Sewage/Sludge (1)
Lube Oil (4)	Waste (2)	Motor Oil (1)	

**Sources** of these spills include the following:

<b>Spill Sources</b>		
Drug Lab (58)	Logging (3)	Illegal Dumpsite (1)
Commercial (25)	Capacitor Spill (2)	Municipal Discharge (1)
Transportation Vehicle (15)	Other (2)	Natural Phenomenon (1)
Motor Vehicle (7)	Abandoned Drum Leak (1)	Sewage Runoff (1)
Domestic (5)	Construction Site (1)	Transformer (1)
Dairy (4)	Other (2)	Transportation Rail (1)
Industrial (4)	Fire – Outdoor (1)	Unknown (1)

## Reported Spill Causes



For 2000, the most current statistical year available for releases, Lewis County reported the largest amount of chemicals (4.2 million pounds) released into the air in the state of Washington. TransAlta Centralia Generation Mining reported releasing 4.2 millions of pounds of toxins, all but 1,000 pounds of the county's total released. Lewis County's release totals accounted for 14% of the state total for the year. This made Lewis County the top reporting county and TransAlta the top reporting facility in the state. This does not include such things as diesel and gasoline spills from accidents, methamphetamine drug labs, illegal dumping of hazardous materials, etc.

The rise in methamphetamine drug labs in Washington State in the past 10 years is staggering. Lewis County ranks in the top percentage:

<b>Clandestine Drug Lab Cleanup Activity 1990-2002 Department of Ecology – Spill Response</b>		
<b>Rank</b>	<b>County</b>	<b>Total Incidents</b>
1	Pierce	2206
2	King	980
3	Thurston	659
4	Spokane	632
<b>5</b>	<b>Lewis</b>	<b>281</b>

<b>Lewis County Increase in Clandestine Drug Lab cleanup Activity 1992-2002</b>											
1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
1	2	3	4	7	9	31	33	43	61	83	277

**VULNERABILITY:**

The combination of possible sources of exposure to our sizable population and workforce presents complex problems to responders. It is difficult to find a home, school, hospital or place of business that is not vulnerable to the possibility of a hazardous materials release.

Hazardous chemicals are prevalent throughout our society. While industry is the primary user and maintainer of hazardous chemicals, we also have them in our homes, in our cars, at our places of work and frequently where we vacation. They move through our society on our highways, rail lines, and pipelines. Major transportation routes are utilized by our trucking industry to transport chemicals to not only manufacturing plants but also businesses and retail outlets. It is safe to say that nearly every one of the Lewis County residents is vulnerable to the effects of a hazardous chemical spill.

Clandestine drug labs and illegal dumping present yet another concern. Over the past few years, Lewis County has seen a dramatic growth in the number of drug labs in the county. Each of these has to be treated as a chemical hazard site and decontaminated before the property can be used again. Illegal drug labs can be set up in homes, apartments, vacant buildings, shacks in the forest or even in a van parked on the street. Illegal dumping continues to be a concern throughout the county.

Biologically hazardous materials (etioloical materials) are present in Lewis County. Commonly, these materials: blood cultures and samples, bandages, hypodermic needles, scalpels etc., are generated by hospitals, clinics, nursing homes, home care, veterinarians and drug users. Through improper disposal of etioloical substances, Acquired Immune

Deficiency Syndrome (AIDS), Hepatitis, and other diseases are spread. Decontamination of most of the material generated by hospitals and clinics is done in house in autoclaves. This is especially true of hardware such as needles, surgical tools, etc. Contractors handle much of the rest. Still there is a certain percentage, especially that which is generated by the general public, that makes its way into the environment.

Radiological hazards can occur from accidents at medical facilities, research facilities, or colleges that use radiological materials. As of June 2002, the Washington State Department of Health listed 7 licensees for radioactive materials in Lewis County. While each of these utilizes radioactive materials, the quantities used and stored in-house are very small. On the other end of the scale, radioactive materials are shipped through the county in route to or from our military bases here in Washington. These could potentially move through the county by any of the normal methods of transportation: rail, plane, or truck.

Releases or spills might also be caused by natural disasters. Floods, windstorms, and earthquakes have all caused spills in the past. Another possibly for a hazardous materials release is during an act of terrorism. This is discussed in the section on terrorism.

### **EFFECTS:**

The effects of a hazardous materials incident depend largely on the nature of the spill, location of the spill, local weather conditions, and area of incidence. Any incident in which hazardous materials are involved has the potential for escalation from a minor incident into a full-scale disaster. The hazardous properties of chemicals, motor fuels, radioactive substances and other potentially dangerous materials range from explosive to highly flammable to poisonous.

These materials have the potential to contaminate the air, water, and land and can be harmful to human, animal and plant life. In addition they can cause destruction of buildings and property, business interruption, contamination of land, and long-term environmental degradation. The release of hazardous materials may also result in the short term or long term evacuation of the affected area. In the case of some radioactive materials the effects of a spill could last for generations.

One effect of a major hazardous materials incident often overlooked is the budgetary impact felt by the responding forces. Most emergency response agencies are not able to absorb extraordinary expenses such as overtime, equipment loss, depletion of supplies, fuel use and other expenses associated with a long-term incident. While the party responsible for the spill is liable for the costs of the operation, reimbursement may be a long time in coming.

### **MITIGATION:**

The Department of Ecology provides 24-hour spill response to deal with nearly all types of environmental emergencies. State law requires all spills to be reported to the Emergency Management Division of the Military Department, the Department of Ecology, and the Local Emergency Planning Committee (LEPC) by the responsible party. In turn, Lewis County Emergency Management is notified of spills in the county and appropriate action is then taken.

Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA), also known as the Emergency Planning and Community Right-to-know Act (EPCRA), was established to prepare state and communities for potential chemical emergencies. Another purpose was to increase the public's knowledge and access to information on the presence of hazardous chemicals in their communities. Title III citizens have the "right-to-know" about hazardous substances in and around their community.

Lewis County has an active Local Emergency Planning Committee committed to improving preparedness of emergency response organizations and awareness for the members of the community. Continued training, exercising, and guidance will help the response community deal with new challenges as they arise. A strong outreach program, cooperative agreements between agencies, and comprehensive planning will help the LEPC to be prepared for any emergency.

Community awareness and responder training are only a part of an effective HAZMAT program. Ideally, the time to stop a spill is before it happens, with safety guidelines followed faithfully by generators/users of hazardous chemicals and with the exercise of care and judicious handling in the transport phase of their life cycle.

Lewis County Emergency Management maintains warning and alert systems and includes shelter-in-place and evacuation projects in community outreach programs.

Emergency Management also maintains a Comprehensive Emergency Management Plan (CEMP) that includes a Hazmat plan and has developed a computer-mapping program that includes the county's hazardous storage sites and vulnerable infrastructure.

# TERRORISM

## **DEFINITION:**

The unlawful, premeditated use of violence, or threat of violence committed by a group of two or more individuals against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof, in furtherance of political or social objectives.

Terrorism activities may employ the use of weapons or devices that are intended, or have the capability, to cause death or serious bodily injury to a significant number of people through the release, dissemination, or impact of toxic or poisonous chemicals or their precursors; a disease organism; or radiation or radioactivity. Weapons of this nature are called Weapons of Mass Destructions (WMD).

Weapons of Mass Destruction (WMD) include the following device types:

- Any explosive, incendiary, bomb, grenade or rocket having a propellant charge of more than four ounces, or a missile having an explosive or incendiary charge of more than one quarter ounce, or mine or device similar to the above
- Poison gas
- Any weapon involving a disease organism
- Any weapon designed to release radiation or radioactivity at a level dangerous to human life

## **HAZARD IDENTIFICATION:**

Until the past couple years, terrorist incidents in the United States involved “conventional” threats in the form of plastic explosives, agricultural chemicals (fertilizer mixer with diesel fuel), and car, pipe or letter bombs using materials easily obtainable through open markets. Terrorism may now include the use of weapons of mass destruction including nuclear, biological, and chemical agents. The nuclear threat includes both the direct detonation of a nuclear device and the use of a “dirty bomb” which could distribute radioactive material with a conventional explosive. First responders need to also be alert for secondary devices targeting them.

Although terrorism can strike at any given time or place, there are a few specific sites of potential terrorism that should be noted. Military installations, government offices and institutions, dams, water supply sources, power distribution systems, communications terminals, and financial centers are all susceptible to incidents of terrorism within the state.

Random acts of violence, such as detonation of an explosive device in public areas, especially areas with large concentrations of people, are also within the scope of terrorism.

On April 19, 1999, two men using a 24-foot rental truck packed with ammonium nitrate, fertilizer, fuel, and other explosives bombed the Oklahoma Murrah Federal Building. The explosion blew up about half of a 9-story building and killed 169 people. This example of homegrown terrorism reminds us that radical beliefs and hatred do not have to come from outside the country.

In the United States, the most recent international terrorist attack was September 11, 2001 when two commercial airplanes flew into the World Trade Center’s twin towers in New York City; another into the Pentagon in Washington, D.C.; and with another crashing in a field in rural Pennsylvania.

The increasing accessibility of more exotic agents, such as biological, chemical, and even nuclear (WMD) weapons, significantly raises the concern over terrorism in our country. The September 2001 mailing of anthrax letters to the media and members of Congress signaled a new and alarming trend in international terrorism. Whether internal or external in their origin, terrorist have shown that the capability of carrying off such an attack is possible in today’s world.

**HISTORY:**

In the United States, most terrorist incidents have either involved small extremist groups or individuals who have used terrorism to achieve a designated objective

To date, no known or claimed terrorist actions have been recorded in Lewis County. On several occasion, weapons caches involving small arms, automatic rifles and ammunition have been discovered in the county and confiscated by law enforcement officials, but with no apparent connection to organized terrorist groups.

Regional Terror and Violent incidents include the following:

<b>Regional Terror and Violent Extremist Cases</b>	
May 2012	Ian Stawicki – Opened fire at Seattle Coffee shop, hijacked car, killed himself.
Oct 2011	Abdisalan Hussein Ali – 3 <sup>rd</sup> American killed as Al-Shabaab suicide bomber.
Sept 2011	Michael McCright – Vehicular Assault against US Marines on I-5 in Seattle.
June 2011	Abu Khalid Abdul-Latif and Walli Mujahidh – Seattle MEPS attack plot.
May 2011	Joseph Brice – Amateur IED maker advertising via YouTube in Clarkston, WA.
Jan 2011	Keven Harpham – Foiled Spokane MKL Jr. Parade backpack bomb plot.
Nov 2010	Mohamed Osman Mohamud – Foiled Portland Christmas Tree VBIED Bombing.
Nov 2009	Maurice Clemmons – Murdered 4 Lakewood Police Officers at a coffee shop.
Oct 2009	Christopher Monfort – Murdered Seattle Police Officer and firebombed vehicles.
Dec 2008	Ruben Shumpert – Ex-convict joins al-Shabaab, killed in Somalia fighting.
Mar 2008	Earth Liberation Front (*ELF) – Destroyed 4 Snohomish homes with arson fires.
July 2006	Naveed Afzal Haq – Seattle Jewish Federation shooting deemed “hate Crime”.
Dec 2005	Oussama Abdallah Kassir – Trainer at AQ terror training camp in Bly, Oregon.
Dec 2005	Michael Curtis Reynolds – Agreed to blow up Oil Pipelines in Idaho for AQ.
Nov 2005	Dominick Sergio Maldonado – Active Shooter and kidnap at Tacoma Mall.

<b>Regional Terror and Violent Extremist Cases</b>	
June 2003	Paul Douglas Revak – US Coast Guard facility bomb plot in Bellingham, WA.
Oct 2002	“Portland 7” – Attempt to join AQ and fight against US forces in Afghanistan.
May 2001	ELF’s Justin Solondz and Briane Waters – UW Horticulture Building Arson.
Dec 1999	Ahmed Ressay – LAX Millennium Bomb Plot; intercepted at Port Angeles, WA.

**VULNERABILITY:**

Modern terrorism thrives best in the anonymous, interdependent urban/industrial environment. A very few individuals, who know how the system works, have the power to inflict tremendous damage on the unprotected infrastructure. Cities and their lifelines – power, water, sewers, transportation and communications – are especially vulnerable. Any basic or essential service upon which large numbers of people depend constitutes an attractive target for violence. The disruption of such an action and the resulting publicity it will generate makes an attractive target. Additional terrorist opportunities may include any or all of the following:

- Economy
- Food production and distribution systems
- Communications networks
- Energy production sites
- Storage and transportation systems

While the range of targets for contemporary terrorists is virtually unlimited, recent history has shown that a preference for certain vulnerable organizations or sites does exist. There are three major goals of foreign terrorists:

1. Hurt the economic infrastructure of the United States
2. Scare the population
3. Gain recognition for their cause

All of these can be done by the threat alone, without actually striking if the target group believes the threat is credible. The attacks on the United States have shown that the threat is credible.

The infrastructure of Lewis County has many points that could be attacked by either internal or external groups. Highway bridges, banks, gas pipelines, power lines, industry, especially those which have large quantities of hazardous chemicals, are all largely unprotected. Because of our free society, major governmental and economic entities are vulnerable. The anthrax attack shows what is possible for someone with the ability to manufacture similar disease organisms.

In summary, Lewis County, like other parts of the nation, is very vulnerable to attack by terrorist, especially the new breed, the suicide bomber who has no interest in surviving his or her act of vengeance.

**EFFECTS:**

The effects of terrorism include, but are not limited to death, injury and a feeling of fear and helplessness in the general population. It can destroy property, lifelines and the basic social fabric. On a large scale, it destroys major portions of a large city's infrastructure creating physical and economic hardship for some time in addition to the initial death and destruction. Long-term psychological damage to a portion of the population is also possible.

Many of our county's essential services rely on "single failure point" systems that may be completely unguarded or at best are easily accessible. In the event of terrorist actions it is to be expected that law enforcement, fire, and service repair agencies will be temporarily overtaxed and unable to immediately repair damages. Service may be disrupted for a relatively long period of time as responding agencies attempt to deal with the terrorists before turning to the damage itself.

A terrorist incident would effect and disrupt communications, transportation, food and energy production, medical and health services.

**MITIGATION:**

It will be difficult – perhaps impossible – to interdict the actions of dedicated terrorist. However, through the coordination of national, state, and local government antiterrorism efforts and the judicious employment of public and private safety systems we have the capability to significantly reduce the threat of this blight against the people, economy, environment, and property of Lewis County.

Community emergency plans have been developed and adapted to allow first responders to respond quickly to terrorist activity.

Emergency management promotes a public awareness campaign and provides awareness level training opportunities to first responders.

Lewis County has been organized into a Homeland Security Region to plan, exercise, and train at a regional level for threats from terrorist activities.

Terrorist cells usually consist of small secretive groups of individuals that are by their very nature difficult to track, difficult to predict their targets, and difficult to defend against. However, through education of the public, training of first responders, proper coordination of public resources, our public and private safety systems offer an unprecedented capability to negate terrorism.

Lewis County should use existing processes and methodologies developed for the successful management of their threat potentials as a starting point. Using the plans and systems developed for other threats, modifying them to fit a terrorism scenario, and using information gleaned from others who have dealt with terrorism in the past will facilitate the development of a comprehensive county terrorism program.

## TRANSPORTATION

### **DEFINITION:**

Transportation systems in Lewis County consist of road, rail, and air. All of these forms of transportation are prone to accidents that could lead to an emergency or disaster. The accidents may have either a natural or human cause.

For the purposes of county planning, we are not referring to the typical auto versus auto accidents that are handled on a day-to-day basis by emergency responders. This planning transportation hazard refers to those incidents that threaten the environment, lives, or property of a significant number of people.

### **HAZARD IDENTIFICATION:**

#### **Road Transportation**

Lewis County has a variety of freeways, highways, and roads that serve the area. The principal roadways include Interstate-5 and Highway 12. All major highways carry high volumes of traffic, including large numbers of commercial vehicles. Commercial vehicles include busses (commercial and school), commercial goods vehicles, and hazardous materials vehicles.

Privately owned vehicles and local bus services provide the primary means of transportation for individuals in Lewis County.

A major road transportation emergency could be caused by any one of these carriers. It may not just affect those on the road, but hazardous materials could require closure of businesses, sheltering-in-place, or evacuation.

#### **Railroad Transportation**

Lewis County railroad passenger transportation is Amtrak. There are also major industrial railroad lines (Burlington Northern, Santa Fe and Union Pacific) that run both north and south through the county.

#### **Air Transportation**

There are no major airports in Lewis County, but the county is in the flight patterns for most major airlines traveling between Seattle and Portland. Military aircraft often use airspace in Lewis County for conducting training exercises

## **HISTORY:**

### **Road Transportation**

There have been no large-scale transportation disasters in Lewis County, although I-5 has been closed periodically due to multiple car and truck accidents and during flooding events. The four day closure of I-5 during the November 1990 flood was estimated to have resulted in \$2.1 million in transporting losses Washington State and another \$2.2 million in other transportation traffic delays.

The December 3, 2007 4-day closure of I-5 was estimated to have cost \$4 million an hour for lost revenue. This closure forced a 440-mile detour through the mountains and around the floodwaters. The City of Chehalis estimated business losses during the month of December at \$6 million per week while closed.

A State of Washington **one-year later** update from the 2007 flood indicated the statewide transportation losses from the December 3 flood increased as follows:

<b>December 2007 Transportation Losses Calculated One-Year Later</b>	
Transportation Infrastructure Damage	<b>\$110 Million</b>
Government Revenue Loss	<b>\$70 Million</b>
Transportation Disruption Losses	<b>\$360 Million</b>
<b>Transportation Losses This Incident</b>	<b>\$540 Million</b>

### **Railroad Transportation**

Although there have been cases of train accidents and derailments involving pedestrians and vehicles, none have involved hazardous materials or caused widespread disruption.

### **Air Transportation**

In the mid 1980s a small private light aircraft crashed into one of the Southwest Washington Fairgrounds entertainment stages. The pilot received minor injuries and no one else was hurt. The building sustained major damage. Had the accident occurred several weeks later, the Fair would have been operating, and the potential for mass casualty injuries would have been enormous.

There were two separate military aircraft crashes in eastern Lewis County in 1988. Whidbey Island Naval Air Station training aircraft (Grumman A-6E Bombers) crashed in eastern Lewis County on April 16<sup>th</sup> and May 6<sup>th</sup>, 1988. Each aircraft carried only a pilot and one crewmember that were killed. The crashes both occurred in the same area east of Riffe Lake.

These incidents point out the potential impact should a larger commercial airliner with hundreds of passengers crash in the county.

### **VULNERABILITY:**

#### **Road Transportation**

Traffic accidents are influenced by weather conditions, speed of traffic, and number of vehicles occupying the road. Conditions that usually lead to accidents may include:

- Rain
- Fog
- Ice
- High speed
- Heavy traffic congestions

The County is likely to experience an increase in the number of accidents along its highways as population and traffic congestion increases. Many of the trucks passing through the county daily are transporting hazardous materials that increase the potential affects of the hazard.

#### **Railroad Transportation**

The greatest risk from freight cars traveling through the county is the potential for a hazardous materials spill. Possible death or injury could occur as people's daily activities merge closer and closer to railroad tracks. A major train wreck, especially involving hazardous materials, could directly affect any one or several of the communities along the rail lines.

A passenger train accident could result in a major mass casualty incident.

#### **Air Transportation**

The flight patterns from the Chehalis/Centralia airport and some of the other small airfields in the county pass over populated areas.

The majority of airplane accidents occur during or shortly after takeoff or in the process of landing. As the population increases, many of these once isolated airports will become surrounded by residential or business districts. This increases the possibility of a major accident.

The September 11, 2001 terrorist attacks on the Pentagon and the New York World Trade Center indicated the damage that could happen should a plane fly into any one of a number of facilities in Lewis County. Potential targets could include dams and bridges.

**EFFECTS:**

Transportation accidents, depending on the type, can have a profound effect on the community at large. Some involve quantities of hazardous materials requiring evacuation and/or hospitalization of a large number of people. They may cause long-term ecological damage to some portions of the environment.

Even when no hazardous materials are involved, transportation accidents may become mass casualty incidents. As such they can overtax the medical, fire, police and volunteer response agencies. They may damage private property, destroy businesses, close roads, highways, shipping lanes or airports.

**MITIGATION:**

For any type of transportation accident, mitigation involves adherence to safety guidelines and using caution in unusual conditions or situations. Regulations on safety and maintenance need to be updated as new technology is introduced and new information is gathered as to the cause of accidents.

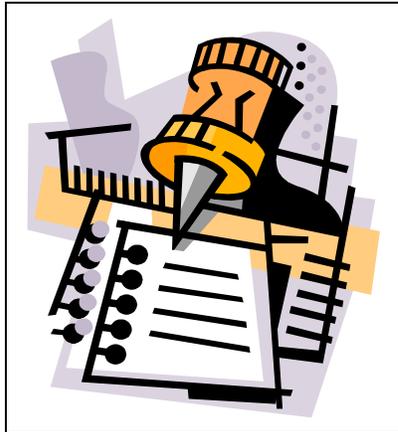
Required regular inspections must be carried through to prevent transportation incidents on the following:

- Private vehicles
- Commercial carriers
- Highways
- Airports

Examples of other mitigation measures that have been conducted in the past include:

- Conducting seat belt education and enforcement
- Mandating drug testing for drivers, airline, ship and train crews
- Limiting the number of hours airline pilots are allowed to fly each week

# ATTACHMENTS



## Attachment A

# Hazard Risk Rating Criteria

## Probability of Occurrence

Probability of occurrence is an objective description (High, Medium, Low) of the probability of a hazard impacting Lewis County within the next 25 years. Probability is based on a limited objective appraisal of a hazard's frequency using information provided by relevant sources, observations and trends.

**High:** There is a great likelihood that a hazardous event will occur in the next 25 years.

**Medium:** There is a moderate likelihood that a hazardous event will occur in the next 25 years.

**Low:** There is little likelihood that a hazardous event will occur in the next 25 years.

## Vulnerability

Vulnerability is an objective description (High, Medium, Low) of the potential impact a hazard could have on Lewis County. It is the ratio of population, property, commerce, infrastructure and services at risk relative to the entire county. Vulnerability is an estimate generally based on a hazard's characteristics.

**High:** The total population, property, commerce, infrastructure and services of the county are uniformly exposed to the effects of the hazard of potentially great magnitude. In a worst case scenario there could be a disaster of major catastrophic proportions.

**Medium:** The total population, property, commerce, infrastructure and services of the county are exposed to the effects of a hazard of moderate influence; or an important segment of population, property, commerce, infrastructure and services is exposed to the effects of a hazard. In a worst case scenario there could be a disaster of moderate to major, though not catastrophic, proportions.

**Low:** A limited area or segment of population, property, commerce, infrastructure or service is exposed to the effects of the hazard. In a worst case scenario there could be a disaster of minor to moderate proportions.

## Risk Rating

Risk Rating is an objective description (High, Medium, Low) of the overall threat posed by a hazard over the next 25 years. It is a subjective estimate of the probability of occurrence and vulnerability.

**High:** There is a strong potential for a disaster of major proportions during the next 25 years. Historically it is suggested that occurrences of multiple disasters of moderate proportions are likely. The threat is significant enough to warrant a major program effort to prepare for, respond to, recover from, and mitigate against this hazard. This hazard should be a major focus of the county's emergency management training and exercise program.

**Medium:** There is moderate potential for a disaster of less than major proportions during the next 25 years. The threat is great enough to warrant modest effort to prepare for, respond to, recover from, and mitigate against this hazard. This hazard should be included in the county's emergency management training and exercise program.

**Low:** There is little potential for a disaster during the next 25 years. The threat is such as to warrant no special effort to prepare for, respond to, recover from, or mitigate against this hazard. This hazard need not be specifically addressed in the county's emergency management training and exercise program except as dealt with during hazard awareness training.

**Attachment B**

**East Lewis County Flood of Record –  
November 6-10, 2006 – Cowlitz River**

**Flood – East County, Cowlitz River**

Mission # 06-3338 FEMA DR 1671

**\*East County Record Flood Event**

**2 Deaths**

Private Damages: \$9,279,250

Public Structures: \$17,308,230

**Total preliminary damages: \$26,649,480**

**EVENT DESCRIPTION:**

During the first week of November, 2006, the Pacific Northwest underwent a sharp transition from a rather dry and benign weather pattern to a very wet pattern. This occurred as the persistent ridge that dominated much of the eastern Pacific throughout the month of October broke down, and a fast zonal jet stream developed across the Pacific Ocean. November 2 began with a cold air mass in place across the Pacific Northwest, and the first in a long series of vigorous upper level disturbances approaching the coast. Meanwhile, warmer than normal sea surface temperatures in the central tropical Pacific Ocean resulted in enhanced thunderstorm activity in that region, sending plumes of deep moisture northwestward into the mid latitude regions of the central and eastern Pacific Ocean.

As the first disturbance moved onshore, the deep subtropical moisture began overrunning the cold air in place across western Washington and northwest Oregon. Moderate to locally heavy precipitation developed by early afternoon November 2, resulting in widespread 2-5 inch rainfall totals across the western Washington and northwest Oregon Coast Range, as well as lower elevations of the Cascade Mountains. In middle to higher elevations, precipitation started off as snow or freezing rain, then gradually changed over to rain as warmer air moved in from the Pacific Ocean.

November 3 offered western Washington and northwest Oregon a brief respite from the rain as the previous day's upper level trough moved east into the Rockies. However, the next significant frontal system was taking shape offshore, pulling in another plume of subtropical moisture streaming northwest from near Hawaii. As this frontal system moved onshore early November 4, another 2-4 inches of precipitation fell across the Olympics, as well as the Cascades and Coast Range of northern Washington and Oregon. With freezing levels 8,000 feet or above, this precipitation fell almost exclusively as rain, except at the very highest peaks of the Cascade Mountains.

While this was occurring, a very deep moisture outflow from western Pacific Typhoon Cimarron was already beginning to feed into the next major developing low pressure system south of the Aleutian Islands. This was the third and most powerful low pressure system in the series of disturbances to move across the Pacific during the first week of November. The strength of this low pressure system allowed strong southwesterly flow to develop ahead of it, which provided precipitation enhancement across west and southwest facing slopes of the

Olympic Mountains, as well as the Cascades and Oregon Coast Range as the system moved onshore November 5-6. In addition the tropical nature of the moisture entrained into this system resulted in very high freezing levels across the Cascade Mountains.

The combination of these features resulted in a record rainfall event across western Washington November 5-6, which caused widespread severe flooding across western Washington and coastal northwest Oregon. Many locations in the Olympic Mountains, Washington Cascades, and northern Oregon Coast Range received 5-10 inches of rainfall in less than a 24-hour period. By November 7, most reporting stations across western Washington and northwest Oregon had exceeded their normal monthly rainfall for the entire month of November.

On **November 4, 2006**, the National Weather Service issued a Flood Watch for several western Washington counties, including Lewis County, indicating that conditions were favorable for flooding. Lewis County waterways have traditionally been slow to rise, sometimes taking a day or so for water to reach flood predictions. The Chehalis River headwaters in rolling hills above Pe Ell are generally slow to flow down to the Twin Cities. However, when rain fronts stall over the mountains, the Cowlitz water races off Mount Rainier and the surrounding hills very quickly and engulfs the downstream communities. That's what happened in early November when the worst flooding ever to hit the communities of Packwood and Randle exploded through the area with a fury that destroyed a bridge, pulled homes into the seething river, destroyed at least one protective dike and caused two deaths.

Record levels of rainfall continued through November 5<sup>th</sup>. The average annual rainfall for the Centralia area is 46.71 inches. On November 6<sup>th</sup>, there was 3.45 inches recorded. By November 14, 2006, the November monthly rainfall reached 12.69 inches of precipitation, compared to the average November rainfall of 6.27 inches. The record for most rainfall during a 24-hour period, locally, is 3.96 inches. Rainfall in the Packwood and Randle area before and after the flood is not available; however, considerably more precipitation typically falls in the east county than in the Centralia area.

Shortly after 4:48 a.m. on November 6, 20-year old Andy McDonald, a hunter from the Seattle area, was reported missing in Packwood. His Chevrolet pickup was reported to have been washed into the river as he was attempting to turn around to evacuate the rapidly flooding area, got too close to the river, and the bank gave way. The truck slid into the river and was caught up in the current, disappearing downstream. A call went out for Search and Rescue (SAR) with dive teams at 5:03 a.m.

Once SAR teams were on site, the flooding situation was apparent to be life threatening and a call went out for immediate evacuations of all low-land hunters, campgrounds, and private residences. It is presumed that the record rainfall and mountainous debris formed natural dams that then breeched, exploding into "flash flood" type surges with cascading water/debris walls that accumulated in some places to heights up to 12.5 feet. In some cases, the debris included whole fir trees exploding under foundations and leaving deposits up to 8 feet of gravel and silt.

At 5:39 AM on Monday, November 6, 2006, the Lewis County Emergency Operations Center (EOC) was activated at Level I under Washington State Mission #06-3338. The

Lewis County Sheriff's Office EOC/ECC was fully staffed at a Level I at 7:58 a.m. on the same day.

Weather Bulletin No. 8, issued at 8:16 a.m. November 6, stated that heavy rain would continue through the night, causing widespread river flooding across Western Washington, including Lewis County. Many rivers were to experience major flooding and some were expected to approach record levels. The Nisqually River at the National gauge was expected to be two feet over flood stage; the Cowlitz River was expected to crest at 0.6 feet over flood stage. Neither prediction would have amounted to much more than minor inconvenience to east Lewis County.

Evacuations and rescues had been underway in Lewis County for over 7 hours when the National Weather Service bulletins caught up to the severity of the situation. Bulletin 12, issued at 12:13 p.m. on November 6 stated the following:

*“The Cowlitz River at Packwood will crest at 4.6 feet over flood stage. The Cowlitz River is expected to reach 10 feet over flood stage at Randle.”*

This delay in accurately predicting the severity of the rain in Lewis County put many first responders in peril as they continued their efforts to notify all the low-lands areas of the need for evacuations. The task was monumental due to the timing of the event just as hunting season had begun. It was estimated there were over 1,000 hunters spread out in approximately 200 camps that needed to be notified of the potential situation that could include landslides, limited road access, and if not immediately evacuated, potentially the need to remain in their camps for an extended period of time.

Rescues and resource requests required the EOC be elevated to Level III at 12:30 PM. The EOC remained at Level III until November 10 at 2:00 PM when it was downgraded to Level I. The EOC continued at Level I for assistance to the Packwood Disaster Relief Center and response to windstorms on November 13 and November 15 and anticipated return to flood levels expected following those storms.

Skate Creek Road North at the Lewis County Line was indefinitely closed with no travel allowed across the bridge into Pierce County. Evacuating residents at Paradise Estates needed to use Forest Service 52 Road leading to Packwood.

There was a one-lane closure on Carr Road due to a mudslide.

Ultimately, flooding and channel migration caused severe erosion of the river bank, completely destroying dozens of homes, washing many of them downstream. The numerous debris dams also contributed to the unanticipated extremely rapid rise of the Cowlitz River, particularly in the Packwood area.

### **Emergency Declaration:**

At 10:00 AM Monday, November 6, 2006, the Lewis County Board of County Commissioners declared a Local Emergency for the Ashford area for efforts to save the Kernahan Bridge. This is at the entrance to Lewis County and Paradise Estates. By 3:07, the Commissioners declared a Local Declaration of Emergency for the area of Randle and

Packwood. By 9:00 a.m. Tuesday, November 7, 1006, a Local Declaration of Disaster was declared.

River gauges on the Cowlitz River, indicated that the river crested at Packwood at just over 14.59 feet at 4:30 p.m. November 6 and fell below flood stage the morning of November 7. At Randle, the river reached flood stage about noon on November 6, cresting at 25.15 feet at 2:00 p.m. on November 7. US Geological Services (USGS) river gauge data indicate that it fell below flood stage just after midnight on November 9.

The Chehalis River at Centralia reached flood stage on the evening of November 7, cresting at over 67 feet early on November 8, and falling below flood stage later that same day (see USGS Flood Stages and river gauge data, page 16). Some localized flooding occurred, particularly in low-lying areas along the River in the Chehalis and Centralia areas. Preliminary reports from Centralia officials estimated damage to public infrastructure in excess of \$4 million. Much of the area flooded included farms and agricultural land. Some homes received minor water damage in Centralia. Low income apartments in Chehalis were hard-hit in the flooding with 6 families being displaced for as long as 3-6 months.

While the Chehalis/Centralia area experienced some minor flooding, the east County communities of Packwood and Randle were particularly hard hit.

### **Cowlitz River Takes Two Lives:**

The Cowlitz River claimed two lives. Two vehicles were reported swept away in the flooding. Early on November 6, a hunter, driving a pickup truck, had been carried away in the rising floodwaters. Later that day, the truck was recovered with the body of the driver in the cab.

One other confirmed death was attributed to the flood. Late in the day on November 7<sup>th</sup>, a 63 year-old Mossyrock resident was swept down the Cowlitz River when he proceeded beyond a "Road Closed" barrier and attempted to drive from Silverbrook Road onto US Highway 12, heading westbound. The floodwaters were 5-6 feet deep on the roadway in that area at the time. Witnesses observed the man trying to escape out the rear slider window but the truck was swiftly carried downriver and sank into deep water before he could escape. Rescue personnel were on the scene within two minutes; however, dive team crews were unable to reach the truck due to the swift waters.

Beginning on Monday morning, November 6, the Local Packwood Fire Department and the Lewis County Search and Rescue (SAR) responded to and coordinated the evacuation of about 65 hunting camps containing approximately 200 hunters. Throughout the remainder of the day, the local fire, SAR, and Sheriff's Office personnel implemented evacuation plans, warning people of rising waters and engaging in rescue operations of those trapped by floodwaters.

Flooding on the Cispus River, a tributary to the Cowlitz River, forced the evaluation of 110 students from the Cispus Learning Center, located south of Randle.

Emergency Management (DEM) issued an update at 6:00 PM, including **road closures** on: Chehalis Avenue, NW Folsom Street, and NW Rhode Island Place in Chehalis; Davis Creek Road (bridge out), Peters Road (sink hole), and State Route 131 (water over the roadway), State Route 508 (major landslide and roadway seriously undermined), Carr Road (washed out), and US Highway 12 (major landslide) in Randle; Skate Creek Road, in Mineral; State Route 123 (water damage and debris) in Packwood; Hadaller Road (slide) near Mossyrock; and Wold Road (significant section washed out by flooding) near Paradise Estates. **Restrictions** were issued for the following roads due to water over the road: Alvord, Big Hanaford, Little Hanaford, Roswell, Sawall, and Teitzel in Centralia; Cline, Kiona and Silverbrook in Randle; Meier East in Winlock; Ray in Toledo; Nicholson in Onalaska. **Bridges closed** included Davis Creek Bridge (washed out) and the Kernahan Bridge (footings compromised).

Morton High School had water coming into the building. Evacuations were listed at 610, including 200 hunters, 110 students from Cispus, and 37 citizens from Silverbrook, High Valley, and the Burton Creek areas.

The formation of debris dams resulting from trees and other material swept downstream during the flooding caused the upper Cowlitz channel to move in numerous places. In some places in the Packwood and Randle areas this was the first time flooding had reached this level since 1948.

The dramatic and sudden flooding in the Packwood-Randle area forced the evacuation of approximately 200 hunters in 65 camps and 410 residents and rescue of 314. This was the single largest rescue operation ever undertaken in Lewis County.

Lewis County Emergency Management estimated that approximately 300 people had to flee their homes to stay with friends, relatives, and hotels, mostly in the Randle/Packwood area. Early reports indicated that five homes in High Valley were confirmed totally destroyed, having floated down the Cowlitz River. One additional home was totally destroyed when a tree crushed it, followed by floodwaters eight feet deep. An additional four to five homes at Timberline Village were totally destroyed.

At 3:07 PM, November 6, 2006, the County Commissioners declared a Local Emergency for Lewis County as a Disaster Area. The Governor declared Lewis County a Disaster area on the same day.

### **November 7:**

Search and rescue operations continued all day Tuesday, **November 7** in both the Packwood and Randle areas as flooding continued, particularly in Randle. On Wednesday, rescue operations began for hunters in national forest land stranded due to roads that were washed out or blocked by slides. Twenty-five rescuers and two US Coast Guard helicopters searched the area. In addition, one local news helicopter (KIRO TV) covering the flood was called on to perform a rescue operation. Night fell November 7 with nineteen residents and one dog rescued from the upper Cowlitz area, and eighteen others awaiting daylight for rescue.

The Randle and Packwood Operations Centers were initially established with resources drawn from the local fire departments, Sheriff's Office, Search and Rescue, Dive Team, Washington State Department of Transportation and Lewis County Public Works Department.

White Pass School District closed schools. Shelters were set up in the Randle area at the Glenoma Elementary School, the Bob Lyle Building in Morton, and at the Mossyrock Junior High School. In the Packwood area, Red Cross shelters were established at the Four Square Church, the Presbyterian Church, and at the Packwood Elementary School. Relief centers were set up at the Randle Fire Department and the Packwood Elementary School Gym.

Evacuation transportation was provided by Lewis Mt. Transit and by local school districts using school buses.

Sandbag filling stations were set up at the Packwood Department of Transportation facility on Highway 12 and the Randle Fire Department.

Evacuations due to flooding took place in the downtown Randle/Highway 12 area; on State Route 131/Woods Creek Road area; along the River Run Ranch Road, Cline Road, Chapman Road, Skinner and Spears Roads; Slagle Road; and in Silverbrook.

In Packwood, the following areas were evacuated due to floodwaters: High Valley Division 8—Mt. View Drive; High Valley Divisions 4 and 6—lower end; High Valley Division 1; Timberline—lower end; Coal Creek Road; Goat Rocks—lower end; Baker, Blakely, Kauer, Stover and Cedar Creek roads. In addition, the following areas were evacuated due to dike failures: High Valley, Timberline, and Coal Creek. Upper High Valley Divisions 8 and 11 were evacuated due to the potential for channel migration that could have flooded the area. Dike failures allowed the Cowlitz River to change its course in the Packwood area, with the channel reportedly moving 500 or more feet in some areas, destroying many homes. By morning's end of the next day, the Cowlitz River at Packwood was back below flood stage.

A debris flow on the Newaukum River caused the waters to be backed up early in the morning. The situation was downgraded to Level II at about 1:00 p.m. when the waters broke through, clearing the debris flow.

Tacoma Power increased flow into the Cowlitz River below the Lake Mayfield Dam to 25,000 cubic feet per second, adding to the already impacted Toledo area.

An 84 year old man was hospitalized due to exposure after being stranded in his vehicle with his dog near the Centralia-Chehalis Airport.

### **November 8:**

**November 8<sup>th</sup>** EOC operations remained at Level II, with 24-hour operations. The Cowlitz River was still above flood stage. Inaccessible roads continued to hamper damage estimate reporting. By midmorning, some reaches of the Cowlitz River had receded and were no longer above flood stage. However, many lowland depression areas remained covered with

water. Seventeen air rescues were performed, with 25 to 50 waiting for the next daylight period. It was estimated that 50 to 100 additional hunters were stranded (not knowing that roads had been washed out or were closed).

Some areas of Randle became accessible by early morning, but Packwood was still not accessible. National Guard assets, seven rescue boats, a single-engine Cessna and a Coast Guard helicopter were in use. First reports indicated that public water systems in Packwood, Randle, and Vader had been damaged by the flooding. Bottled and trucked water were being supplied to the affected areas. Residents of High Valley Divisions 8 and 11 in Packwood, were being allowed back into their homes. The Red Cross shelter that had been opened at the Mossyrock Junior High School was closed. Shelters were still opened in Packwood and Chehalis. School was cancelled in the White Pass School District and in Vader.

The City of Chehalis reported a water main was damaged due to debris striking the Jackson Highway Bridge to which it was attached. To restore water service, crews replaced 120 feet of the damaged 12-inch line with a temporary one.

### **November 9:**

On **November 9<sup>th</sup>**, the EOC remained at Level II activation, with 24-hour operations. The Cowlitz River dropped below flood stage just after midnight. Two available helicopters and a fixed-wing Cessna were used for reconnaissance and rescue operations. They were flown over Mineral, Ashford, Elbe, Walupt Lake, and several area campgrounds, searching for citizens in need and stranded hunters. Rescue operations in the upper Cowlitz Valley concluded on Thursday, November 9. However, search and rescue operations continue in the high mountain areas for stranded hunters. Seventy ground personnel, three helicopters, and two heavy equipment vehicles were involved in the operations used to clear roads where hunters were known to be trapped.

Public Works teams continued to clear major roadways, with the secondary road assessment done on November 10<sup>th</sup>.

### **November 10:**

On Friday, **November 10**, the Red Cross, White Pass Coalition, and local church organizations joined in the recovery efforts, including conducting surveys, starting recovery paperwork, and distributing donated supplies.

The EOC was downgraded to a Level I operation at 2:00 p.m., and Highway 12 to Packwood was reopened later in the day. This allowed some residents access to flood-damaged property for the first time.

Recovery and cleanup activities began. Forest Service Road 52 was also reopened. The Lewis County Sheriff's Office Mobile Command Unit moved to the Packwood Elementary School Gym. A distribution center was opened for the affected communities of Packwood and Randle. It furnished bottled water, food, and cleaning supplies. Public Works crews

began clearing and removing debris on the affected secondary roads. Crews began the windshield survey and collecting damages estimates.

**Preliminary East County Property Damages:**

Early estimates from ground crews indicated the following:

- 15 homes totally destroyed.
- 300+ homes with minor to major damages (25-50% damages of market value)
- Numerous animal carcasses in fields (cows, goat, sheep, chickens, horses)
- Hundreds of homes and property covered with woody debris and silt/gravel
- The NACO Campground at Milepost 126 was totally destroyed
- Pets trapped in trailers that floated downriver



Cowlitz River at Packwood

Tacoma Power continued to release water from the Lake Mayfield Dam at a rate of 30,000 cubic feet per second (cfs), potentially flooding areas downstream of Toledo. The city and local fire district were advised.

State/FEMA inspection teams estimated 62 of 144 primary residential homes they inspected received major damage or were a total loss. Accessibility to the Randle/Packwood community was an issue in making an accurate count; however it is estimated that at least 350-400 homes sustained some type of flooding damage. County Assessor records indicated there were a total of 769 homes in the Upper Cowlitz area with 185 of those being vacation homes. There were 467 residential structures and 196 mobile homes. This represented a significant percentage of the homes in the two communities having received some type of flood damage. The hardest hit community, Randle, was comprised primarily of senior citizens, disabled, and others living on limited incomes. The Packwood area contained many vacation homes. Those landowners at least had resources and some ability to recover from the event.

Hampton Lumber at Randle was closed due to the flood, with no early estimates of economic losses.

**November 11:**

By **November 11**, Lewis County Public Works reviewed over 70 public infrastructure sites for preliminary damage estimates that totaled an estimate of approximately \$7 million. One privately operated public water system reported an estimated of \$30,000 to replace flood-damaged water lines; however damages could range upward to \$130,000 once a structural inspection report was completed on two holding tanks that sustained support beam damage during the flood.

The Red Cross continued conducting damage surveys in the Randle-Packwood area and completed inventories of 200 area homeowners.

Due to closed roads, uncertainty as to whom to contact, and the Veterans' Day holiday, private damage reporting was slow. By November 11, 149 citizens and 11 businesses reported damages their damages. Combined estimates of structure and personal property losses were approximately \$8.5 million.

**November 12:**

On **November 12**, 2006, the City of Vader, located on the lower Cowlitz River below Lake Mayfield, reported an initial estimate of \$6,800 flood damages to their water system. Twenty-one thousand gallons of water had to be trucked to the City to replace contaminated water that could not be used.

Officials from the Lewis County Sheriff's Office reported that about 200 people registered flood damage at the Red Cross station set up at the Packwood Elementary School. The Red Cross reported that food, cleaning supplies, bottled water and dry clothing were distributed from their shelters to displaced citizens.

By Monday, November 13, the Board of County Commissioners authorized free disaster debris disposal at county solid waste transfer stations. Vouchers for free disposal were made available at the Randle Fire Station and at the Packwood Elementary School. By November 30, the transfer stations had taken in a total of 243.52 tons of flood debris with an over-time cost of personnel and rental equipment of \$12,600. The following includes the Transfer station amounts:

- Morton Transfer Station      92.91 tons
- Packwood Drop Box          115.35 tons
- Central Transfer Station      35.26 tons

**Packwood Relief Center:**

A community supported Relief Center was established at the Packwood Elementary School Gym. The Relief Center distributed cleaning supplies, mental health information, access to local support networks, food and clothing. It was operated by the Lewis County Sheriff's Office. Requests for assistance with access issues, repairs, and debris disposal were received and processed. Local businesses (Sterling Breen and Harrison Christian) donated heavy

equipment such as trucks, loaders, and back hoes to assist with reopening private driveways. In total, 178 volunteers contributed 5,254 hours to assist with the rescues, distribution of supplies and emergency cleanup.

**Shelters – American Red Cross Mount Rainier Chapter, Disaster Services:**

Severe flooding on the Cowlitz River from November 6 through November 8 affected several areas of the river basin, particularly in the Randle and Packwood areas. On Monday, November 6, 2006, the Red Cross started initial responses by setting up a client shelter in Mossyrock at the Mossyrock Middle School. The shelter was operational from November 6 through November 7, with eight Lewis County volunteers operating the shelter.

A shelter was opened at the St. John’s Lutheran Church on November 7 and sheltering operations were consolidated at the new shelter. The shelter was staffed by seven Lewis County volunteers and several others from Thurston County. It operated twenty-four hours a day. The Red Cross served 123 meals to 68 people over a period of 11 nights. The Salvation Army also served meals. The Packwood Four Square Church sheltered another 30 people for almost two weeks.

A list of the shelters used during the November 6, 2006 flood event included the following:

Glenoma Elementary, Randle	Presbyterian Church
Bob Lyle Building, Morton	Packwood Elementary School
Mossyrock Middle School	St. John’s Lutheran Church
Four Square Church, Packwood	

The Yakima Valley Chapter of the Red Cross completed disaster assessment operations in the Morton and other east county areas by Saturday, November 11, with nine personnel in two teams. Four Disaster Assessment teams (two persons on each team) from the Olympia Headquarters completed surveys in the area west of Morton, including in Chehalis, Centralia, Vader, Toledo, Napavine, Salkum and all surrounding areas. By November 13, damage assessments operations were complete in Lewis County. Many homes and businesses reported various levels of damages.

The American Red Cross - Mount Rainier Chapter Office, located in Chehalis, completed over 66 flood-related cases. Many businesses experienced damages and time loss.

Cleanup supplies, recovery materials, and water/food were distributed throughout the affected areas, particularly in the Packwood and Randle areas. Many affected families accepted assistance from family members or friends so shelter numbers are not a good representation of all the families that were displaced by the flood event.

Many areas were affected by bridge and road closures. Major landslides occurred at State Route 508, US Highway 12 near Randle, and Hadaller Road near Mossyrock. The bridge was out at Davis Creek and the footings were compromised at Kernahan Bridge, closing it to traffic. It was uncertain how long some residents would need to “walk in” to reach their

homes. There were health concerns due to compromised wells and public water supplies. Many septic systems were rendered inoperable. Flood-related mold issues were expected to be a significant concern.

Dead livestock washed downstream and end up on other owner's properties. There was also a shortage of dry livestock feed supplies in the area after the flood. Several trailers washed down the river with family pets inside them. Volunteers and other property owners released trapped pets and provided food/water for them until their owners could retrieve them or animal control could gain access to the area.

The Red Cross actively documented and addressed the above concerns or referred questions and concerns to the appropriate agencies. By the end of November, 41 staff and volunteers committed 1,980 hours to the Lewis County response effort. On November 14, the Red Cross dispatched two nurses and the Lewis County Health Department sent a Mental Health representative to the east county to assist with needs of those affected by the flood event.

Local Red Cross resources were significantly affected and financial reserves were reduced to a critical level following the flood, two windstorms and an ice storm that occurred within the month of November.

### **Impacts – Salvation Army and Community Support:**

The Salvation Army provides direct and indirect support to the flood disaster relief efforts. Acting as an agent for the Salvation Army, the City Clerk of Mossyrock provided indirect support, issuing vouchers for needed supplies and other Salvation Army-funded relief resources to meet the needs of those displaced by the flood and winter storms.

The Salvation Army provided 134 meals and one case of water to those who were housed in the Red Cross shelter located at St. John's Lutheran Church.

The following supplies were provided to residents of the east county during the flood event: twenty-five cans of baby formula; 152 jars of baby food; 7 boxes of rice and cereal; and multiple packages of diapers and wipes, both for infant and adult use. Also provided were cold drinks and snacks for the EOC team. Truckloads of donated items were sent from: Wal-Mart, Mt. Tahoma Community food Bank, Blantons Market, Home Depot, World Vision, M & M Transport, Bethel Assembly of God Church and the White Pass Community Service Coalition.

The Packwood Relief Center distributed donated goods valued at over \$31,000. The value of time contributed by 114 weekend volunteers (11 days) that assisted with private property debris removal was in excess of \$8,800.

### **Health Impacts:**

Contaminated drinking water was a major health concern. In the Packwood High Valley area, several public water supplies were compromised due to inundation and broken lines. The public water supplies that were significantly impacted include: the High Valley Country

Club Water System; Timberline Village; Cascade Peaks; and the Lewis County Fire District 14 Water Supply.

In the lowlands, the known impacted water supplies were: the Boistfort Water System; City of Chehalis; Vader Water Supply; and the Enchanted Valley Water Supply. It was estimated that as many as 23 public water systems were affected by the flooding.

Single-family residential contaminated wells were also a concern. However, the exact number of contaminated wells is not known. Lewis County, through their micro-certified water laboratory, provided flushing and disinfecting procedures and free bacterial testing to homes with wells that were covered by the flood waters. The total of wells tested is not available.

Gravity septic systems in flooded areas were not be impacted by flooding. When the groundwater returned to normal, they became operational again. However, mound and sand-filter systems and Glendon systems could have been washed away and no longer be operational. The number of impacted systems in the flooded areas is approximately 65 single-family residential on-site treatment systems. Failed septic systems contribute to continued public health risks and surface contamination issues.

Community on-site sewage disposal systems in flood areas may have discharged waste to floodwaters. Displaced residents had to initiate recovery efforts to obtain potable water, reestablish sanitary sewage systems, and remove contaminated materials and reduce exposure to potential contaminants from flooding, such as mold.

The final boil water notice in effect for contaminated public water systems (Vader) was revoked on November 29<sup>th</sup>. Due to its inability to treat its surface water to a safe level, the city of Vader trucked in over 20,000 gallons of water. The turbidity of the water entering the intake at the river exceeded the ability of the plant to treat to less than 1 NTU (State Health Standard). The plant had to be shut down and the filters cleaned prior to again being operable. The continued operation of the plant required a laborious effort of continuously checking the turbidity at the intake, and manually back flushing to assure effective treatment. This resulted in the plant being unable to keep up with user demand and too short a chlorine contact time to meet state health requirements. The plant continued to operate in this manner until river turbidity dropped below 70 NTUs. With the imminent risk of treatment failure, the Washington State Department of Health continued to keep the system on a Boil Water Advisory.

### **Significant Effects on Local Governments**

Emergency Management (DEM), Sheriff's Office, Public Works, Community Development, and other city and county staff focused on disaster efforts, postponing their regular work during and after the flood event. This resulted in additional overtime necessary to "catch up" delayed regular work.

During the flood events, the normal flow of traffic was interrupted on numerous county roads, state and federal highways, including Interstate 5 freeway ramps in Chehalis, US

Highway 12 in the Packwood/Randle area, State Route 508, in the east county, and on dozens of city streets as well.

Cost estimates related to county and city staff efforts to support flood relief were too varied and difficult to total due to there being 5 natural winter storm events within four weeks time. However, at least 89 road repair projects on 59 roads were identified that had flood damage relating to flooding, landslides or damage to bridges from this event. The loss of upper-income vacation homes in the Packwood area further drained county government with losses from property tax revenues.

The State Department of Transportation and Lewis County Public Works personnel responded quickly on November 6<sup>th</sup>. Public Works mobilized all field staff to assess damage to public infrastructure, mainly roads and bridges, on the first day of flooding. In addition, Public Works crews assisted in opening roads, clearing debris including removal of a log jam at the Jackson Highway Bridge that crosses the Newaukum River within the Urban Growth Area of the City of Chehalis. That debris dam caused damage to the City water main located on the bridge superstructure. City staff replaced over 100 feet of 6-inch main with a temporary line.

Lewis County Public Works was the county's department most affected by the flood. Preliminary estimates fixed the cost in excess of \$6.5 million. County work crews, equipment and other resources were taxed beyond normal levels during the flood event. Examples include:

- Public Works crews were required to work overtime to respond to the event, increasing the County's salary budget.
- Thousands of County-owned sandbags and sand were used during the event. Another 35,000 sandbags stored in Randle were lost in a flooded building.
- County-owned vehicles were used to transport personnel, materials and equipment in response to the flooding. They were also used for placement of barricades. Loaders and other equipment were used to move debris to clear roads, culverts, and water channels. Administrative vehicles were used by supervisors and management to assess damage during and after flooding.
- County gasoline and diesel fuel were used for operation of vehicles and equipment during and after the event.
- Barricades, traffic control devices, markers and cones were used to direct traffic flow. Small equipment, such as pumps and generators were also used.
- Cellular phones were used for contact with emergency response personnel at an additional unbudgeted cost.
- A private airplane was used to fly the affected flood areas and take photographs to document the event and to assist in recovery efforts.

On November 14, 2006 the following information was sent by the Lewis County Road Maintenance manager as a supplement to the above:

“In 2006, the Cowlitz River peaked in Packwood at 14.59’ on November 6<sup>th</sup> at 4:40 P.M. To complicate matters, the bridge on Skate Creek Rd, (Kernahan Bridge)

became impassable when the approach on the Lewis County side gave way, making the exit or entrance nonexistent from Lewis to Pierce County. The Paradise Estates community and many outdoorsmen were stranded. Immediately crews from both Lewis and Pierce Counties responded to determine a solution that would allow for a temporary escape for those trapped up in the hills, or by the Nisqually River. Approximately ten, 10-yard dump truck loads of rip-rap and quarry spalls were dumped into an expanding hole, eventually allowing for one lane to be opened. This work was done by the end of the day on Monday, November 6<sup>th</sup>.

Eventually all routes between Randle and Packwood were closed. One of the county maintenance crew members was trapped on the Packwood side of Highway 12 with his dump truck. Utilizing his truck, he continued working to repair roads as he could to move people out of unsafe areas.

Large holes developed in many of the roads as they were undermined by rivers, waters from overflowing ditches, and an onslaught of large debris.

As the water receded, crews dispatched by Public Works moved into an assessment mode and began traveling throughout the county to evaluate the damage to the infrastructure. The approaches to two bridges had been destroyed. One bridge was seen floating down the river. Three roads were washed away and some residents remain trapped on their property, unable to reach any public road.

Public Works utilized 116 pieces of equipment, including trucks. All of the “Road Closed” signs were used. Numerous hours of work by road crews, bridge inspectors, and engineering field crews taxed Public works resources and tested our endurance. Major storm events stretch our work forces, resources, and our capacity to assist others”.

Lewis County Community Development Department staff flew over the flood damaged areas, including Packwood, Randle and the Chehalis/Centralia area, photographing damage. The Building Official and building inspectors spent the entire day on November 14 assisting with preparation of flood damage reports in the Randle, Packwood and Mineral areas. Due to the new river channel, some properties were not permitted for repairs as they were now in the river channel.

### **Effects on Business**

Much of the business impact was due to disruptions from road closures. Agricultural operation losses due to flooding are not reported to the county Emergency Management Office, so they are not included in this report. Service businesses, including parcel post delivery, grain/feed suppliers, and food suppliers were not able to make deliveries and that was another financial blow to the community.

### **Effects on Agriculture:**

Much of the rural upper Cowlitz River basin is devoted to agriculture, including hay production and cattle grazing. There are no estimates of the financial loss associated with agriculture during this flood. From aerial reconnaissance, it is clear that much damage was sustained, including dead livestock, lost feed and pasture land, and soils eroded or covered with sand, gravel and woody debris deposited by the floodwaters.

The extent of countywide damage to drainage ditches, fences, dikes/levees that occurred is unknown, but is projected to be in the range of \$500,000 to \$1,000,000.

Many smaller levees are the responsibility of the homeowners; and therefore, are not reflected in the damage estimates previously reported.

The outlook for future planting, replacement of livestock and facilities are unknown. An additional financial hardship was experienced by citizens not directly impacted by flood waters, but none the less impacted by lack of transportation around and through the area.

**Insurance Estimates:**

The extent of insurance to cover losses is unknown. Estimates by the State/FEMA team indicated less than 15% of the citizens they interviewed had any type of insurance.

**Lewis County Response:**

Resources and services utilized to respond to the incident included the following **43 agencies:** (Provided rescue, incident management, EOC and roads services):

Lewis County Sheriff's Office	Lewis County Fire District 14 - Randle
Lewis County Emergency Management	Lewis County Fire District 15 – Winlock
Lewis County Communications E911	Thurston County Fire District 1
Lewis County RACES/ARES	Army National Guard (trucks)
Packwood Fire Department	US Forest Service
Randle Fire Department	WA State Department of Transportation
Lewis County Search and Rescue	Washington State Patrol
Lewis County SAR Dogs	WA ST Emergency Management Dept (EMD)
Lewis County Dive Team	US Navy helicopter
Lewis County Posse	US Army helicopters
Lewis County ATV	US Coast Guard helicopter
Thurston County SAR teams – Ground, Jeeps	KIRO TV helicopter (rescue)
AMR (3 ambulances)	American Red Cross
Chehalis Fire Department	The Salvation Army
Centralia Fire Department	White Pass Community Coalition Services
Lewis County Fire District 3 – Mossyrock	Cascade Mental Health
Lewis County Fire District 4 - Morton	Mossyrock Elementary School
Lewis County Fire District 6 – Chehalis	Morton High School
Lewis County Fire District 8 – Salkum	Napavine School District
Lewis County Fire District 10 - Packwood	White Pass High School
Lewis County Fire District 12 – Centralia	Private citizen rescue boats and support
Lewis County Fire District 13-Curtis	

EOC Response by discipline (43 persons) totaled the following hours (this includes only the hours in the Lewis County Sheriff's Office Training Room EOC and does not reflect any of the staffing at the Incident Command Posts in Randle or Packwood):

Agency	EOC Hours
LCSO	326.50
Lewis County Public Works	197.75
DEM	139.25

Lewis County  
Hazard Identification and Vulnerability Analysis

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Volunteers	65.25
Other (Fire, city liaisons, PD, City Public Works)	60.50
E911	49.25
Total EOC hours recorded:	<b>838.5</b>

**Agencies Participating in Recovery:**

- Emergency Management & Lewis County Sheriff's Office
- Lewis County Community Development & Public Works
- Lewis County Fire District # 14 - Randle
- American Red Cross (immediate needs, sheltering, surveys)
- The Salvation Army (food)
- Lewis County Public Health

**Non-Public Agencies:**

- Church Organizations – shelters
- Private business heavy Equipment support
- Community volunteers

**Displaced Citizens:**

- November 6, 2006 – 200 hunters  
110 Cispus Students  
37 citizens (Silverbrook, High Valley, Burton Creek)
- November 8, 2009 203 – Randle citizens  
50 – persons awaiting rescue  
100+ - hunters with unknown status
- **700+ total displaced citizens (estimated)**

**Rescue Missions**

- **314 Rescues** (24 missions pending at one time, longest pending rescue was 3 days, over 200 persons were involved in the 4-day rescue operation for a total of 5,200 hours serviced)
- **165 families evacuated**
- Welfare checks were made on approximately 200 hunting camps to ensure they had enough food/water or access to leave the impact zone
- 6 helicopters were used in the rescues

**Deaths – 2 (vehicle involved)**

- November 6, 2006 – 20-year old Seattle elk hunter Andy McDonald. Drowned when a riverbank gave way and his truck plunged into the swollen Cowlitz River near Jody's Bridge.
- November 7, 2006 - 63 year-old Mossyrock resident, Richard Greetan, was swept down the Cowlitz River when he proceeded beyond a "Road Closed" barrier and attempted to drive from Silverbrook Road onto US Highway 12, heading westbound.

River crest levels and times were as follows:

Lewis County  
Hazard Identification and Vulnerability Analysis

River	Flood Stage	Record	Crest	Predicted Forecast
Cowlitz at Packwood	10.5'	13.73' 12-02-77	<b>14.6'</b> 1630, 11-06-06	<b>15.9'</b>
Cowlitz at Randle	18.0'	25.02' 02-09-96	<b>25.2'</b> 1445, 11-07-06	<b>29.9'</b>
Nisqually at National	10.0'	12.18' 02-08-96	<b>12.8'</b> 1715, 11-06-06	<b>12.5'</b>
Nisqually at Mineral Creek	N/A		<b>14.12'</b> 1900, 11-06-06	
Newaukum	9.1'		<b>13'</b> 1400, 11-07-06 Phase III	
Skookumchuck	83.2'		<b>80.46'</b> 1400, 11-07-06	
Chehalis at Doty	11.6'		<b>14.65'</b> 1800, 11-06-06 Phase II	
Chehalis at Mellen (Centralia)	65'		<b>67.53'</b> 1700, 11-08-09 Phase I	

**Preliminary Damage Assessment Totals:**

NOTE: In the initial phase of the event, preliminary damage estimates received totaled the following (The preliminary estimate is generally understated with final total repair/replacement costs being significantly higher than the early estimates. Also, at least half the damages were not reported to Emergency Management in the brief reporting period [private/business damages within 7 days of the event, public infrastructure within 7-10 days] when many citizens have been displaced).

**Preliminary Individual Assistance Damage Reports:**

Preliminary **Individual Assistance** (Residential and business) damage reports for the November 6, 2006 Flood included the following:

Category	Claims	Structure Losses	Property/Inventory Losses
<b>Residential</b>	<b>160</b>	4,189,450	\$ 3,322,100
<b>Businesses</b>	<b>16</b>	1,012,500	\$ 755,200
Private and Business damages <b>Subtotal: \$ 9,279,250</b>			
<b>Public Structures</b>	<b>10 agencies</b>	Combined at right	\$ 17,370,230
<b>Total All Reported Losses:</b>			<b>\$ 26,649,480</b>

**Public Assistance** Damages reports included the follows agencies:

Lewis County  
Hazard Identification and Vulnerability Analysis

Agency	Type of Damage	Estimate
Lewis County	Roads, debris, water and buildings, overtime	\$ 6,493,337
Centralia	Water control, buildings, overtime	4,227,500
Vader	Utilities	4,040
Toledo	Water facilities, buildings, utilities, overtime	1,008,340
Chehalis	Parks, utilities, overtime	54,317
Morton	Parks, water control	40,390
Lewis County PUD	Utilities, parks, debris	628,706
Energy Northwest	Roads, water control, utilities	1,623,000
City of Tacoma (Rail)	Parks, debris, overtime, buildings	3,228,600
Lewis County Fire District # 14 - Randle	Building, (Insured)	62,000
<b>Total Public Assistance Damages:</b>		<b>\$ 17,370,230</b>

**FEMA Disaster Assistance Claims:**

The FEMA Disaster Recovery Center in Packwood reported the following claims were filed with them:

Centralia	5	Packwood	51
Chehalis	26	Pe Ell	1
Curtis	1	Randle	112
Glenoma	2	Toledo	4
Mineral	2	White Pass	1
Morton	13	Winlock	3
Onalaska	3		
*Total FEMA Claims filed at DRC in Packwood <b>224</b>			
*This total doesn't include claims filed directly with FEMA			

By February 28, 2007 the Stafford Act program assistance (FEMA recovery funds) to **254** qualifying individuals/households included the following amounts:

IHP (Individual and Household Assistance)	\$ 438,096
HA (housing assistance for rent, repairs)	357,028
ONA (Other Needs Assistance for medical, personal property, transportation, funeral)	163,481
<b>Total Lewis County Awards</b>	<b>\$ 958,605</b>
<b>Average Lewis County Award = \$ 3,774</b>	
<b>(State average = \$ 4,423)</b>	

## Attachment C

# West Lewis County Flood of Record – December 3, 2007 – Chehalis River

On Monday, December 3, 2007, record rainfall resulted from three Pacific Coast storms that slammed across much of Western Washington. Approximately 14"-20" of rainfall from the "super storm" fell in the Willapa Hills, causing widespread record flash flooding through Pe Ell, Boistfort, Doty, Adna and finally to the cities of Chehalis, and Centralia.

At the highest, Chehalis River crests at Mellen Street were nearly 10 feet over flood stage (74.78'). The previous record level was 74.30 reached in February, 1996.

The Doty river gauge was swept down the river after reaching a maximum of 30.04', 18.6 feet over flood stage (8.5' higher than the previous record level).

USGS scientists determined that the peak stream flow at their gauging station on the Chehalis River near Doty reached a flow of 63,100 cubic feet per second (cfs). By comparison, the previous record peak flow was 28,900 cfs, reached during the February 1996 flood.

Flood waters raged over many areas that had never been flooded previously and were not considered to be in the floodway.

By 2:30 a.m., local fire department personnel began evacuating residents along the river banks as a series of mud and log debris cracked against bridge abutments. Millions of board feet of timber and mud slides dammed up portions of the river, holding back waters until finally a wall of water 4'-18' crashed through the blockages and ripped through the valley floor. Residents were caught off guard by water slamming through one side of their homes while they escaped out the other. Thousands of dairy cows, horses, sheep, and pets were lost to the river.

Three transportation bridges were taken out by swiftly moving debris. Entire homes were washed into the river, many with families stranded on rooftops or in attics praying for rescue. Many areas of the county, including the local hospital, became islands in the middle of an ocean of muddy water and debris.

### **The Rescue**

The Lewis County EOC was activated at 0455, December 3, 2007 to organize rescues. (The NWS didn't issue a Flood Warning until 9:05 a.m.)

Lewis County Dispatch received over 1,400 calls in the first 24 hours of operation (more than 300 times their normal load). Lack of access forced the creation of 6 field commands that were coordinated from the Lewis County Forward Incident Command Post.

Water rescues self-deployed where possible with official water rescues and air rescues continuing for 5 days and nights. Semi-truck drivers were air-lifted by helicopter from their submerged units in local parking lots.

Local landmarks and street signs were covered by water making it difficult to see what area you were in or find any specific addresses. All helicopters were staffed with a LCSO deputy to provide rescue site coordinates by GPS. They also carried chain saws and axes to chop through roofs to reach victims trapped in attics. Over 500 rescues were completed without loss of life to any human being, victim or rescuer. Over 25 boats and 7 helicopters were used in the rescues. One hundred and sixty-eight helicopter rescues were completed.

Once flood waters were receding, the mission changed to fighting fires as wet hay inside barns began to smoke from spontaneous combustion due to moisture.

The EOC continued to operate approximately 10 days. As roads were opened, areas had to be searched to ensure all persons got out safely. Animal carcass disposal, health concerns and hazardous materials issues had to be addressed. Three large water systems were down. The Boistfort Valley Water Corporation, servicing approximately 2,800 residents, did not have potable water until March 21, 2008.

Sheriff's Office and County Department staff (112) provided over 7,000 hours of response and recovery time from December 3-13, 2008. Over 24 government and community groups assisted in the recovery efforts.

In the initial phase of the event, preliminary damage estimates exceeded \$166.1 million. This was estimated at only about one-third of the total damages.

None of the local levees failed during the event. The excessive amount of water simply spilled over the top of them.

This flooding event impacted a population of approximately 30,000 residents. Exit 77 of Interstate 5 was quickly inundated with 14 feet of water and remained closed for 4 days. Closure of this section of the freeway created a 440 mile detour route for transportation to continue.

Major shopping and business centers along I-5 and the Miracle Mile between Centralia and Chehalis took on 5-8 feet of water. Over 3,000 homes received some type of water damage. Approximately 1,000 of those homes were in the "major" to "destroyed" category. Fifty-five homes in the west county area were either swept into the river or had to be destroyed.

Over 20 shelters were established in the first few weeks of the event. Red Cross opened 9 shelters and served 2,115 meals and 2,766 snacks. The Salvation Army became an island itself and sheltered many residents there. The EOC coordinated serving 1,500 meals a day from December 5 through December 23 to victims and volunteers that came to help with the clean-up activities.

Approximately 500 of the impacted residents were rental homes that were a double loss to the community for as much as six months. Due to the lack of affordable rental properties,

many of these people had to relocate outside the Lewis County area. Schools reported over 400 children homeless in the weeks after the flood.

**SUMMARY:**

The response phase stretched the capacity of this small community, but the on-going recovery phase has taken months and in some cases, will continue for years to reach full restoration. An outpouring of donated goods and organizations wanting to assist with the rebuilding are still continuing today.

Ten counties were impacted during this flooding event; however, the amount of losses in Lewis County exceeded the combined total for all the other counties.

An event of this nature is estimated to be a “medium” sized event for the State of Washington; however, it is an event of catastrophic proportions to the limited resources in a rural county such as Lewis. The lack of loss of human lives is attributed to a well-practiced response team that performs annual full-scale exercises and a well-prepared, self-sufficient community. The preparedness of the Boistfort Community resulted in the first Boistfort Valley home being ready to be re-occupied in 5 weeks! Within 8 months, the Dryad community had 85 of 100 substantially damaged homes occupied. A self-directed recovery of this size is unprecedented anywhere else in the Nation!

**One – Year later:**

Many small, independent businesses failed to reopen after the flood. Twenty-nine businesses reopened anywhere from 6-11 months after the flood. It remains to be seen in this declining economy if their resources are enough to sustain them through the next 2-3 years as they continue to rebuild.

The Lewis County Assessor reduced the property values by \$46 million. Those tax losses are re-appropriated to the non-impacted properties when taxes are levied.

Lewis County Public Works is approximately 95% completed with the flood damage repairs, except for rebuilding two bridges that are pending FEMA approval. Unfortunately, they have had to delay their regular maintenance schedule to complete the flood damage projects, and are now almost a full year behind in their routine road work.

The Long Term Recovery Organization (LTRO) has received 225 requests for assistance. Only about 25 of those family case files have been closed. This means 91% of those families still need assistance with construction, household goods, financial management and emotional issues. Volunteers continue to contribute approximately 1,200 hours per months in assistance for recovery needs.

The town of Pe Ell continues to struggle to find funding for the estimated \$2.2 million needed to make repairs to the city water system.

Washington State Department of Transportation reported that the 4-day closure of Interstate 5 resulted in a \$48 million loss to the shippers and transportation industry. These losses are

part of an on-going push by the State Legislature to find a solution to the I-5 flooding problem.

The Curtis Rail Line (Port of Chehalis) has a project pending for \$1.8 million in grant funds for flood repair of a 10-mile stretch of rail track that is also used by the Historic Steam Train. The residential recovery is a stellar example that everyone in Lewis County and the supporting community can take great pride in:

<b>Lewis County 12-03-07 Chehalis Flood Flood Damage Recovery Report One Year Later</b>				
Category	Lewis County	Chehalis	Centralia	Totals
Homes Substantially damaged in 12-3-07 flood	<b>149</b>	<b>139</b> (270 impacted)	<b>350</b> (600 impacted)	<b>638</b> (1,019)
Repair Permits issued	<b>*149</b>	<b>71</b>		
Moisture Inspections			<b>350</b>	
Destroyed/Demolished Homes	<b>55</b>	<b>30</b>	<b>20</b>	<b>105</b>
Elevated Homes	<b>62</b> (more pending)	<b>15</b> (30 needed)	<b>10-12</b> (Grant for up to 30 more)	<b>89</b>
Considered for Abatement (buy-out)		<b>15</b>		<b>15</b>
<b>*Dec 3, 2007 through February 29, 2008</b>				

<b>Hazardous Debris Cleanup / Disposal Report</b>	
From Chehalis River Flood 12-03-07 Prepared 11-20-08	
Material	Quantity
Oil, gas, paint materials	3,500 gallons
Oil-contaminated debris & containers	17,000
Containers	2,800
Tires (stockpiled)	800

**Costs of December 3, 2007 Flood:**

**Lewis County Disaster Declaration**

Private Damages (1501 claims): **\$121,116,834**

Public Damages (31 agencies): **\$ 45,046,686**

**Total preliminary damages: \$166,163,520**

**FEMA reported aid to Lewis Co. (3-20-08)**

Housing Assistance: \$9,583,635  
Other Needs: \$2,266,483  
Small Business Admin loan \$19,615,500  
PA paid to date State/County: \$8,034,990

Total Paid to Lewis County as of 3-20-08: **\$39,500,608**

**(Total to all WA State: \$72,525,057)**

110 Lewis County residents received the maximum allowable - (\$28,800).

State estimates the 4-day closure of Interstate 5 cost \$4 million an hour for loss of revenue. This closure forced a 440-mile detour around the floodwaters. City of Chehalis estimated business losses during the month of December at \$6 million per week while closed.

Lewis County adjusted tax rolls by \$48 million in property value losses.

**SUPPLEMENTAL: One –year later**

**One-Year Later Financial losses to businesses, transportation, tax revenue, private and public structures total:**

**\$ 512,068,100**

**SUPPLEMENTAL: 3 YEARS LATER**

**Chehalis River Basin Flood Authority Rpt Feb. 17, 2010**

**\*Total Economic losses \$938 million**

**Business Closures as of 11-20-08:**

1. CLS Communications (16 years business), closed 5-31-08
2. Bedroom World (Fairway Shopping Center, Lost hundreds of thousands in inventory and closed its doors, never reopening after the flood.
3. Kluh Jewelers – (34 years - \$300,000 in damages)
4. Great Music Company (Open since 1978 in three locations-30 years) – 7-31-08
5. Fairway Shopping Center lost three businesses, not named

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**Businesses that Reopened prior to 11-20-08:**

**Within a Month:**

1. Chehalis-Centralia Airport (10 days)
2. Twin City Town Center – Chehalis
3. Walgreens

4. Big 5 Sporting Goods
5. Aarons
6. Home Depot
7. Shop 'n Kart
8. Sunbirds Shopping Center
9. Gootee Chevrolet - Pontiac – Buick
10. Sorensen Trucking – Chehalis (lost \$500,000 in revenue to due I-5 Closure plus \$500,000 in lost products and repairs to vehicles)

**Four Months:**

1. Boistfort Valley Water System (2,500-3,000 customers, \$810,000 in damages)

**Six Months:**

1. K-Mart
2. Dirty Thumb Nursery
3. Fairway Lanes (Bowling Alley \$650,000)
4. Camera Exchange
5. Secrets Family Hair Salon (Fairway)
6. El Dorado Restaurant
7. Veterans memorial Museum
8. Boistfort Valley Farm

**Seven Months:**

1. SWW Fairgrounds

**Eight Months:**

1. Peppertree Park & RV Park
2. Kresky Plaza. Includes: Cellular connections, Molto Bello Spa Salon, Allstate Insurance & Picture This Family Portrait Studio)

**Nine Months:**

1. Kilmer's Flooring America – (Kresky Ave, Centralia)

**Eleven Months:**

1. Twin City Senior Center
2. Curtis Store