WASHINGTON STATE

HAZARD IDENTIFICATION AND VULNERABILITY ASSESSMENT

Foreword

The *Washington State Hazard Identification and Vulnerability Assessment* (HIVA) assesses natural and technological (man-made) hazards in Washington State. Assessment is the initial step in the emergency management process that leads to mitigation against, preparedness for, response to, and recovery from hazards. Hazards have the potential of becoming disasters or emergencies that can adversely affect the people, environment, economy, and property of the state.

Hazard assessment helps emergency managers rate the risk, determine vulnerability, and predict the adverse impact of disasters and emergencies. Emergency managers with good hazard assessments can effectively organize resources and develop comprehensive emergency management plans to minimize the impact of disasters and emergencies.

The HIVA contains information from federal, state, and local government as well as from public sources. The Washington State Emergency Management Division (EMD) publishes the document. Recommendations on how this document can be improved should be addressed to the Washington State Military Department, Emergency Management Division, Plans Section, Camp Murray, Washington 98430-5122.

From the Director

The emergency management approach is continually improving. As we emphasize the most important parts of emergency management, then we will put our resources to best use.

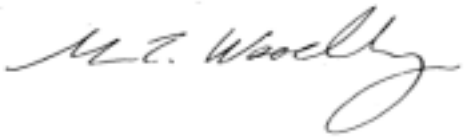
An integrated emergency management approach involves hazard identification, risk assessment, and vulnerability analysis. Primarily, this document describes the hazard identification and assessment for Washington State. The next important step for the state and local jurisdictions is setting priorities and moving toward reducing potential impact of our worst hazards. This is done through mitigation and prevention strategies that are later described in the Matrices section of this document. Mitigation and prevention are not just equal phases in the emergency management process, they are the pervasive and required functions from which all preparedness, response, and recovery activities must flow. This process requires complete community involvement and an in-depth risk assessment and vulnerability analysis of all potential hazards.

This process to integrate emergency management processes can be described best in the following chart. The hazard identification and risk assessment involves identifying the types of hazards, their likelihood of occurrence, location in the community, impact, and strength. Risk assessment is the measure of the probability that damage to life, property, economy, and environment will occur if a hazard manifests itself. Vulnerability describes someone's or something's exposure to a threat. The distinction between risk and vulnerability is important. A home located in a 500-year floodplain could be considered vulnerable to a 500-year flood although the risk of that flood happening may be low. The risk of a park located in a floodplain being struck by a flood may be quite high, but the park would not be considered vulnerable to damage because the flood's effect upon it would be small. In short, vulnerability is a measure of what and how much you stand to lose. The vulnerability analysis identifies and quantifies what is susceptible to damage.

Hazard identification and risk assessment coupled with a vulnerability analysis are important factors in determining mitigation priorities. When we are unable to mitigate the effects of a hazard, then we must continue to do the kind of things we have always done to get ready. When we cannot mitigate, we must be ready to prepare, respond, and recover. This process enhances and focus' our get ready and go activities.

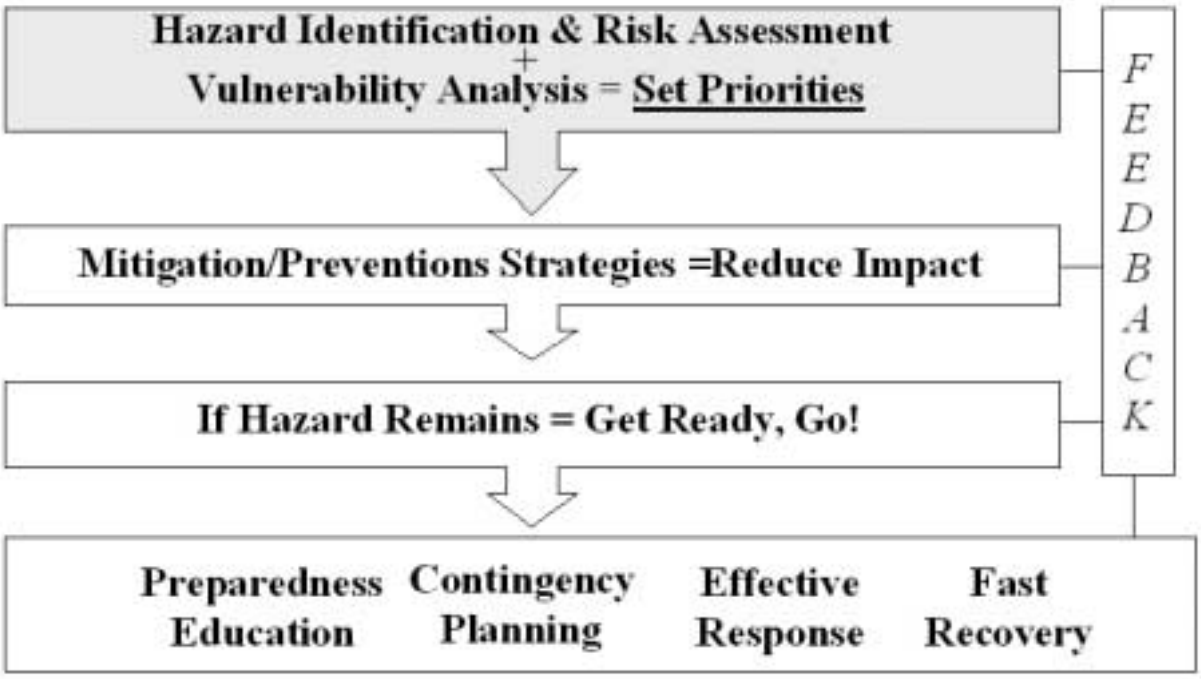
The goal in simplest terms is to define the problem, try to stop the impact of the problem, and then get ready to respond and recover from those impacts we could not prevent. This document is only the first step in a comprehensive process to build a "disaster resistant Washington."

Sincerely,



Glen L. Woodbury
Director

An Integrated Emergency Management Approach



WASHINGTON STATE
HAZARD IDENTIFICATION AND VULNERABILITY ASSESSMENT

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HAZARD IDENTIFICATION AND VULNERABILITY ASSESSMENT

Purpose

This HIVA describes natural and technological (human-made) hazards, which can potentially impact the people, economy, environment, and property of Washington State. It serves as a basis for state-level emergency management programs and assists political subdivisions in the development of similar documents focused on local hazards. It is the foundation of effective emergency management and identifies the hazards that organizations must mitigate against, prepare for, respond to, and recover from in order to minimize the effects of disasters and emergencies. The HIVA is not a detailed study, but rather a general overview of hazards that can cause emergencies and disasters.

Background

Washington State experiences significant impacts from natural hazards including floods, storms, wildland fires, earthquakes, and volcanoes. Beyond natural hazards, there are technological hazards, including nuclear power plant incidents, chemical weapon stockpiles, dam failures, and hazardous material spills. All of these require assessment and determination by state, county, and city officials in order to organize resources so loss can be prevented or minimized.

From 1956 to 1998, Washington State qualified for 35 Presidential Major Disaster Declarations. These include 27 floods, the 1998 city of Kelso residential landslide, the 1994 El Nino disrupting salmon migration, the 1991 wildland fires in Pend Oreille, Spokane, Stevens, and Whitman counties, the 1993 Inaugural Day windstorm, the 1986 Spokane dam failure, the 1980 Mount Saint Helens eruption, the 1965 Puget Sound earthquake, and the 1962 Columbus Day windstorm. In addition to the Presidential Major Disaster Declarations, many events occur that cause severe impacts to the state, counties, and cites, as well as to businesses and individuals.

Scope

A HIVA is applicable to all cities and counties in the state. State law requires all political subdivisions to be part of an emergency management organization and to have an emergency management plan. 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 *Washington State Comprehensive Emergency Management Plan* (CEMP).

The HIVA contains hazards that are not present in all areas of the state and therefore need not be part of a local assessment. Examples are volcanoes, avalanches, and tsunamis, which are limited to specific geographical locations. On the other hand, a political subdivision may have a hazard that the state has not assessed in this document. Unique hazards may exist in certain locales, which should be considered in the development of the written local hazard assessment, but are not appropriate for inclusion in a state-level document.

Some hazards require in-depth scientific and quantifiable analysis to justify expenditure of money and personnel resources. An example may include flood plain studies required to mitigate against, prepare for, respond to, and recover from flooding. Mitigation may include building of dikes, dredging of river channels, or removing people and structures from harms way and allowing open space. Preparedness may include public education and sandbag storage. Response may include evacuation and sheltering of people and pets. Recovery may include flood debris clean up and repair of damaged structures.

Washington State's detailed hazard analyses are contained elsewhere in strategies, programs, and plans. The scope of this document is to identify the state's hazards and then describe them in terms of definition, history, identification and assessment, and conclusion.

As a minimum, political subdivisions need a HIVA. Detailed hazard analysis may be required for specific hazards deemed necessary by political subdivisions.

Geography

Washington State is the 20th largest state in the United States, with 39 counties encompassing 66,582 square miles. There are approximately 34,219 square miles of forest land, 25,000 square miles of farm and range land, 25 mountains over 8,000 feet, three national parks, nine national forests, and hundreds of state and county parks, recreational areas, and wildlife preserves.

The distance from the Canadian border to Vancouver, Washington is 276 miles and the distance from Seattle to Spokane is 280 miles. Washington's coastline measures 157 miles. The inland shoreline measures 3,026 miles along the Strait of Juan de Fuca, Puget Sound, and the islands of the Puget Sound.

There are 8,000 lakes and 40,000 miles of rivers and streams. The Columbia River, one of the longest rivers in the United States, flows through Washington for more than 700 miles and drains more than half of the state.

Western Washington has a milder climate than any other region in the United States that is located as far north. Eastern Washington has warmer summers and colder winters than Western Washington. Moist winds from the Pacific Ocean bring large amounts of precipitation to Western Washington. By the time weather systems reach Eastern Washington, they have lost much of their moisture. Average precipitation is 135 inches in parts of the Olympic Peninsula and six inches in the Columbia Plateau area.

Economy

The 10 largest public companies in Washington State are the Boeing Company, Costco Wholesale Corporation, Microsoft Corporation, Weyerhaeuser Company, Washington Mutual Inc., Paccar Inc., Nordstrom Inc., Safeco Corporation, Airborne Freight Corporation, and Quality Food Centers, Inc. (Fred Meyer and QFC).

In addition to the best-known products of aircraft and computer software, Washington State produces a wide variety of raw and manufactured products.

- Food and agriculture - wheat, fish, seafood, fruit, beer, wine, vegetables, hops, hay, and animal fodder.

- Forest - timber, lumber, building materials, pulp, paper, furniture, and musical instruments.

- Manufactured - trucks, marine vessels, computers, food processing equipment, test and measuring equipment, mining equipment, medical equipment, sporting goods, gifts, and fine handicrafts.

Demographics

The "2000 Population Trends for Washington State," produced by the Forecasting Division of the Office of Financial Management, shows Washington State's population as 5,803,400 as of April 1, 2000. This is an increase of 0.8 percent over the last year compared to a 1.3 percent gain for 1998-1999 and annual gains of nearly 3 percent in the early 1990s. Annual net migrations gains to Washington have declined from 54,600 in 1997 to 10,000 in 2000.

The fastest-growing Washington counties in terms of percentage changes were Clark, Jefferson, and Grant counties. In terms of numerical population change, King County gained an estimated 178,000 persons over the decade. For the same period, Snohomish gained nearly 128,000 people; Pierce County gained 120,000; and Clark County gained 107,000. See Table One for county changes over the last decade.

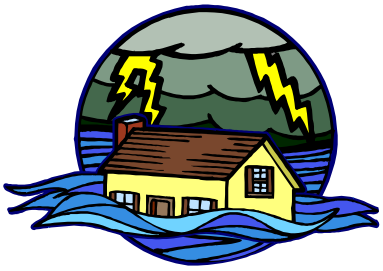
Resources

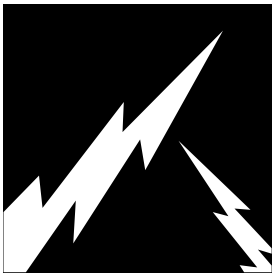
Washington State Emergency Management Division
Washington State Department of Community, Trade, and Economic Development
Washington State Government Information and Services
Washington State Office of Financial Management
National Weather Service

Table One
Population by County - April 1, 1990 to April 1, 2000

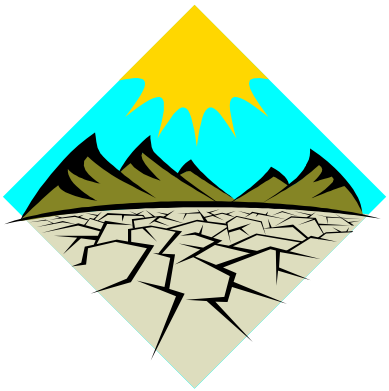
	1990	2000	Change	Percent Change	Natural Increase	Net Migration
Washington State	4,866,663	5,803,400	936,737	19.25	382,910	553,827
Adams	13,603	15,800	2,197	16.15	2,046	151
Asotin	17,605	20,000	2,395	13.6	493	1,902
Benton	112,560	140,700	28,140	25	11,693	16,447
Chelan	52,250	62,600	10,350	19.81	4,354	5,996
Clallam	56,204	66,700	10,496	18.67	-343	10,839
Clark	238,053	345,000	106,947	44.93	25,622	81,325
Columbia	4,024	4,100	76	1.89	-9	85
Cowlitz	82,119	94,900	12,781	15.56	4,064	8,717
Douglas	26,205	32,200	5,995	22.88	2,334	3,661
Ferry	6,295	7,300	1,005	15.97	212	793
Franklin	37,473	45,900	8,427	22.49	7,224	1,203
Garfield	2,248	2,300	52	2.31	-141	193
Grant	54,798	71,500	16,702	30.48	7,277	9,425
Grays Harbor	64,175	67,100	2,925	4.56	1,638	1,287
Island	60,195	74,200	14,005	23.27	5,219	8,786
Jefferson	20,406	26,800	6,394	31.33	-247	6,641
King	1,507,305	1,685,600	178,295	11.83	109,804	68,491
Kitsap	189,731	230,200	40,469	21.33	17,864	22,605
Kittitas	26,725	32,500	5,775	21.61	989	4,786
Klickitat	16,616	19,600	2,984	17.96	840	2,144
Lewis	59,358	69,000	9,642	16.24	1,848	7,794
Lincoln	8,864	10,000	1,136	12.82	-79	1,215
Mason	38,341	49,300	10,959	28.58	923	10,036
Okanogan	33,350	38,500	5,150	15.44	2,119	3,031
Pacific	18,882	21,300	2,418	12.81	-474	2,892
Pend Oreille	8,915	11,200	2,285	25.63	329	1,956
Pierce	586,203	706,000	119,797	20.44	52,061	67,736
San Juan	10,035	12,700	2,665	26.56	79	2,586
Skagit	79,545	102,300	22,755	28.61	4,755	18,000
Skamania	8,289	9,900	1,611	19.44	318	1,293
Snohomish	465,628	593,500	127,872	27.46	48,079	79,793

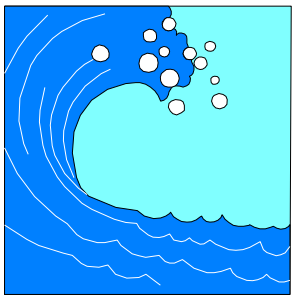
Table One Population by County - April 1, 1990 to April 1, 2000						
	1990	**2000**	**Change**	**Percent Change**	**Natural Increase**	**Net Migration**
Spokane	361,333	415,000	53,667	14.85	22,010	31,657
Stevens	30,948	38,500	7,552	24.4	1,280	6,272
Thurston	161,238	204,300	43,062	26.71	10,774	32,288
Wahkiakum	3,327	3,900	573	17.22	-122	695
Walla Walla	48,439	54,200	5,761	11.89	2,037	3,724
Whatcom	127,780	163,500	35,720	27.95	8,363	27,357
Whitman	38,775	41,300	2,525	6.51	1,960	565
Yakima	188,823	214,000	25,177	13.33	25,717	-540
Office of Financial Management, Forecasting Division						





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.

History

Avalanches in Washington State have killed over 190 people since 1910, exceeding deaths from any other natural cause. See Table Two for list of Severe Avalanches in Washington State.

Hazard Identification and Vulnerability Assessment

Avalanches occur in four mountainous areas of the state. The Cascade Range is the largest and most extensive area, followed by the Olympic Mountains, the Blue Mountains, and the Selkirk Mountain Range in northeast Washington. The west slopes of the Cascades and Olympics receive extensive snow due to their size and orientation to Pacific marine airflow. The Blue Mountains, the Selkirk Mountains, and the east slopes of the Cascades have shallower, less dense snow packs and a cooler winter climate. The avalanche season begins in November and continues until early summer for all mountainous areas of the state. In the high alpine areas of the Cascades and Olympics, the avalanche season continues year around.

More people are working, traveling, and living in hazardous avalanche areas. The increasing development of recreational sites in the mountains brings added exposure to people using these sites.

In a severe winter, avalanches can close mountain highways joining Eastern and Western Washington. Considerable money is spent on structural avalanche defenses on Snoqualmie Pass to protect Interstate 90 (I-90). The Washington State Department of Transportation budget for removing avalanche snow and ice from the six highways through the Cascades is $20 million per year.

Avalanche expenses are a regular winter occurrence for transportation arterials and ski areas. Highway avalanche closures also have a significant impact on statewide commerce. In the 1996-1997 winter there were 11.5 days of closure of I-90 over Snoqualmie Pass. An impact study revealed that closing I-90 over Snoqualmie Pass for just one hour has an economic cost of $485,000 per hour. The total cost of closing the I-90 in the winter of 1996-1997 was $134 million.

Losses are also realized by the timber industry, homeowners, power companies, recreational resorts, snowmobile riders, snow skiers, snow boarders, and mountaineering groups. Individuals involved in recreational activities are at the greatest risk of injury when using backcountry areas.

Conclusion

The United States Forest Service, National Park Service, Washington State Department of Transportation, and most major ski areas within Washington State have programs to monitor avalanche zones and forecast avalanche hazards. Artillery or hand-placed explosives are often used to create small avalanches to avoid the uncontrolled impact of larger ones. Areas are posted if an avalanche danger is known.

Timber harvest must be regulated near developments, highways, and utilities since forests help to stabilize the snow pack and denuded slopes contribute to avalanche release. Reforestation should be encouraged in slide zones affecting highways, buildings, power lines, and other improvements.

County, state, and federal land use planners must acquire information and make recommendations on potential avalanche hazards likely to affect people and property in mountainous areas. Because there is no sure way to keep the public out of avalanche-prone areas, better avalanche detection and avoidance would help. All county, state, and federal agencies, along with private interests, should coordinate their efforts in making winter observation data available to the public. Avalanche education, training, and proper equipment, including 457 KHz transceivers, shovels and probes, are strongly recommended for winter backcountry users.

Resources

Washington State Emergency Management Division
Washington State Department of Transportation
National Weather Service
United States Forest Service
United States National Park Service

Table Two
Severe Avalanches

Date	Location	Casualties
March 1, 1910	Stevens Pass	Two trains were swept off their tracks killing 96.
1930's	Harts Pass	5 miners dead
1939	Mount Baker	6 dead
1953	Source Lake	1 dead
1958	Silver Creek	4 buried
1962	Granite Mountain	2 dead
1962	Stevens Pass	2 buried
1966	Mount Baker	1 dead
1966	Snoqualmie Pass	1 buried
1971	Yodelin	4 dead, several buried
1971	Snoqualmie Pass Highway	1 dead
1974	Source Lake	2 dead
1975	Mount St. Helens	5 dead
1981	Mount Rainier	19 dead, 18 injured
1988	Mount Rainier	3 dead
1992	Mount Rainier	2 dead
1993	Snoqualmie Pass	5 injured
1994	Mission Ridge	1 dead
1995	McClellan Butte	1 injured
1996	Snoqualmie Pass	2 buried but recovered uninjured
1996	Index	3 dead (trip began on December 27, 1996 and recovery was on January 1, 1997)
1996-97	Snoqualmie Pass	Hundreds of travelers were stranded after I-90 closed due to repeated avalanches during the holidays
January 18, 1998	Drop Creek, north of Ellensburg	Snowmobile buried, 1 dead
June, 1998	Mount Rainier	1 climber dead, several climbers injured
1998	Mount Baker	1 dead
1999	Mount Baker	1 snow boarder and 1 skier dead

DROUGHT

Definition

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

History

The Washington State Legislature in 1989 gave permanent drought relief authority to the Department of Ecology and enabled them to issue orders declaring drought emergencies. See Table Three for list of Drought Occurrences in Washington State.

Hazard Identification and Vulnerability Assessment

Nearly all areas of the state are vulnerable to drought. The area in Central Washington just east of the Cascades is particularly vulnerable.

In every drought, agriculture is adversely impacted, especially in non-irrigated areas such as dry land farms and rangelands. Droughts impact individuals (farm owners, tenants, and farm laborers), the agricultural industry, and other agriculture-related sectors. Lack of snow pack has forced ski resorts into bankruptcy. There is increased danger of forest and wildland fires. Millions of board feet of timber have been lost. Loss of forests and trees increases erosion causing serious damage to aquatic life, irrigation, and power development by heavy silting of streams, reservoirs, and rivers. Three energy curtailments, during drought periods prior to 1977, caused temporary unemployment.

Problems of domestic and municipal water supplies are historically corrected by building another reservoir, a larger pipeline, a new well, or some other facility. Short-term measures, such as using large capacity water tankers to supply domestic potable water, have also been used. Low stream flows have created high temperatures, oxygen depletion, disease, and lack of spawning areas for our fish resources.

Conclusion

As a result of droughts, agriculture uses new techniques. Federal and state governments play an active role in developing new water projects and soil conservation programs. RCW 43.83B.400-430 and Chapter 173-166 WAC pertain to drought relief.

Better forest fire protection techniques decrease total acreage burned. Progress is made in dealing with the impact of droughts through proper management of water resources. Drought information collection assists in the formulation of programs for future water-short years.

Drought forecasting information and mitigation strategies used in Washington State:

- Irrigation prior to forecasted drought
- Advance warning of changes in stream flows
- Measurement of snow pack conditions
- Studies of areas subject to wind erosion
- Loans for purchase of seed for spring planting and fuel for farm equipment
- Limit irrigation and sprinkling
- Study of ground water supplies
- Shut down of logging operators
- Water conservation measures
- Reduce hydroelectric power use
- Voluntary energy conservation programs
- Purchase of out-of-region energy
- Cloudseeding
- Apply for federal drought relief programs
- State drought legislation
- Consider emergency supplemental ground water permits

Resources

Washington State Emergency Management Division
Washington State Department of Ecology
Washington State Department of Natural Resources
National Weather Service

Table Three Drought Occurrences	
Date	**Occurrence**
July-August 1902	No measurable rainfall in Western Washington.
August 1919	Drought and hot weather occurred in Western Washington.
July-August 1921	Drought in all agricultural sections.
June-August 1922	The statewide precipitation averaged .10 inches.
March-August 1924	Lack of soil moisture retarded germination of spring wheat.
July 1925	Drought occurred in Washington.
July 21-August 25, 1926	Little or no rainfall was reported.
June 1928-March 1929	Most stations averaged less than 20 percent of normal rainfall for August and September and less than 60 percent for nine months.
July-August 1930	Drought affected the entire state. Most weather stations averaged 10 percent or less of normal precipitation.
April 1934-March 1937	The longest drought in the region's history – the driest periods were April-August 1934, September-December 1935, and July-January 1936-1937.
May-September 1938	Driest growing season in Western Washington.
1944	Water shortages in Spokane.
1952	Every month was below normal precipitation except June. The hardest hit areas were Puget Sound and the central Cascades.
January-May 1964	Drought covered the southwestern part of the state. Precipitation was less than 40 percent of normal.
Spring, 1966	The entire state was dry.
June-August 1967	Drought occurred in Washington.
January-August 1973	Dry in the Cascades.
October 1976- September 1977	Worst drought in Pacific Northwest history. Below normal precipitation in Olympia, Seattle, and Yakima. Crop yields were below normal and ski resorts closed for much of the 1976-77 season.
October 1991- September 1994	Water supply in Yakima River basin was 65 percent of normal.

EARTHQUAKE

Definition

An earthquake is ground shaking caused by an abrupt shift along a fracture in the earth, called a fault.

History

Washington State, especially the Puget Sound basin, has a history of frequent earthquakes. More than 1,000 earthquakes are recorded in the state annually. A dozen or more cause shaking and occasional damage. Large earthquakes in 1949 (magnitude 7.1) and 1965 (magnitude 6.5) killed 15 people and caused more than $200 million (1984 dollars) in damage in several counties. The state experienced at least 20 damaging events in the last 125 years. Most earthquakes occur in Western Washington. However, some damaging events and the state's largest earthquake of 1872, occurred east of the Cascade Crest. Geologic evidence documents prehistoric magnitude 8 to 9.5 coastal earthquakes and magnitude 7+ shallow depth earthquakes in major urban areas.

The most recent earthquake, on February 28, 2001, was a deep, 6.8 magnitude earthquake located 17.6 kilometers northeast of Olympia in the Puget Sound. One person died of a heart attack, over 700 people were injured, and damages were upward of $1 billion at the time of the earthquake. See Table Four for list of significant Earthquakes in Washington State.

Hazard Identification and Vulnerability Assessment

Large oceanic and continental crustal plates move 3-4 centimeters annually in the Pacific Northwest over the surface of the earth. These plates may move in sideswipe or head-on collisions. Where they collide they build up stresses and then release energy as earthquakes. Washington is located at the middle of an offshore head-on collision convergent boundary called the Cascadia Subduction Zone that extends from southern British Columbia to northern California. The inland extent of related earthquake activity is the Cascade Mountain Range where the volcanoes mark the melting edge of the subducting (sinking) Juan de Fuca Plate that is made of oceanic crust. The overriding plate is known as the North American Plate and is made of continental crust.

Washington is vulnerable to earthquakes originating from three sources: in the subducting slab, in the overriding plate, and between the colliding plates. Historically, the most damaging events occur at depths of 15 to 60 miles in the subducting plate. Examples are the 1949 magnitude 7.1 Olympia event (approximate recurrence rate is 110 years for this size) and the 1965 magnitude 6.5 Seattle – Tacoma event (approximate recurrence rate is 35 years for this size). Historically, these events do not have aftershock activity.

Shallow crustal earthquakes occur in the overriding continental plate within 20 miles of the surface. Historic examples occurred on Maury Island in 1995, near Deming in 1990, near North Bend in 1945, and on the St. Helens fault in 1981. All these earthquakes were of magnitude 5 – 5.5. The St. Helens seismic zone could produce a magnitude 6.2 – 6.8. The Seattle Fault evidence suggests a previous magnitude 7+ occurred about 1100 years ago. Larger events are

possible such as the 1872 magnitude 7.4. Many aftershocks were reported with the 1872 event and are the evidence for its shallow depth since shallow crustal earthquakes often are followed by aftershocks unlike the deeper subducting slab events. At least nine of the earthquakes in Table Four were shallow depth.

Great earthquakes of magnitude 8 to 9+ occurred between colliding plates, at the interface of the Juan de Fuca and North American Plates. The recurrence rate for these events is approximately every 550 years but is irregular, with the interval between events ranging from 200 years to 1,100 years.

Earthquakes cause damage by strong ground shaking and by the secondary effects of ground failures, tsunamis, and seiches. The strength of ground shaking (strong motion) generally decreases or attenuates with distance from the earthquake source. Shaking can be much higher when earthquake waves are amplified by bedrock and then pass into softer geologic materials such as unconsolidated sediments. West Seattle and downtown Olympia are examples where amplification has occurred and ground shaking was much stronger than in other areas.

Ground failures caused by earthquakes include fault rupture, ground cracking, slumps, landslides, rockfalls, liquefaction, uplift and subsidence. Faults often do not rupture through to the surface. Unstable or unconsolidated ground is most at risk to the remaining effects. Any of these failures will effect structures above or below them.

Earthquakes can cause large and disastrous slides, including debris avalanches from volcanoes. Strong shaking can cause cohesive sediments to lose strength. Loss of strength in clay-rich soils can cause landslides and other ground failures. Liquefaction occurs when water-saturated sands, silts or gravels are shaken so violently that the grains lose their points of contact and rearrange themselves, squeezing the water out of the shrinking pores and causing it to flow outward forming sand “boils” or causing lateral spreading of overlying layers. Liquefaction causes loss of bearing strength under structures, triggers slides, and floats low-density structures, such as fuel tanks and pilings.

Tsunamis are long-period waves that result from the water column being displaced by seafloor uplifting or subsiding, or by landslides or submarine slides, or sometimes volcanic explosions in the water. Seiches are standing waves in an enclosed or partially enclosed body of water similar to sloshing waves in a bathtub and can be caused by strong shaking. Washington has had minor damage from seiches historically. Tsunami deposits exist that appear to be related to the Seattle Fault and the Cascadia Subduction Zone events. Washington is also at risk to tsunamis from distant earthquakes.

Conclusion

Washington ranks second in the nation after California among states susceptible to earthquake loss according to a Federal Emergency Management Agency (FEMA) study. The study predicts an annualized loss of $228 million. Seattle is seventh and Tacoma is 22nd on a list of cities with more than $10 million in annualized losses. It is important to protect our economic base. The functionality of our critical facilities and lifelines such as hospitals, fire stations, schools, power, communications, transportation, fuel delivery systems, dams, etc. will be even more vitally

important than the immediate dollar losses following a major earthquake. Historic earthquakes provide loss of life and property data in 1949 and 1965. Since then, population and development have grown and without mitigation we expect higher loss due to the greater exposure. This requires a focus on implementing mitigation measures in our communities in all areas of our lives, including home, school, business, and government:

- Examine, evaluate, and enforce building and zoning codes.
- Identify geologically hazardous areas and adopt land use policies.
- Provide public information on actions to take before, during, and after an earthquake.
- Develop and maintain mitigation, preparedness, response, and recovery programs.

Resources

Washington State Emergency Management Division
Washington State Department of Natural Resources, Geology and Earth Resources Division
Washington State Department of Transportation
University of Washington Geophysics Program
United States Geological Survey
Federal Emergency Management Agency

Table Four
Washington State Significant Earthquakes

Date	Time (PST)	Latitude Longitude	Depth (Km)	Mag	Location
December 14, 1872	2140	48°48' 121°24'	shallow	7.4	North Cascades
December 12, 1880	2040	47°30' 122°30'		5.5	Puget Sound
April 30, 1882	2248	47°00' 123°00'	deep	6.0	Olympia area
November 29, 1891	1521	48°00' 123°30'		5.0	Puget Sound
March 6, 1893	1703	45°54' 119°24'	shallow	4.9	Southeast Washington
January 3, 1896	2215	48°30' 122°48'		5.7	Puget Sound
March 16, 1904	2020	47°48' 123°00'		5.3	Olympics eastside
January 11, 1909	1549	48°42' 122°48'	deep	6.0	Puget Sound
August 18, 1915	0605	48°30' 121°24'		5.6	North Cascades
January 23, 1920	2309	48°36' 123°00'		5.5	Puget Sound
July 17, 1932	2201	47°45' 121°50'	shallow	5.2	Central Cascades
July 15, 1936	2308	46°00' 118°18'	shallow	5.7	Southeast Washington

Table Four Washington State Significant Earthquakes					
November 12, 1939	2346	47°24' 122°36'	deep	5.7	Puget Sound
April 29, 1945	1216	47°24' 121°42'		5.5	Central Cascades
February 14, 1946	1914	47°18' 122°54'	40	6.3	Puget Sound
April 13, 1949	1155	47°06' 122°42'	54	7.1	Puget Sound
August 5, 1959	1944	47°48' 120°00'	35		Northwest Cascades
April 29, 1965	0728	47°24' 122°24	63	6.5	Puget Sound
February 13, 1981	2209	46°21' 122°14'	7	5.5	South Cascades
April 13, 1990	2133	48°51' 122°36'	5	5.0	Deming
January 28, 1995	1911	47°23' 122°21'	16	5.0	17.6 km NNE of Tacoma
May 2, 1996	2104	47°46' 121°57'	7	5.3	10.2 km ENE of Duvall
June 23, 1997	1113	47°36' 122°34'	7.4	4.9	5.5 km NE of Bremerton
July 2, 1999	1743	47°05' 123°28'	41	5.1	8.2 km N of Satsop
February 28, 2001	1054	47° 09’ 122° 52.4	52.4	6.8	17.6 km NE of Olympia

FLOOD

Definition

A flood is an inundation of dry land with water. Types of floods in Washington State are primarily river, surface water, flash, and tidal.

History

From 1956 to 1998 there have been 27 Presidential Major Disaster Declarations floods in Washington State. Since 1971, every Washington State county has received a Presidential Disaster Declaration for flooding. See Table Five for list of Floods in Washington State.

Hazard Identification and Vulnerability Assessment

Flooding is a natural feature of the climate, topography, and hydrology of Washington State. Flooding results from bodies of water overflowing their banks; structural failure of dams and levees; accumulation of runoff surface water; tsunamis; and erosion of a shoreline. Two planning concerns are sudden onset and flood elevation in relation to topography and structures. Other factors contributing to flood damage are water velocity, debris carried by water, duration of flood conditions, and ability of soil to absorb water. Flooding predominates throughout the winter and early spring due to melting snow, breakaway ice, and rainy weather.

- Many rivers in Western Washington flood every two to five years. These include rivers flowing off the west slopes of the Cascades (Cowlitz, Green, Cedar, Snoqualmie, Skykomish, Snohomish, Stillaguamish, Skagit, and Nooksack), out of the Olympics (Satsop, Elwha, and Skokomish), and out of the hills of southwest Washington (Chehalis, Naselle, and Willapa). Long periods of rainfall and mild temperatures are normally the cause.
- Several rivers in Eastern Washington also flood every two to five years, including the Spokane, Okanogan, Methow, Yakima, Walla Walla, and Klickitat. Flooding on rivers east of the Cascades results from periods of heavy rainfall, mild temperatures, and from the spring runoff of mountain snow pack.
- During the 1996-97 winter storms, areas not prone to river flooding experienced surface water flooding due to high groundwater tables or inadequate urban storm sewer drainage systems. Residents not living in a flood plain had several inches of water in basements, as a result of groundwater seepage through basement walls. Floods contaminated domestic water supplies, fouled septic systems, and inundated electrical and heating systems. Fire-fighting access was restricted, leaving homes vulnerable to fire. Lake levels were the highest in recent history, and virtually every county had areas of ponding not previously seen. Areas of notable damages included south Snohomish County ferry terminal, sewage pumping station failures and flooded homes. Homes in Thurston County were flooded and damaged. A newly developed lake in an industrial park in Pierce County was washed out.
- Eastern Washington is prone to flash flooding. Thunderstorms, steep ravines, alluvial fans, dry or frozen ground, and light vegetation, which tend not to absorb moisture, cause

the flooding. The city of Wenatchee experiences flash flooding because three canyons are located west of the city, the terrain is rocky, and the vegetation is sparse. A thunderstorm with two inches of rain west of the city is devastating.

All the Pacific coastal counties, as well as some inland coastal counties and counties at the mouth of the Columbia River, are susceptible to wind and barometric tide floods. Much of the recent development in Washington State occurs in or near flood plains. This development increases the likelihood of flood damages in two ways. First, new developments near a flood plain add structures and people in flood areas. Secondly, new construction alters surface water flows by diverting water to new courses or increases the amount of water that runs off impermeable pavement and roof surfaces. This second effect diverts waters to places previously safe from flooding.

Flood plains, or areas at risk for flooding, make up approximately 7.5 percent of the state's total land area. These areas contain an estimated 100,000 households. All the homes and citizens that live in them are vulnerable to flood damage. Only about 22 percent of the homes in flood plains are insured against flood losses. Uninsured homeowners face greater financial liability than they realize. During a typical 30-year mortgage period, a home in a mapped flood plain has about a 26 percent chance of being damaged by a 100-year flood event. The same structure only has about a one-percent chance of being damaged by fire.

Most cities and counties in Washington participate in the National Flood Insurance Program and have developed local ordinances to better regulate and direct development in flood plain areas. These local ordinances regulate planning, construction, operation, maintenance, and improvements - private or public. Ordinances ensure that work is properly planned, constructed, operated, and maintained to avoid adversely influencing the regimen of a stream or body of water or the security of life, health, and property against damage by floodwater.

Conclusion

Many homes, located in flood plains, are vulnerable to flood damage. Adding to this vulnerability is new growth creating pressure to develop marginal land located near flood plains. As development increases, drainage basins are "built-out," and the volume of storm water runoff and the area that it floods will increase. As a result, homes that were once outside mapped flood plains face a threat of flooding. Currently, 35-40 percent of the National Flood Insurance claims come from outside the mapped flood plains. Developments within flood plains should be limited to non-structures such as parks, golf courses, and farms. These facilities have the least potential for damage, but maximize land use.

Floods cause loss of life and damage to structures, crops, land, flood control structures, roads, and utilities. Flood damages in Washington State exceed damages by all other natural hazards.

The public should be made aware of hazardous areas and given information on flood insurance, mitigation, preparedness, response, and recovery. Local jurisdiction emergency management plans should establish warning, evacuation, housing, and other emergency procedures. This should include awareness of potential disease, hazardous material release, or debris that may affect floodwater.

The National Weather Service and other federal cooperative agencies have an extensive river and weather monitoring system and provides flood watch and warning information to the public via radio, television, Internet, Teletype, and telephone.

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

Resources

Washington State Emergency Management Division
United States Army Corps of Engineers
Federal Emergency Management Agency
National Weather Service

Table Five
Floods

Date	Occurrence
May-June 1948	Snowmelt flooding broke lake and river records in Eastern Washington and along the Columbia River. Vancouver, Camas, Kalama, and Longview suffered flooding.
February 1956	Flooding occurred in Adams, Benton, and Franklin Counties. Federal Disaster Number 50 was assigned for the event.
March 1957	Flooding affected Douglas, Grant, and Lincoln Counties. Federal Disaster Number 70 was assigned for the event.
March 1963	Flooding occurred in the counties of Columbia, Garfield, Grant, Whitman, and Spokane. Federal Disaster Number 146 was assigned for the event.
December 1964	Flooding and heavy rains affected Asotin, Benton, Columbia, Cowlitz, Garfield, Grays Harbor, King, Kittitas, Klickitat, Lewis, Mason, Pacific, Pierce, Skamania, Snohomish, Wahkiakum, Walla Walla, Whitman, and Yakima Counties. Federal Disaster Number 185 was assigned for the event.
January 1971	Flooding, heavy rains, melting snow affected the counties of Columbia, Garfield, Grays Harbor, Lewis, Sakgit, Whatcom, and Yakima. Federal Disaster Number 300 was assigned for the event.
January 1972	Flooding and severe storms affected Asotin, Cowlitz, Grays Harbor, Lewis, Skagit, Whatcom, and Yakima Counties. Federal Disaster Number 332 was assigned for the event.
February 1972	Flooding and heavy rains occurred in King, Pierce, and Thurston Counties. Federal Disaster Number 328 was assigned for the event.

Table Five Floods	
Date	**Occurrence**
May-June 1972	Snow melt in North Central Washington counties of Chelan, Douglas, and Okanogan, combined with heavy rains, produced major flooding on the Okanogan and Methow Rivers in Okanogan County and the Entiat River in Chelan County. All three rivers reached record stages. Federal Disaster Number 334 was assigned for the event.
January 1974	Flooding, severe storms, and snowmelt affected Asotin, Benton, Columbia, Ferry, Kitsap, Klickitat, Lewis, Mason, Pend Oreille, Stevens, Thurston, Whitman, and Yakima Counties. Federal Disaster Number 414 was assigned for the event.
December 1975	Heavy rain and high freezing levels caused major flooding on rivers in Benton, Cowlitz, Grays Harbor, King, Kittitas, Lewis, Mason, Pierce, Skagit, Snohomish, Thurston, Whatcom, and Yakima. The flooded rivers included the Cowlitz, Chehalis, Skykomish, Snoqualmie, Snohomish, Stillaguamish, Skagit, and Nooksack. Federal Disaster Number 492 was assigned for the event.
December 1977	Heavy rain, mild temperatures, and snow melt runoff caused major flooding on the Nisqually, Skykomish, Snoqualmie, and Snohomish Rivers. Affected counties included Benton, Clark, Cowlitz, Garfield, Grays Harbor, King, Kittitas, Klickitat, Lewis, Pacific, Pierce, Snohomish, Thurston, Wahkiakum, Whitman, and Yakima. Federal Disaster Number 545 was assigned for the event.
December 1979	Flooding, storms, mudslides, and high tides affected Clallam, Grays Harbor, Jefferson, King, Mason, Skagit, Snohomish, and Whatcom Counties. Federal Disaster Number 612 was assigned for the event.
December 1982	Flooding, severe storm, and high tide affected Whatcom County. Federal Disaster Number 676 was assigned for the event.
January 1986	Flooding and severe storms affected Clallam, Jefferson, and King Counties. Federal Disaster Number 757 was assigned for the event.
February 1986	Flooding, heavy rains, and mudslides occurred in Cowlitz County. Federal Disaster Number 762 was assigned for the event.
November 1986	Heavy rain, mild temperatures, and snow melt runoff generated major floods on the Chehalis, Skookumchuck, Skykomish, Snoqualmie, and Snohomish Rivers. Less severe flooding occurred on the Satsop, Skokomish, Cedar, Stillaguamish, Skagit, and Nooksack Rivers. Flooding occurred in Cowlitz,King, Lewis, Pacific, Snohomish, and Wahkiakum Counties. Federal Disaster Number 784 was assigned for the event.
March 1989	Flooding and heavy rains affected Douglas, Okanogan, Stevens, and Whitman Counties. Federal Disaster Number 822 was assigned for the event.

Table Five Floods	
Date	**Occurrence**
January 1990	Flooding occurred on the Chehalis, Skookumchuck, and Deschutes Rivers as heavy rain and severe storms affected the counties of Benton, Grays Harbor, King, Lewis, Pierce, Thurston, and Wahkiakum. Federal Disaster Number 852 was assigned for the event.
November 1990	Floods and severe storms occurred in the counties of Chelan, Clallam, Grays Harbor, Island, Jefferson, King, Kitsap, Kittitas, Lewis, Mason, Pacific, Pierce, San Juan, Skagit, Snohomish, Thurston, Wahkiakum, Whatcom, and Yakima. Rivers with major flooding were the Skagit and Nooksack Rivers. The Thanksgiving weekend floods set record stages on the Naselle, Willapa, Hoh, Calawah, Dungeness, Skokomish, Cedar, Skykomish, Snoqualmie, Snohomish, Stillaguamish, Chiwawa, Wenatchee, Elwha, and Klickitat Rivers. Major floods occurred on the Skagit, Nooksack, and Yakima Rivers. During this event 2 people died and the Interstate 90 Lake Washington floating bridge sank. Federal Disaster Number 883 was assigned for the event.
December 1990	Floods, storms, and high winds affected the counties of Island, Jefferson, King, Kitsap, Lewis, Pierce, San Juan, Skagit, Snohomish, and Whatcom. Federal Disaster Number 896 was assigned for the event.
December 1994 - February 1995	Heavy rain, combined with high freezing levels and low level snow melt produced floods. The Skokomish River flooded repeatedly driving residents from their homes on four occasions. Mudslides in the area, caused traffic problems and damage to highways. Floods occurred on the Willapa, Naselle, Chehalis, Satsop, and Deschutes Rivers in December 1994. In February 1995, the Snoqualmie River reached its highest level since the November 1990 flood.
November – December 1995	Flooding and wind in the counties of Chelan, Clallam, Clark, Cowlitz, Grays Harbor, Island, Jefferson, King, Kittitas, Lewis, Mason, Pacific, Piearce, Skagit, Snohomish, Thurston, Wahkiakum, Whatcom, and Yakima. Federal Disaster Number 1079 was assigned for the event.

Table Five Floods	
Date	**Occurrence**
February 1996	Heavy rains caused flooding in the counties of Adams, Asotin, Benton, Clark, Columbia, Cowlitz, Garfield, Grays Harbor, King, Kitsap, Kittitas, Klickitat, Lewis, Lincoln, Pierce, Skagit, Skamania, Snohomish, Spokane, Thurston, Wahkiakum, Walla Walla, Whitman, and Yakima and the Yakima Indian Reservation. Snowfall beginning January 26, 1996, followed by heavy rain in February, mild temperatures, and mountain snow melt caused severe flooding throughout the entire northwest. Three people died in Washington. Mudslides occurred throughout Washington. Traffic flow both east and west, north and south along major highways were shut down for several days. Snow closed Interstate 90 at Snoqualmie Pass. Mudslides and flooding closed Interstate 5 in Lewis County. Record floods occurred on the Columbia, Snoqualmie, Cedar, Chehelis, Nisqually, Skookumchuck, Klickitat, Skokomish, Cowlitz, Yakima, Naches, Palouse, Walla Walla Rivers, and Latah Creek. Federal Disaster Number 1100 was assigned for the event.
December 1996 - January 1997	Rain, ice, and snow caused flooding. Federal disaster number 1159 was assigned for counties of Adams, Asotin, Benton, Chelan, Clallam, Clark, Columbia, Cowlitz, Douglas, Ferry, Franklin, Garfield, Grant, Grays Harbor, Island, Jefferson, King, Kitsap, Kittitas, Klickitat, Lewis, Lincoln, Mason, Okanogan, Pacific, Pend Oreille, Pierce, San Juan, Skagit, Skamania, Snohomish, Spokane, Stevens, Thurston, Walla Walla, Whatcom, and Yakima.
March 1997	Heavy rain and mountain snowmelt caused flooding in counties of Grays Harbor, Jefferson, King, Kitsap, Lincoln, Mason, Pacific, Pierce, Pend Oreille, and Stevens. Federal Disaster Number 1172 was assigned for event.
April 1997	Heavy rain and mountain snowmelt caused flooding in Pend Oreille County. Federal Disaster Number 1182 was assigned for event.
May 1998	Heavy rain caused flooding in Ferry and Stevens Counties. Federal Disaster Number 1252 was assigned for the event.

LANDSLIDE

Definition

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

History

In 1872, a landslide triggered by an earthquake blocked the flow of the Columbia River north of Wenatchee for several days. Areas historically subject to landslides include the Columbia River Gorge, the banks of Lake Roosevelt, and the Puget Sound coastal bluffs. One of the largest known active, single-block landslide areas in the United States is near Stevenson in Skamania County.

In November 1994, a landslide occurred about one-half mile west of Randle in Lewis County, resulting in the closure of State Route 12. Washington State Department of Transportation (WSDOT) cost of repair was $18 million.

In February 1996, numerous landslides occurred during the rainstorms that pounded the entire Northwest. Interstate 5, in Cowlitz County, was entirely cut off by a landslide and numerous state and county roads were closed for weeks due to mudslides. In Pierce County, a landslide resulted in two locomotives and two rail cars falling into Puget Sound, creating a hazardous materials incident.

From November 1996 through March 1997, a series of wet winter storms delivered snow, freezing rain, and warm rain, producing floods and landslides. Prior to the storms, the late autumn months had above normal precipitation, building soil moisture, and heavy snow packs. The combination of pre-existing soil moisture, heavy rain, and rapid snow melt brought soils to saturation. On the gentler plains, perching of water and emergence of ground water from shallow aquifers caused flooding in low lying areas. In the steep bluffs that border Puget Sound, Lake Washington, and larger river valleys, lateral movement of ground water toward the free faces caused water pressures that triggered hundreds of landslides. Saturation of the soils in Whatcom and Clark Counties caused landslides that ruptured two natural gas lines causing explosions.

Massive landslides of large rock debris, snow, and ice occurred on Mount Adams between August and October 1997. The slide in October was approximately 1,500 feet thick and 750 feet wide with an estimated volume at three million cubic meters of rock. The slide was attributed to heavy rain in addition to the exceptionally wet weather in 1995 through 1997.

In 1999 a federal disaster was declared for a landslide affecting a residential area in the city of Kelso. Geotechnical engineers predicted the landslide would engulf 137 homes.

Also in 1999, Thurston County experienced landslides affecting residences and private and county roads at Carlyon Beach/Hunter Point, Sunrise Beach, and Sunset Beach. A total of 44

homes were declared unsafe for inhabitance. The landslide continues at Carlyon Beach. At Sunrise Beach, Thurston County government and property owners have been successful with engineering and construction effort to stop the land movement. At Sunset Beach property owners have paid for successful actions to stop land movement.

Irrigation in parts of Eastern Washington has reactivated ancient slides and caused others where none previously existed. The White Bluffs of the Ringold Formation near Richland lie on the eastern edge of the U.S. Department of Energy's Hanford Energy Reservation. These bluffs are soft clay stone, siltstone, and sandstone susceptible to sliding when saturated by irrigation.

Hazard Identification and Vulnerability Assessment

Landslides range from shallow debris flows to deep-seated slumps. These take lives, destroy homes, businesses, and public buildings, undermine bridges, derail railroad cars, cover clam and oyster beds, interrupt transportation infrastructure, and damage utilities. Sinkholes affect roads and utilities. Losses go unrecorded because of no claims to insurance companies, no report to emergency management, no media coverage, or because transportation damages are recorded as maintenance.

Due to population density and desire of people to have a home with a view, an increasing number of structures are built on top of or below slopes subject to land sliding. Inconsistent slope mapping and land use regulations in landslide areas make the public unaware of the risk associated in building in potentially vulnerable areas. Land is not stable indefinitely. People believe that if a bluff has remained stable for the last 50 years, it will remain so for the next 50 years regardless of the development or maintenance.

Land stability cannot be absolutely predicted with current technology. The best design and construction measures are still vulnerable to slope failure. The amount of protection, usually correlated to cost, is proportional to the level of risk reduction. Debris and vegetation management is integral to prevent landslide damages. Corrective measures help, but still leaves the property vulnerable to risk.

These are characteristics that may be indicative of a landside hazard area:

- Bluff retreat caused by sloughing of bluff sediments, resulting in a vertical bluff face with little vegetation.
- Pre-existing landside 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.

Conclusion

By studying the effects of landslides in slide-prone areas, we can plan for the future. More needs to be done to educate the public and to prevent development in vulnerable areas. WAC 365-190-080 states that geologically hazardous areas pose a threat to the health and safety of citizens when incompatible development is sited in areas of significant hazard. Some hazards can be mitigated by engineering, design, or construction so that risks are acceptable. When technology cannot reduce the risk to acceptable levels, building in hazardous areas should be avoided.

Ordinances identifying geological hazards are now in place in most cities and counties. Information regarding steep slope hazards is available from local planning and building department. Landslide losses are reduced 95-100 percent where the established ordinances are rigorously applied.

The least expensive and most effective landslide loss reduction measure is by avoidance. The next most economical solution is mitigation using qualified expertise with an investigation report review process. The most costly is repair of landslide damages. The cost of proper mitigation is about one percent of the costs otherwise incurred through losses and litigation.

Resources

Washington State Emergency Management Division
Washington State Department of Natural Resources
Federal Emergency Management Agency
United States Army Corps of Engineers
National Weather Service

SEVERE STORM

Definition

An atmospheric disturbance manifested in strong winds, tornadoes, rain, snow, or other precipitation, and often accompanied by thunder or lightning.

History

On the morning of January 20, 1993, the day of the Presidential Inauguration, a powerful low-pressure system swept through central Western Washington causing great destruction, numerous injuries, and the loss of five lives. Winds averaging 50 miles per hour with gusts to 100 miles per hour caused trees to fall and knocked out power to 965,000 customers.

During the 1996-97 winter storms, high snowfall and cold temperatures resulted in significant snow accumulations. The accumulations aggravated by rain, drifting snow, and ice in roof drains caused excessive weight and the collapse of structures. Over 400 boats sank due to the collapse of covered marina slips. In Yakima County, a warehouse with toxic chemicals collapsed. Skamania County indicated the weight of the 12-36 inch snow pack, with water content of 67 percent, was the equivalent of nine feet of snow. High winds and ice contributed to the repeated and extended power outages to over 500,000 power customers during December 1996-February 1997.

In 1997, 14 tornadoes struck Washington. In May 1997, Tacoma experienced a small tornado that did an estimated $125,000 in damages in a narrow swath across ten city blocks. Tornadoes also touched down north of Spokane and east of Vancouver the same day. Other counties spotted funnels clouds that did not touchdown. In August 1997, tornadoes, accompanied by heavy rain and wind, touched down across the state. See Table Six for list of Severe Storms in Washington State.

Hazard Identification and Vulnerability Assessment

All areas of Washington State are vulnerable to the severe local storms. The affects are generally transportation problems and loss of utilities. Transportation accidents occur, motorists are stranded, and schools, businesses, and industries close. The affects vary with the intensity of the storm, the level of preparation by local jurisdictions and residents, and the equipment and staff available to perform tasks to lessen the effects of severe local storms.

Most storms move into Washington from the ocean with a southwest to northeast airflow. Maritime air reaching the Olympic Mountains rises upwards and cools. As this airflow reaches higher elevations and cools, there is less ability to hold moisture and rain occurs.

- Windstorms with sustained winds of 50 miles per hour are powerful enough to cause significant damage and occur frequently. Affected areas are primarily located at the openings of long passes through the mountains, at the base of the mountains, and at the edges of large expanses of open water.

- Tornado funnel shaped clouds generally affect areas of three-quarters of a mile wide and 16 miles long. Tornadoes are produced by strong thunderstorms that generate damaging hail, heavy rain, and wind.

- Blizzards and snowstorms accompanied by high wind and drifting snow occur occasionally throughout the state.

- Ice storms occur when rain falls from a warm, moist layer of atmosphere into a below freezing, drier layer near the ground. The rain freezes on contact with the cold ground and exposed surfaces causing damage to trees, utility wires, and structures.

- Hailstorms occur when freezing water in thunderstorm clouds accumulates in layers around an icy core. Hail damages crops, structures, and transportation systems.

- Dust storms occur east of the Cascades. Wind, following dry periods, blows dirt and light debris aloft.

- Extreme heat temperatures during the summer months occur primarily in Eastern Washington. Individuals, pets, livestock, wildlife, and crops are all affected.

Conclusion

Local jurisdiction plans should reflect warning and notification of the public, prioritization of roads and streets to be cleared, provision of emergency services, mutual aid with other public entities, procedures for requesting state and federal assistance if needed. To prepare for severe local storms, local jurisdictions should provide public information on emergency preparedness and self-help.

Resources

Washington State Emergency Management Division
National Oceanic and Atmospheric Administration
National Weather Service

Table Six Severe Storms		
Date	**Storm Type**	**Description**
February 1, 1916	Snowstorm and wind	Twenty-one inches of snow fell in Seattle in 24 hours and 2 to 4 feet in other parts of Western Washington. In January and February Seattle received 58 inches of snow.
November 7, 1940	Wind	Tacoma Narrows Bridge collapsed due to induced vibrations from 40 miles per hour winds.
January 1950	Snowstorm and wind	Blizzard dumped 21 inches of snow on Seattle and killed 13 people in the Puget Sound region. The winter of 1949-50 was the coldest recorded in Seattle with average temperatures of 34.4 degrees.
November 1958	Wind	High winds in Western Washington.
October 1962	Wind	Columbus Day Storm struck from northern California to British Columbia and is the windstorm all others are compared to. Recorded winds gusts were 150 miles per hour in Naselle, 100 in Renton, 92 in Bellingham and Vancouver, and 88 in Tacoma. Federal disaster number 137 was assigned for the event.
August 1967	Heat	Spokane had 11 consecutive days with 90 degrees or warmer. The heat wave affected Eastern Washington and Northern Idaho.
April 5, 1972	Tornado	In Vancouver, a tornado damaged an area 9 miles long and one quarter of mile wide causing extensive damage to an elementary school, shopping center, houses, utility lines, and trees. At the shopping center six people were killed, 11 critically injured, and 300 people treated for minor injuries. Damages were estimated at $6 million. Tornadoes also touched down in Spokane and Stevens Counties.
1974	Wind	Violent windstorm in Camas and Washougal.
February 1979	Wind	Hood Canal Bridge destroyed by windstorm.
November 1981	Wind	High winds in Western and Eastern Washington.
November 1990	Wind and flood	The Lake Washington floating bridge sank, killing two and causing $250 million in damages.

Table Six Severe Storms		
Date	**Storm Type**	**Description**
January 20, 1993	Wind	Inauguration Day Storm damaged homes, businesses, and public utilities leaving thousands without power for days from Longview to Bellingham. The state EOC coordinated resources. The National Guard provided generator power and equipment. The Energy Office priorities power restoration. The American Red Cross sheltered 600 people and fed 3,200 meals. Department of Transportation and State Patrol coordinated transportation routes and road closures. Federal Disaster Number 981 was assigned for the event.
August 1994	El Nino	Adverse weather in counties of Clallam, Grays Harbor, Jefferson, Pacific, Wahkiakum, and Whatcom affected salmon migration. Federal Disaster Number 1037 was assigned for the event.
December 1995	Rain, flood, and wind	Storms starting in California generated winds of 100 miles per hour, continued north causing three states, including Washington, to issue disaster proclamations. Federal Disaster Number 1079 was issued for the incident.
February 7, 1996	Rain and flood	The Washington State Emergency Operations Center (EOC) activated to handle severe floods covering state. These were considered the most destructive and costly in state history and 19 counties were covered under a Presidential disaster declaration. Three people were killed. Total damages were estimated at $400 million, an estimated 691 homes destroyed and 4,564 damaged. The EOC remained activated through February 23. Federal Disaster Number 1100 was issued for the incident.
April 24, 1996	Rain, flood, and wind	The state EOC activated because the state was covered with flooding rivers and high wind warnings. Six counties declared states of emergency. The EOC remained activated until April 25.
November 19, 1996	Ice storm	The state EOC activated in response to storm conditions around the state. The city of Spokane and Spokane County declared an emergency and 100,000 customers were without power for nearly two weeks. In Puget Sound 50,000 customers were without power as well as thousand others across the state. There were 4 deaths and $22 million in damages. The EOC remained activated until December 1. Federal Disaster Number 1152 was issued for the storm.

Table Six Severe Storms		
Date	**Storm Type**	**Description**
December 4, 1996	Winter storm, ice, wind, and gale warning	The state EOC activated in response to storms rushing across the state, which caused road closures and power outages. Pend Oreille County declared an emergency because of snow and power outages. The Governor proclaimed emergencies for Pend Oreille and Spokane Counties. The EOC remained activated until December 5. This storm was part of Federal Disaster Number 1152.
December 26, 1996	Winter storm, wind, gale warning, flood, landslide, and avalanche	The state EOC activated in response to storm fronts pushing across the state causing structures to collapse under the heavy weight of snow, road closures, power outages, landslides, and 20 weather related deaths. The Governor declared emergencies for 37 counties – only Douglas and Franklin Counties were not included. The Washington National Guard had 110 personnel on active duty. The EOC remained activated until January 15, 1997. Federal Disaster Number 1159 was issued for the storm.
January 31, 1997	Rain and flood	The state EOC activated in response to lowland floods in Walla Walla, Asotin, and Columbia Counties. Flood warnings were in effect for Klickitat and Columbia Rivers. The EOC remained activated until February 1. This incident was part of Federal Disaster Number 1159.
March 18, 1997	Rain and flood	The state EOC activated in response to widespread flooding throughout Washington State and remained activated until March 26.
May 22, 1997	Flood	The state EOC activated in response to severe flooding in Pend Oreille County. The Governor issued a proclamation of emergency and activated the National Guard, which provided water and traffic control. The EOC remained active until June 30. Federal Disaster Number 1182 was issued for the incident.
May 31, 1997	Tornado and thunderstorm	A total of 4 tornadoes touched down in Spokane and Stevens plus one in Tacoma and one in Vancouver. Thunderstorms produced hail up to 3 inches in diameter, heavy rain, flash flooding, and 80 mile per hour winds.
October 29, 1997	Rain and wind	Heavy rain and gusty winds passed over the state on October 29 especially the southern Cascade Range. The EOC activated on October 30 in response to floods. Flood warnings were in effect for 11 Western Washington rivers and watches for all rivers in five western counties. The EOC remained activated until October 31.

Table Six Severe Storms		
Date	**Storm Type**	**Description**
January 11, 1998	Winter storm and flood	The state EOC activated on January 14 in response to storms affecting Lewis, Mason, Thurston, and Pierce Counties. The EOC remained activated until January 19.
May 27, 1998	Flood	The state EOC activated in response to small stream flooding in Stevens, Ferry, Pend Oreille, and Okanogan Counties. State and county roads were washed out and homes flooded. The EOC remained activated until June 2. Federal Disaster Number 1252 was issued for the incident.
November 19, 1998	Winter storm	The state EOC activated for problems associated with forecast high winds. Winds of 80 miles per hour were recorded toppling trees and causing power outages to 15,000 customers. The EOC remained activated until November 23.
December 29, 1998	Winter storm	The state EOC activated in response to flooding threat caused by heavy rain and mountain snow melt. Stevens and Snoqualmie passes were closed due to avalanche hazard. Stranded holiday travelers unable to go over Snoqualmie Pass caused Kittitas County to declare an emergency. Nisqually river flooding caused evacuation of 45 residents of a McKenna nursing home. In Cathlamet 400 residents were without water causing Wahkiakum County to declare an emergency. Pullman declared an emergency because of flooding. The EOC remained activated until December 31.
March 3, 1999	Storm	The state EOC activated due to a severe storm affecting Western Washington. The storm generated sustained winds of 40 miles per hour with one gust recorded at 129. The Coast Guard recommended that all marine vessel report to safe moorage. The EOC remained activated until March 8.
October 27, 1999	Wind	A strong Pacific frontal system moved across Washington causing power and phone outages. Marine storm and coastal flood warnings were issued for the coast. One citizen died when a tree fell on them. The EOC remained activated until March 28.
November 9, 1999	Rain and flood	The state EOC activated on November 12 because of weather conditions in Western Washington. The Skagit River rose to six feet above flood stage. Flooding was most severe in Hamilton. Two shelters were opened for evacuees. The EOC remained activated until November 13.

Table Six Severe Storms		
Date	**Storm Type**	**Description**
December 14, 1999	Rain and flood	The state EOC activated on December 15 in response to widespread flooding in Western Washington. A tropical weather system brought in heavy rain and caused snowmelt and flooding. Emergency declarations were issued in Grays Harbor, Jefferson, Skamania, and Wahkiakum Counties. Sixteen counties were impacted by the weather system. The EOC remained activated until December 18.

TSUNAMI

Definition

A tsunami is a series of waves usually caused by earthquakes. Underwater volcanic eruptions and landslides can also generate tsunamis.

History

From 1992 to 1996 over 2,000 people were killed by tsunamis occurring in Nicaragua, Indonesia, Japan, the Philippines and Peru. Property damage was nearly one billion U.S. dollars. The Washington coast had a serious tsunami after the 1964 Alaska earthquake in Prince William Sound, resulting in $105,000 (in 1964 dollars) in damage. During the 20th century, the 1964 event was the most serious tsunami to reach the Washington coast, but geological investigations indicate that tsunamis have struck the coast many times in the last few thousand years. On October 1994, a tsunami warning was issued for the Washington coast due to a magnitude 8.1 earthquake off Russia's Kuril Islands that spawned a tsunami.

The Washington State EOC activated on June 9, 1996 after the Alaska Warning Center issued a Tsunami Watch for the Washington coast and the Puget Sound. An earthquake of magnitude 7.5 near Adak, Alaska generated a seismic wave of 2.5 feet. The state EOC returned to normal operations on the same date after the Tsunami Warning Center determined there was no threat to Washington State.

Studies indicate that about a dozen very large earthquakes with magnitudes of 8 or more have occurred in the Cascadia Subduction Zone, which is at least 75 miles off the coast of Washington. Computer models indicate that tsunamis waves can be up to 30 feet in height and could affect the entire Washington Coast.

Hazard Identification and Vulnerability Assessment

Tsunamis can be induced locally off the coast of Washington by the Cascadia Subduction Zone or at a considerable distance, such as from Alaska, or Japan.

The Washington coast and the Strait of Juan de Fuca are vulnerable to tsunamis generated at a considerable distance in the Pacific Ocean or by a local Cascadia Subduction Zone earthquake. These areas and the Puget Sound are also vulnerable to tsunamis generated by local crustal earthquakes or by surface and submarine landslides.

A tsunami, generated by a Cascadia Subduction Zone earthquake directly off the coast of Washington State, could arrive in less than a half-hour. The tsunami waves from a Cascadia Subduction Zone earthquake located off the shore of Northern California or Northern British Columbia may reach the coast of Washington State in an hour or less.

Large Pacific Ocean tsunamis have wave crest to wave crest distances of 60 miles apart and can travel at about 600 miles per hour in the open ocean. As the waves reach shallow water of the coast, the waves are slowed forcing the water to form walls of 30 feet or more. A tsunami can

traverse the entire 12,000 to 14,000 miles of the Pacific in 24 hours, striking land with great force.

Tsunamis can cause death and can cause major damage to port facilities and public utilities. It can damage breakwaters and piers because of the wave impact and scoring action. Ships moored in harbors may be swamped, sunk, or left stranded on shore. Railroad yards and oil tank farms near the waterfront are particularly vulnerable to damage, which can result in spreading of hazardous materials or fire. Any resulting oil fire would be spread by the wave. Communities may be disrupted due to tsunami damage until debris can be cleared, wharves and piers rebuilt, and utilities restored.

Conclusion

Early warning, education, zoning, evacuation routes, and structural design will aid in reducing the disastrous effect of tsunamis. For tsunamis generated by local events, the time of arrival is only a few minutes. The shaking of an earthquake may be the only warning residents have of an impending tsunami. People in areas susceptible to tsunamis should seek high ground for safety by following signs identifying evacuation routes.

Communities can take preventive action if warning is received early enough (two to five hours), which is possible for tsunamis generated at a distance. People can evacuate. Ships can clear harbors or seek a safe anchorage. Planes and rolling stock can move inland. Owners can close shutters and board up buildings**.**

Comprehensive educational programs are important to keep the public informed of the danger and of steps to be taken for personal protection. Paradoxically, the tsunami warning may cause people to endanger themselves by venturing close to shore to watch the spectacular event.

Resources

Washington State Emergency Management Division
Washington Department of Natural Resources, Geology and Earth Resources Division
Washington State Department of Ecology
United States Geological Survey
National Oceanic and Atmospheric Administration
National Weather Service

VOLCANO

Definition

A volcano is a vent in the earth's crust through which magma (molten rock), rock fragments, gases, and ashes are ejected from the earth's interior. A volcanic mountain is created over time by the accumulation of these erupted products on the on the earth's surface.

History

On May 18, 1980 at 8:32 a.m., Mount St. Helens erupted killing 57 people. After a 5.1 magnitude earthquake, the volcano's summit slid away in a huge landslide, the largest in earth's recorded history. The landslide depressurized the volcano's magma system, triggering a powerful explosion that ripped through the sliding debris. Rock, ash, volcanic gas, and steam were blasted upwards and outward to the north.

The lateral blast produced a column of ash and gas that rose more than 15 miles into the atmosphere in 15 minutes. From a second eruption, magma erupted explosively from the newly created crater. Then avalanches of hot ash, pumice, gas, and pyroclastic flows poured out of the crater and spread five miles to the north. Over the course of the day, prevailing winds blew 520 million tons of ash eastward across the United States and caused complete darkness in Spokane.

During the first minutes of the eruption, parts of the blast surged over the new crater rim and down the west, south, and east sides of the volcano. The hot rock and gas melted snow and ice, creating surges of water that eroded and mixed with loose rock and debris to form lahars (mudflows). The lahars poured into river valleys, ripping trees from their roots and destroying roads, bridges, and streambeds. The most destructive lahar was in the North Toutle River and increased in size as it traveled downstream destroying bridges and homes. It reached maximum size in the Cowlitz River at midnight about 50 miles downstream from Mount St. Helens. See Table Seven for list of Volcano Eruptions in Washington State.

Hazard Identification and Vulnerability Assessment

Scientists define a volcano as active if it has erupted in historic time or is seismically or geothermally active. By this definition Mount Rainier, Mount Baker, and Mount St. Helens are active volcanoes. Even Glacier Peak has erupted as recently as a thousand years ago and possibly even as late as the 17th century. Mount Adams is also capable of renewed activity.

Volcanoes commonly repeat their past behavior. It is likely that the types, frequencies, and magnitudes of past activity will be repeated in the future. Volcanoes usually exhibit warning signs that can be detected by instruments or observations before erupting. However, explosions caused by heated material coming into contact with ground water can happen without warning. In the future Washington State can expect volcanoes avalanches, lahars (mudflows), lava flows, pyroclastic flows, and tephra falls, and collapse of a sector of a volcano within the Cascade Range. Valleys are vulnerable to lahars, volcanic debris flows, and sedimentation, which can destroy lakes, streams, and structures. Areas downwind of a volcano eruption are vulnerable to

reduced visibility, ash fall, and caustic gases. Some of the after effects of a volcanic eruption are:

- Avalanches of glacial ice, snow, rock, and debris from volcanic mountains cause damage down slope and in valleys. Avalanches can occur without warning, travel rapidly, and carry large amounts of material.
- Lahars or volcanic mudflow originate from volcanic landslides or from the eruption of melted water. Lahars move faster on the steep slopes nearest their source, and attain speeds of 15 to 60 miles per hour. The highest speed measured on the slopes of Mount St. Helens was 90 miles per hour. Lahars attain depths of hundreds of feet in the canyons near their origin and spread out over valleys downstream. A large volume lahar may overtop or destroy a dam by suddenly displacing water or creating huge waves.
- Magma or molten rock or lava originates from the main cone or cinder cone of a mountain. Cascade Range volcanic magma flows have been short and slow moving. The heat of the magma may start forest or grass fires. Flows bury roads and escape routes. Magma flows bury roads and escape routes.
- Pyroclastic flows are hot avalanches of lava fragments and gas formed by the collapse of thick lava flows and eruption columns.
- Tephra falls are from explosive eruptions that blast fragments of rock and ash into the air. Large fragments fall to the ground close to the volcano. Small fragments and ash can travel thousands of miles downwind.
- Steam and gas explosions containing pulverized lava and rock fragments bombard areas as far away as 10 miles. Steam explosions occur any time that hot material comes into contact with water, glacial ice, or snow. No eruptive activity is necessary for this to occur.
- Clouds of carbon dioxide and toxic gases kill vegetation and animals with chemical poisons, internal or external burns, and asphyxiation.
- Ash falls are harsh, acidic, gritty, smelly, and causes lung damage to the young, old, or people suffering from respiratory problems. When atmospheric sulfur dioxide combines with water it forms diluted sulfuric acid that causes burns to skin, eyes, mucous membranes, nose, and throat. Acid rains affect water supplies, strip and burn foliage, strip paint, corrode machinery, and dissolve fabric. Heavy ash falls blots out light. Heavy demand for electric light and air conditioning cause a drain on power supplies. Ash clogs waterways and machinery. It causes electrical short circuits, drifts into roadways, railways, and runways. Very fine ash is harmful to mechanical and electronic equipment. The weight of ash causes structural collapse, particularly when it becomes water saturated. Because it is carried by winds it continues as a hazard to machinery and transportation systems for months after the eruption.
- Volcanic earthquakes occur within a volcano. Earthquakes from local tectonic sources or shallow faults in the earth’s crust can also shake a volcano. Examples of such earthquakes include the "St. Helens seismic zone" and "West Rainier zone." All Washington State volcanoes are situated close shallow crustal fault zones.

Conclusion

Preparedness and land use planning are important for mitigation of volcanic hazards. Reducing population growth in paths of lahars, implementing warning systems, and planning and practicing evacuations can lower the potential loss of life and property during future eruptions. These actions can reduce the risk from lahars and provide a measure of safety for those living, working, and recreating in valleys surrounding Washington State's volcanic mountains.

The state, federal, and local governments have joined to develop volcanic hazard plans that address issues of emergency response and strategies for expanded public awareness and mitigations. There are plans in existence for Mount St. Helens, Mount Rainier, and Mount Baker and in progress for Glacier Peak.

Volcanic hazard assessments are published by the U.S. Geological Survey for Mount Rainier, Mount Baker, Mount St. Helens, Mount Adams, and Glacier Peak. As part of their comprehensive planning process, local jurisdictions are encouraged to consider debris avalanche, mudflow, and eruption hazards from these volcanoes.

Resources

Washington State Emergency Management Division
Washington Department of Natural Resources, Geology and Earth Resources Division
University of Washington, Geophysics Program
United States Department of Agriculture
United States Forest Service
National Weather Service
United States Department of Justice
United States Geological Survey, David A. Johnston Cascade Volcano Observatory

Table Seven
Volcano Eruptions

Volcano	**Years ago of Eruption** (Unless noted as A.D.)	**Type of Eruption**
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.

Table Seven Volcano Eruptions		
Volcano	**Years ago of Eruption** (Unless noted as A.D.)	**Type of Eruption**
	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.
Mount Rainier	Before 8750	Tephra
	5,000-6,600	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 explosion 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 Rock dome and eruptive period.
	1980 A.D.	Lateral explosion of north face. Extensive tephra fall, lahars, and pyroclastic flows.

WILDLAND FIRE

Definition

Wildland fires are the uncontrolled destruction of forests, brush, field crops and grasslands caused by nature or humans.

History

The 2000 fire season in Washington State was the worst since the Chelan County fires in 1994. The Governor signed a proclamation early in the fire season because the Northwest United States was experiencing a disastrous fire season. The proclamation authorized firefight training for the National Guard in the event federal, state, local and contracted firefighting resources would be unable to handle the fires. The state mobilized fire service resources six times to fight wildland fires in Central Washington that burned over 300,000 acres. National Guard helicopters were sent to two of the fires and hand crews to one fire. See Table Eight for list of Wildland Fires.

Hazard Identification and Vulnerability Assessment

The fire season runs from mid-May through October. Dry periods can extend the season. The possibility of a wildland fire depends on fuel availability, topography, the time of year, weather, and activities such as debris burning, land clearing, camping, and recreation. In Washington, wildland fires start most often in lawns, fields, or open areas, transportation areas, and wooded wildland areas. They are usually extinguished while less than one acre, but can spread to over 100,000 acres and may require thousands of firefighters several weeks to extinguish. In Washington State, wildland fire protection is provided by federal, state, county, city, and private fire protection agencies and private timber companies.

Wildland fires responded to by city and county fire departments were largely started by human causes. Included in the list of human causes are cigarettes, fireworks, and outdoor burning. Wildland fires started by heat spark ember or flames caused the largest dollar loss, followed by debris burning and cigarettes. Loss per incident for debris fires is three times higher than any other fire cause.

The effects of wildland fires vary with intensity, area, and time of year. Factors affecting the degree of risk include rainfall, type of vegetation, and proximity to firefighting agencies. Short-term loss is the complete destruction of valuable resources, such as timber, wildlife habitat, scenic vistas, and watersheds. Vulnerability to flooding increases due to the destruction of watersheds. Long-term effects are reduced amounts of timber for building and recreational areas. Although crops and orchards are tenth on the list of properties damaged, these had the third highest dollar loss, the highest value, and the greatest potential loss.

Conclusion

Building near wildlands increases loss from fires. Often, structures are built with minimal awareness of the need for fire protection. Wildland fires occur with regularity in Washington State. There are a number of ways to reduce wildland fires and minimize injury and property loss. Mitigation activities include:

- Develop ordinances and educate people
- Develop fire detection programs and emergency communications systems
- Exercise warning systems and evacuation plans
- Plan escape routes for personnel living in wildlands
- Road closures during fires
- Property owner precautions
  - Maintain appropriate defensible space around homes
  - Provide access routes and turnarounds for emergency equipment
  - Minimize fuel hazards adjacent to homes
  - Use fire-resistant roofing materials
  - Maintain water supplies
  - Ensure that home address is visible to first responders

Resources

Washington State Emergency Management Division
Washington State Patrol, Fire Protection Bureau
Washington State Department of Natural Resources, Resource Protection Division
Bureau of Indian Affairs
National Weather Service
United States Forest Service

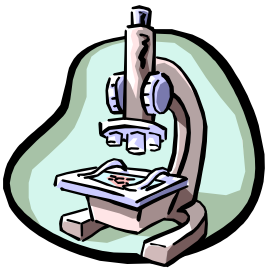
Table Eight
Wildland Fires

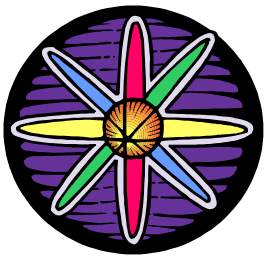
Date	Name	Area	Acres	Deaths
1902	Yacolt	Skamania and Clark Counties	238,900	38
August 20, 1910	Great Idaho Fire	Over 150,000 acres burned in Spokane and Pend Oreille Counties.	3,000,000	85
1919	Sunset	Skamania and Clark Counties	26,900	
1929	Dole Valley	Skamania and Clark Counties	227,500	
1926-31 and 1943	Colville National Forest	Over ½ of the forest burned in Pend Oreille, Ferry, and Stevens Counties		
1929	Toats Coulee	Okanogan County	80,000	
1950	Forks	Western Clallam County	3,000	
July 1970	Lightning Burst	Chelan and Okanogan Counties	188,000	

Table Eight
Wildland Fires

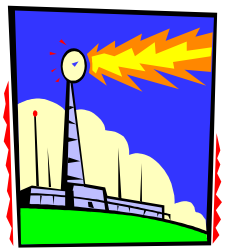
Date	Name	Area	Acres	Deaths
July 1979	Salmon Creek	Okanogan County		
September 1985	Barker Mountain	Okanogan County	60,000	
1987	Hangman Hills	Spokane - 24 residences lost	1,500	2
September 1988	Dinkelman	Chelan County	50,000	1
October 1991	Firestorm 1991	93 fires destroyed 114 homes and 40 buildings in Ferry, Lincoln, Stevens, Pend Oreille, Spokane, and Whitman Counties.	35,000	1
April 1992	Skookum	Klickitat County	51,000	
1992	Castlerock Canyon	Wenatchee - 24 residences lost		
July 1994	Tyee Creek, Hatchery Creek, and Rat Creek	Chelan County	180,000	
June 15, 1996	Konnowac Pass	Yakima County	4,500	
June 29, 1996	Juniper Dunes	Benton County	5,000	
July 30, 1996	Red Mountain	Benton County	5,000	
August 2, 1996	Baird Springs	Grant County	14,000	
August 12, 1996	Bowie Road	Spokane County	3,000	
August 17, 1996	Cold Creek	Benton and Yakima Counties	57,000	
August 31, 1996	Hayward Road	Kittitas County	450	
July 21, 1997	Benton City	Benton County	3,200	
August 3, 1997	Pow Wah Kee	Asotin County	8,000	
August 14, 1997	Newkirk/Redlake	Spokane and Stevens Counties	1,750	
August 26, 1997	Olympia Command	Benton County	5,500	
July 1, 1998	Rattlesnake Ridge	Yakima County	18,000	
July 7, 1998	View Point	Benton County	3,200	
July 10, 1998	Avery	Klickitat County	3,200	
July 27, 1998	Cleveland Complex	Klickitat County	18,000	
August 29, 1998	Dooley	Klickitat County	2,000	
September 2, 1998	Ballpark	Cowlitz County	58	
September 24, 1998	Tucannon	Columbia County	400	
July 9, 1999	Miller Ranch	Benton County	2,000	
September 5, 1999	Stonehenge	Klickitat County	2,500	
June 28, 2000	24 Command	US Department of Energy Hanford Site and Benton County	192,000	
July 17, 2000	Alderdale	Klickitat County	6,180	
July 22, 2000	Rocky Hull	Okanogan County	9,404	
July 27, 2000	Goodnoe Hills	Klickitat County	6,510	

Table Eight Wildland Fires				
Date	**Name**	**Area**	**Acres**	**Deaths**
August 9, 2000	Sixprong/ Wood Gulch	Klickitat County	9,300	
August 24, 2000	Mule Dry	Yakama Indian Reservation and Yakima, Klickitat, and Benton Counties	76,800	





Technological Hazards (Human-Caused)



ABANDONED UNDERGROUND MINE

Definition

An abandoned underground mine is any large excavation in the earth formerly used to extract ore, coal, or mineral, which is no longer in production.

History

Gases from abandoned underground mines can be hazardous. In 1967, four people were overcome by gas at an old tunnel entrance, near Issaquah. All were rescued and recovered. Seattle has several abandoned coalmines that have collapsed and damaged surface structures.

Hazard Identification and Vulnerability Assessment

Underground coalmines present the largest abandoned mine hazard in Washington State. This is because of the extent of the mines and the urban development that has occurred around them. Most residents of cities such as Renton and Bellingham are not aware that they live in former "mining towns," with abandoned mines still present. Almost all coal production from underground mines was in the populated counties of Whatcom, King, Pierce, Thurston, Lewis, and Kittitas. Metal mines, in contrast, tend to be remote from population centers. The Washington State Department of Natural Resources (DNR) has maps of almost every abandoned mine in the state.

Hazards are related to mine shaft openings, the mouths of tunnels and airways, or where mining operations were conducted close to the surface. Openings in developed areas are commonly plugged with mine waste, land clearing debris, or car bodies. These "unengineered" caps may eventually fail, especially where the original slopes are steep. Plugging of mines in which water flows may cause unexpected and sudden outbursts of water at unanticipated locations.

The most obvious effect of abandoned mine cave-ins is the sudden appearance of a hole in the ground. Due to the size and location of the underground opening, holes may be very difficult to plug permanently and after "filling," may reappear unexpectedly. Repairs are costly when holes appear under or near structures, homes, land developments, transportation routes, and utilities. Also, the costs of geological and engineering services to locate, map, and evaluate the safety of sites are expensive.

Conclusion

Land subsidence or ground settling can be the result of underground mining of coal or other minerals, groundwater and petroleum withdrawal, and drainage of organic soils. Earthquakes near abandoned mines may cause cave-ins, surface faulting, and liquefaction. Construction near abandoned underground mines should be regulated and avoided to prevent injury and save property. In some cases, the location of hazards can be assessed by site analysis. When the costs of assessing the hazard and mitigating its effects are too great, it may be inappropriate for development.

The Washington State DNR and local engineering, building, or planning agencies can often provide information regarding the location of abandoned mines.

Resource

Washington State Emergency Management Division
Washington State Department of Natural Resources

CHEMICAL

Definition

Chemical hazard is the release of toxic agents into the atmosphere and environment that can harm population, animals, and food supplies. Hazardous chemicals, such as ammonia, chlorine, propane, and others, are heavily used for various agricultural and manufacturing processes at many locations throughout the state.

History

In 1986, Congress passed legislation requiring the United States Army to dispose of its stockpile of chemical weapons by 2007, as required by international treaty. The federal legislation also directed that "maximum protection" be provided for the public and the environment during the destruction process. The Chemical Stockpile Emergency Preparedness Program (CSEPP) was developed to assist state and local governments in providing "maximum protection." Incineration operations have been successful at Johnson Island in the South Pacific and at Tooele Army Depot in Utah. A burn facility at Umatilla Chemical Depot (UMCD) is under construction with incineration scheduled to start in 2002 and continue for three years. To date, there has been no release of chemical agent from the UMCD that has affected Washington State.

Hazard Identification and Vulnerability Assessment

Hazardous chemicals are used for a variety of purposes and are regularly transported through many areas in Washington State. Ammonia is used as a refrigerant, in agriculture, and in wastewater treatment. Chlorine is used in wastewater treatment, sanitization of drinking water and swimming pools, aluminum manufacturing, and for bleaching paper, wood pulp, and textiles. Propane is widely used as a fuel. Nearly every community has a chemical hazard or a hazardous material transportation system that should be included in public education and emergency planning.

The UMCD in Oregon is a special interest military arsenal storing nerve and blister chemical munitions capable of causing death. The UMCD stockpile includes approximately 3,717 tons of blister and nerve agents. The movement of agents from storage to incineration facilities increases the risk of an accidental release. Possible triggers for an accidental release also include an aircraft crash directly on the installation and earthquakes. Additionally, the high political profile of chemical storage depots increases their vulnerability to terrorist actions.

For CSEPP, the area around the UMCD is divided into emergency planning zones (EPZs). The area surrounding the chemical storage area, out to a distance of approximately six miles, is called the Immediate Response Zone (IRZ). This area could have less than an hour response time, depending on weather conditions, and may receive the highest concentration of agents. A 42-mile stretch of the Columbia River is designated as the Marine Safety Zone (MSZ). Both areas are warned by Tone Alert Radios (TARs) and sirens. The MSZ may be the most vulnerable as people in boats may be within four miles of the UMCD. The zone from the IRZ to 20 miles from the UMCD is called the Protective Action Zone (PAZ). TARs and highway reader-boards provide protective action information within the PAZ. The Precautionary Zone (PZ) extends

from the PAZ with no outer boundary. The risk of adverse impacts to humans is negligible in the PZ.

An accidental release of chemical agent at the UMCD has the potential for creating a plume that could reach approximately 1,500 residents in the IRZ and PAZ of southern Benton County in Washington. A release would affect people camping in state and local parks along the Columbia River. During fishing and boating season, large numbers of people are vulnerable on the Columbia River in the MSZ. Also vulnerable is a large transient population composed of Spanish-speaking farm workers during the harvest season. In addition to the hazard to people, substantial agricultural and fishing industries are at risk. A major transportation corridor with highways, rail lines, and a navigable waterway passes through the IRZ. Another aspect of the hazard is public perception. Even if not exposed to an actual physical threat, many people may panic, believing chemical agents have affected them.

Vulnerable to a chemical release from the UMCD are:

- Unincorporated communities of Plymouth and Paterson in Washington
- Washington State Patrol port-of-entry on Interstate 82
- Several large agricultural operations that employ large numbers of workers
- Contamination of agricultural products valued at over $5 billion annually

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Conclusion

Emergency response planning in Washington and Oregon is focused on CSEPP. State and local plans and standard operating procedures are prepared and routinely exercised. Twenty sirens in the Washington IRZ and Columbia River MSZ provide protection to the public. TARs are distributed to homes and businesses in the Washington IRZ and PAZ. An extensive microwave radio and computer system supports this alert and warning equipment. Decontamination equipment and personal protective equipment are being issued to first responders and hospital personnel. The equipment supports traffic control operations at several points in southern Benton County and at hospitals assisting during a chemical release event. Training and exercise programs are under constant refinement to enhance the preparation process. A comprehensive public education effort is currently underway to explain what to do in the event of a chemical release at the depot. Statewide, businesses that use chemicals are required to have emergency operating plans.

Resources

Washington State Emergency Management Division
Washington State Department of Agriculture
Washington State Department of Health
United States Department of the Army
Federal Emergency Management Agency
Benton County Emergency Management

CIVIL DISTURBANCE

Definition

Any incident that disrupts a community where intervention is required to maintain public safety is a civil disturbance. Examples are demonstrations, riots, strikes, public nuisances, and criminal activities.

History

Washington State witnessed race riots in the 1960s, protests against the Vietnam War in the 1970s, abortion clinic demonstrations in the 1980s, and civil disturbances and allegations of police brutality in the 1990s.

In Seattle a small-scale riot occurred after the 1992 Rodney King verdict. On the night the jury rendered its decision, small groups of people roamed Seattle's downtown streets smashing windows, lighting dumpster fires, and overturning cars. The following day some Seattle residents went to Capital Hill where they set fires and attacked the West Precinct Police Headquarters.

On May 3, 1998, the Washington State Emergency Operations Center (EOC) activated in response to a civil disturbance at the Washington State University in Pullman. The disturbance developed when students' end-of-the-year celebrations got out of hand. The disturbances consisted of large crowds of students lining the streets, throwing rocks, debris, beer bottles, and starting fires. Local and state law enforcement officials were assembled to restore order. Several officials were injured. Washington National Guard (NG) units were placed on standby status.

The Washington State EOC activated on August 26, 1998, in response to the Makah Indian Nation proposed whale-hunting activities at Neah Bay. The state provided resources from the NG, Washington State Patrol (WSP), Department of Fish and Wildlife, Department of Natural Resources (DNR), and Emergency Management Division (EMD), at Clallam County Sheriff's request to control disturbances between protestors and residents.

The Washington State EOC increased response effort, on November 30, 1999, as a result of civil disturbance and violence during the World Trade Organization Ministerial Conference. The city of Seattle declared an emergency and the Governor signed a proclamation of emergency allowing commitment of state resources to support affected local jurisdictions. WSP, Department of Transportation, NG, DNR, EMD, and an Incident Management Team provided support.

Hazard Identification and Vulnerability Assessment

In the United States, protesters and anarchists tend to practice civil disturbance at large, scheduled peaceful gatherings such as union marches or world and global meetings. They believe all types of governments and global organizations are oppressive and undesirable and should be abolished. Their activities involve disruption of activities, resistance, and rejection of

all forms of control and authority. Modern anarchists are well-organized, using command centers, tactical communications, and the Internet for planning and operations. Control of anarchists requires police forces trained and experienced in the Incident Command System and riot control. Effects of anarchism include injury to participants and spectators and property damage.

The last decade has seen increased rioting and looting, in the United States following sporting events. Seattle, home of major sport teams, has the potential to have similar disturbances.

Generally, the cities of Seattle, Spokane, Tacoma, Vancouver, and Bellevue with populations of more than 100,000 are vulnerable to civil disturbances. Smaller college towns like Bellingham, Olympia, and Pullman also are subject to civil disturbances. Olympia, the center of state government, faces an increased potential for civil disturbance. Communities with concentrations of ethnic groups and disparate economic status are susceptible to civil disorder. The presence of professional sports teams can be a catalyst for disruptive behavior. Historically, these elements are the most likely to fuel and sustain a disturbance.

Violent prison or jail uprisings are rare in Washington State, but are a hazard that communities with these facilities should identify and assess. The state has 13 institutions and 18 work release locations. These locations have a population capacity of nearly 15,000 but only a capacity to handle 10,659. Additionally, most counties and cites have permanent or temporary facilities for housing prisoners. Studies show that overcrowding is one of the major causes of uprisings. Overcrowding requires implementation of tighter internal controls, which are unpopular with the prison population. The Constitutional rights of prisoners are difficult to accommodate with inadequate facilities making it difficult to maintain essential services, personal safety, and preservation of property while maintaining incarceration.

Conclusion

The potential for civil disturbance exists in the state. There are major population centers with populations in excess of 100,000 and smaller communities with government offices and colleges. Cities with unions, capabilities of hosting world venues, and ethnic groups are likely areas for civil disturbance. Major sports teams are located in Seattle, the largest city in the state. Civil disturbances in Washington State are probable.

The Washington State Department of Corrections and local corrections offices usually handle prisoner unrest. In the event of emergency, communities may need to be on alert to protect its citizens.

Resources

City and County Law Enforcement Agencies
King County Office of Emergency Management
Washington State Emergency Management Division
Washington State Office of Financial Management
Washington State Patrol
Washington State Department of Corrections

DAM FAILURE

Definition

Dam failure is the uncontrolled release of impounded water resulting in downstream flooding, which can affect life and property. Flooding, earthquakes, blockages, landslides, lack of maintenance, improper operation, poor construction, vandalism, or terrorism cause dam failures.

History

In recent years, dam failures in the United States have prompted renewed public and government concern and action. Public Law 92-367, the National Dam Inspection Act, resulted in the inventorying of dams in the United States and the inspection of non-federal dams nationally. See Table 9 for a table of Dam Failures and Incidents in Washington State.

Hazard Identification and Vulnerability Assessment

The Department of Ecology, Dam Safety Office, in its 1998 Report to the Legislature stated that the responsibility for the 1025 dams in Washington State rests with several agencies. Dam safety units within the respective federal agencies inspect the 69 federally owned and operated dams. Private engineering consultants inspect the 76 non-federal hydropower dams licensed by the Federal Energy Regulatory Commission. There are currently 880 dams in Washington State under the sole jurisdiction of the Dam Safety Office.

Of the dams inspected by the Dam Safety Office, 296 are situated above populated areas. Nearly all of the 115 dams located upstream of three or more residences (high downstream hazard potential) have previously been inspected and are supposed to be on a six-year inspection cycle. However, a decrease in dam safety engineering staff in 1997 resulted in fewer inspections than necessary to meet the six-year inspection cycle. There are 181 dams that have a significant downstream hazard potential where one or two homes are at risk in the event of dam failure. These projects are currently on an inspection cycle of 10 to 12 years. As of February 1999, 14 high downstream hazard potential dams and 14 significant hazard dams existing in Washington State have safety deficiencies.

In general, periodic inspections and follow-up engineering analysis are conducted to:

- Identify defects, especially due to aging
- Evaluate dam operations and maintenance
- Assess dam structural integrity and stability
- Determine the adequacy of the spillways to accommodate major floods
- Assess the stability of dam structures under earthquake conditions

As with any hazard, a community should consider upstream dams when considering building permits or development. On average, Washington State experiences a dam failure approximately once every two years. The majority of failures result from inadequate maintenance and monitoring of the facilities. Failure of a dam can have many effects such as loss of life and

damage to structures, roads, utilities, crops, and the environment. Economic losses also can result from a lowered tax base and lack of power profits.

Conclusion

Three state statutes deal with safety of dams and other hydraulic structures: Chapters 43.21A, 86.16, and 90.03 RCW. These laws provide authority to approve plans for dams, inspect construction, inspect hydraulic works, and require appropriate changes in maintenance and operation. In addition, regulations, policies and procedures, and guidelines have been adopted. They serve to clarify the mission of the Dam Safety Office and to assist the agencies in their efforts to build, operate, and maintain safe dams.

The failure to implement a suitable operation and maintenance program at dams is a common thread in dam incidents occurring in Washington State. Many municipalities operate old reservoir systems and find it difficult to fund effective operation and maintenance programs. While the failure of projects with a high potential for loss of life are increasingly remote, the number of failures of low hazard projects that provide important infrastructure roles are on the rise. With increasing population in the state, homes are frequently being constructed below dams. These dams were not built to the more stringent requirements of high hazard dams, and these present the greatest potential threat to public safety. Dam Safety Office is attempting to examine these smaller dams and get them on a schedule for comprehensive inspections and repair.

Periodic inspections are the primary tool for detecting deficiencies at dams that could lead to failure. Experience shows that corrections of these safety deficiencies in a timely manner can prevent dam failure and other serious incidents from occurring. Periodic inspections help identify dams where significant development has occurred downstream, resulting in the need for more stringent building and planning codes due to greater population at risk.

Resources

Washington State Emergency Management Division
Washington State Department of Ecology, Dam Safety Office
National Weather Service

Table Nine
Dam Failures and Incidents

Date	Name and Location	Nature of Failure and Damage
December 1918	Masonry Dam (Boxley Burst) near North Bend	Excessive seepage through glacial moraine abutment caused mudflow about one mile from reservoir. Destroyed railroad line and village of Eastwick.
February 1932	Eastwick Railroad fill failure near North Bend	Blockage of culvert by slide caused railroad fill to back up water and fail. Water destroyed railroad line and village of Eastwick. Seven deaths.
April 1938	Loup Loup Dam near Malott	Fifty-foot high hydraulic fill dam failed when emergency spillway was undercut during a flood. Flood destroyed 1/2 mile of state highway and 25 homes and left 75 people homeless.
February 1950	Lake Dawn Dam near Port Angeles	Heavy rains caused overtopping and failure of earthen dam. One home was destroyed plus $4,000 in property damage.
December 1967	North Star Sand and gravel dams in Everett	Forty-foot high dam washed out by overtopping due to lack of spillway. Then a twenty-five foot high dam was rebuilt but also failed. Water washed out Great Northern railroad tracks, which derailed passing train.
January 1970	Pillar Rock Dam in Wahkiakum County	Logging road culvert blocked by debris, overtopped, and failed. This caused a twenty five-foot high concrete gravity dam to fail. Three homes and fish cannery were destroyed.
May 1971	Sid White Dam near Omak	Earthen dam failed due to seepage through animal burrows. This caused second dam to fail dumping debris into town of Riverside.
May 1974	Horseshoe Lake blowout near Chewelah	Outlet tunnel through fifty-foot high natural ridge collapsed causing ridge to fail. This drained a twenty-foot deep lake causing extensive flood damage and debris deposits on cropland in downstream valley.
July 1976	White River incident near Auburn	Surge in water flow, caused by increased discharge from Mud Mountain Dam and removal of flashboards at PP&L Diversion Dam, killed 2 children who were playing in the White River.
December 1982	Alexander Lake Dam near Bremerton	Spillway was undermined and failed during heavy rains. This caused damage at fish hatchery and homes in Gorst.

Table Nine
Dam Failures and Incidents

Date	Name and Location	Nature of Failure and Damage
May 1986	Upriver Dam near Spokane	Hydropower facility failed by overtopping. Lightning struck and turbines shut down. Water rose behind dam while trying to restart. Backup power systems failed and could not raise spillway gates in time. This caused $11 million damage to facility. Federal disaster number 769 was assigned for this event.
November 1990	Chinook Dam in Pacific County	Heavy rains overtopped the embankment and undermined the spillway, leading to failure of dam. This caused approximately $100,000 damage to facility.
October 1991	Seminary Hill Reservoir in Centralia	Failure along weak rock zone in hillside caused massive slide, which breached reservoir. Three million gallons of water drained from reservoir in three minutes. Two homes destroyed and many damaged, $3 million in damage.
January 1993	Iowa Beef Processors Waste Pond Dam Number 1 near Wallula and Tri-Cities	Failure of 15-foot high embankment released 300 acre-feet of wastewater. Failure attributed to high reservoir levels due to snowmelt; entering animal burrows near embankment crest and eroding dam. Water washed out Union Pacific railroad tracks, which derailed five locomotives. Damages were $5 million.

HAZARDOUS MATERIAL

Definition

Hazardous materials are materials, which, 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, and create a potential hazard. The hazard can be explosive, flammable, combustible, corrosive, reactive, poisonous, toxic, biological agent, and radioactive.

History

The Washington State Department of Ecology reported 3,988 confirmed hazardous materials spills in 1999. The continuing increase in responses to clandestine methamphetamine labs is of particular concern. The Department of Ecology conducted 789 drug lab responses in 1999 as compared to 339 in 1998, 173 in 1997, and 153 in 1996. See Table 10 for Spills Report Summary.

Hazard Identification and Vulnerability Assessment

Hazardous material incidents are intentional and/or unintentional releases of a material, that because of their chemical, physical, or biological nature, pose a potential risk to life, health, environment, or property. Each incident's impact and resulting response depends on a multitude of interrelated variables that range from the quantity and specific characteristic of the material to the conditions of the release and area/population centers involved. Releases may be small and easily handled with local response resources or rise to catastrophic levels with long-term consequences that require representatives of federal, state, and local governments to be present at the scene, with each level consisting of personnel from between five and 15 different agencies.

The Washington State Hazardous Materials Program consists of several agencies, each responsible for specific elements of the program. A number of strategies have evolved to limit risk, respond to, and recover from hazardous materials releases, intentional discharges, illegal disposals, or system failures. A comprehensive system of laws, regulations, and resources are in place to provide for technical assistance, environmental compliance, and emergency management.

Washington State has 46 Local Emergency Planning Committees (LEPC). These LEPCs, in concert with their respective local emergency management offices, conduct hazard identification, vulnerability analysis, and risk assessment activities for their jurisdictions. Federal and state statutes require LEPCs to develop and maintain emergency response plans based on the volumes and types of substances found in, or transported through, their districts.

Conclusion

The state developed and adopted standardized hazardous materials emergency response training. Training and supporting materials are available to all public emergency responders. Several LEPCs conducted commodity flow studies from 1997 through 1999 with funding from

Hazardous Materials Emergency Preparedness Grants. Hazard identification, vulnerability analysis, and risk assessment documentation and databases for hazardous materials incident are maintained by the Washington State Departments of Ecology, Health, Transportation, and the Washington State Patrol.

Resources

Washington State Emergency Management Division
Washington State Department of Ecology
Washington State Department of Health
Washington State Department of Transportation
Washington State Patrol
United States Environmental Protection Agency

Table Ten
Spills Report Summary

Year	1995	1996	1997	1998	1999
Diesel Fuel	297	792	548	622	603
Gasoline	193	322	258	322	320
Crude Oil	3	6	6	7	4
Hydraulic Oil	72	164	161	63	188
Lube Oil	43	75	63	97	68
Radio Active Materials	0	1	5	8	7
Bombs and Explosives	3	3	5	3	0
Drug Labs	61	137	173	336	789
Other Chemicals	49	101	87	89	428
Unknown Material	149	363	376	443	331
Miscellaneous Substances	336	877	864	754	1250
TOTAL	1206	2841	2546	2829	3988

LOCAL HAZARD

Definition

Local hazards occur in jurisdictions but may or may not have a significant impact on large areas of the state.

History

As an example, the 1984 Everett tire fire burned for three months involving four million tires. Toxic smoke threatened local inhabitants while runoff from firefighter water carried pollutants into the Snohomish River and the Puget Sound.

Hazard Identification and Vulnerability Assessment

Areas near hazard locations are vulnerable to the effects of explosions, crashes, fire, and toxic pollution. Local hazards may include:

- Grain elevators - dust exploding in confined areas
- Munitions and explosives manufacturing and storage locations
- Tire piles - burning causing air pollution with toxic smoke
- Firefighting runoff contaminating water and soil
- Fireworks manufacturing and sales locations
- Transportation vehicles such as airplanes, trains, trucks, ferries, and automobiles
- Oil refineries, chemical, and pharmaceutical manufacturing and storage locations

Conclusion

Many hazards exist locally, which are unique to the local jurisdictions. Local emergency managers should be familiar with these hazards, identify them in their hazard identification and assessment, mitigate the impact, and prepare to respond and recover from incidents.

Resources

Washington State Emergency Management Division
Local Jurisdictions' Hazard Identification and Vulnerability Assessment

PIPELINE

Definition

Pipelines are transportation arteries carrying liquid and gaseous fuels. Pipelines are buried and above ground.

History

On February 8, 1997, a natural gas pipeline caught fire and exploded near Everson in remote, wooded, mountainous terrain and former glacier slide area. A 26-inch pipe carrying natural gas failed because of ground movement of water-saturated soil.

On February 9, 1997, another natural gas pipeline caught fire and exploded near Kalama in a remote area. Ground movement caused a natural gas pipeline break at a weld and an explosion resulted.

On June 10, 1999, a gasoline pipeline leak caught fire and exploded at Whatcom Falls Park in the city of Bellingham. Two 10-year-old boys burned to death. An 18-year old man was killed after fumes overcame him, he fell in Whatcom Creek and drowned. The ruptured gasoline line spewed 277,000 gallons of gas into the creek bed.

Hazard Identification and Vulnerability Assessment

Buried and exposed pipelines are vulnerable to breaks and punctures caused by earth movement, material failure, operator error, construction defects, and tampering. Fuel leaks cause hazardous materials spills, fires, and explosions. Williams Pipeline West (WPW) owns an interstate pipeline with service from Canada, through Sumas, and north from New Mexico. WPW has lines through Whatcom, Skagit, Snohomish, King, Pierce, Thurston, Lewis, Cowlitz, Clark, Skamania, Klickitat, Benton, Yakima, Kittitas, Douglas, Franklin, Grant, Adams, Walla Walla, Lincoln, Spokane, and Whitman counties. On the west side of Washington, the WPW has two parallel pipes. There are 20,174 miles of pipeline with 5-75 feet Right-of-Ways (ROWs). A 26-inch line was installed in 1956 and a 30-inch line was installed in the 1970's. The pipes are coated with a substance similar to mastic. An electron flow on the pipe monitors corrosion. Monitor and compressor stations with telemetry provide the distributor with safety information.

Pacific Gas and Electric (PG&E) Transmission-Northwest has 36-inch and 42-inch pipelines coming from Canada, with service running through parts of Idaho and Spokane, Whitman, Columbia, Franklin, and Walla Walla counties in Washington State.

Both PG&E and WPW have distributors that extend service to homes and businesses. The distribution lines are smaller with less capacity and lower impact. Distribution companies include Puget Sound Energy, Cascade Natural Gas Corporation, Northwest Natural Gas Company, and the Avista Company.

The Olympic Pipe Line Company’s pipeline is a 400-mile system carrying gasoline, diesel, and aviation fuel at pressures of 1,400 pounds per square inch. The lines travel from refineries in

Whatcom and Skagit counties south to Renton, SeaTac Airport, Tacoma, Olympia, and Portland, Oregon. The line carries 14 million gallons a day. As of 1998, the Olympic Pipe Line Company had 42 spills in 32 years. Many were small, but 17 spills were over 2,000 gallons. The 1999 227,000-gallon gasoline spill in Bellingham killing three people was the largest.

Most pipelines are buried; however, there are exposed areas. When crossing rivers, the lines are either attached to a crossing structure or buried below the flood area. In Kalama, the pipe is under the train trestle. On the White River, it is under the riverbed. There are two sites on the Columbia River and both are under the riverbed.

Pipelines and right-of-ways are frequently surveyed for land movement. By law, an entire pipeline has 26 fixed wing or rotary wing aerial surveys per year. At least once a year, someone walks the ROW. When indications of potential problems occur, more surveys are conducted, especially following increased rainfall.

If a pipeline moves during land movement, it can sheer. When the sheer moves across abrasive materials or comes in contact with an ignition source, then sparks can cause the fuel to explode or burn. Monitoring markers are used to denote creeping soil movement for potential strain on the pipe.

Conclusion

Pipeline breaks and punctures are reduced by compliance with safety measures set by the Federal Pipeline Safety Law and following prescribed operations and maintenance procedures. Breaks are reduced by operating with proper pipeline pressure, installing correct thickness and grade of the steel and monitoring its wear, and reducing third party damage from excavators, driving over the lines, and encroachment of pipeline right-of-ways. Disruption of pipeline service impacts our ability to heat homes and businesses and fuel equipment. It can cause the price of fuel to increase.

Resources

Washington State Emergency Management Division
Washington State Utilities and Transportation Commission
Washington State Department of Community, Trade and Economic Development
    Energy Policy Unit
Washington State Department of Transportation
Washington State Department of Ecology
United States Department of Transportation, Office of Pipeline Safety

RADIOLOGICAL

Definition

Radiological hazard is the uncontrolled release of radioactive material that can harm people or damage the environment.

History

In Washington State, there have been no radiological releases affecting local jurisdictions from any nuclear power generating system.

Commercial nuclear plants began generating power in 1957. The United States has had only one major incident that occurred at the Three Mile Island facility near Harrisburg, Pennsylvania in 1979. Other minor incidents have occurred, but these have been infrequent and have caused few off-site consequences.

For more than 40 years, United States Department of Energy-Hanford Site (DOE Hanford Site) manufactured nuclear materials for the nation's defense programs. Chemical and radioactive wastes contaminate many areas of the site. Clean up of the Hanford Site is the largest environmental restoration effort in the nation today. There was a potential for airborne release of radiation during the May 14, 1997 explosion in the plutonium reclamation facility at Hanford.

Hazard Identification and Vulnerability Assessment

Washington State areas capable of radiological release are the Energy Northwest's Columbia Generating Station nuclear power plant located 14 miles north northwest of Richland, the DOE Hanford Site, military bases, medical and research facilities, private industry, and trucks, trains, aircraft, and vessels transiting the state carrying radiological materials.

Energy Northwest operates the commercial nuclear power plant called Columbia Generating Station near Richland. Effects of an emergency at the plant could range from no radioactive release to a radioactive release that would initiate the evacuation of the general population within an approximate radius of 10 miles of the facility. Sirens, tone alert radios, and local media stations would alert the community. Radioactive materials from a release may enter the human food chain via crops or dairy products out to an approximate radius of 50 miles from the facility. Meteorological conditions can influence the size of the contaminated area.

The DOE Hanford Site includes spent nuclear fuel storage tanks, mixed waste storage tanks, and other nuclear waste. Large quantities of industrial chemicals and wastes are stored and used around the DOE Hanford Site. An incident could lead to a radiological or chemical hazardous material release. Those vulnerable to the effects of an incident include the site employees and people in the Richland and surrounding area. Contamination of people, animals, food producers, food processors, and facilities is possible. The event with the most likely offsite consequences is a chlorine leak from one of the water purification facilities.

The Washington State Department of Health licenses nearly 400 facilities in the state that use radioactive materials. These are categorized in three major groups: medical, industrial, and laboratory. Hospitals, clinics, laboratories, and research facilities routinely use radiation in the diagnosis and treatment of medical and dental patients. Industrial applications include various flow gauges, research and development facilities, and radiography to non-destructive test welds and castings for flaws. Medical, industrial, and research use of radiological materials similarly dictate the need for local emergency planning.

Local communities and facilities need to be aware of potentially hazardous nuclear and radiological activities. Military bases such as the Puget Sound Naval Station at Bremerton, Naval Submarine Base Bangor, Fort Lewis, McChord Air Force Base, and Fairchild Air Force Base receive, ship, and store nuclear materials. Although great safety precautions are used and the risk is quite low, an accident could occur. Basic local planning is needed to mitigate and respond to potential incidents.

Another aspect that contributes to the hazard is public perception. Even if not exposed to an actual physical threat, many people may panic, believing radiation may have affected them.

Conclusion

The Columbia Generating Station emergency preparedness programs of Energy Northwest, the state, and the surrounding counties: Adams, Benton, Franklin, Grant, Walla Walla, and Yakima are ready to respond to emergencies. State and county plans are updated annually. These plans meet criteria established by the Nuclear Regulatory Commission, Washington State, and Federal Emergency Management Agency and are exercised regularly to ensure their effectiveness. The facility, federal, state, and local jurisdictions participate in these exercises and are trained to respond to actual emergencies, if required.

While the probability of a catastrophic hazardous material release is small, the consequences from the radiological and chemical hazardous materials are significant. Emergency management programs provide a tested emergency response capability designed to protect the people around hazardous areas.

Generally, shielding, limited exposure time, and increased distance from the source are the keys to effective mitigation and response.

Resources

Washington State Emergency Management Division
Washington State Department of Agriculture
Washington State Department of Health
United States Department of Energy
United States Department of Defense
United States Nuclear Regulatory Commission
Federal Emergency Management Agency

TERRORISM

Definition

Terrorism is the unlawful use of force or violence against persons or property to intimidate or coerce a government or civilian population, in furtherance of political or social objectives.

History

Of the 25 terrorist incidents reported by the Federal Bureau of Investigation (FBI) from January 1990 through December 1997, four occurred in Washington State. Two of these incidents were in Tacoma in July 1993. The American Front Skinheads detonated pipe bombs in Tacoma on July 20 and July 22. The Phineas Priesthood exploded a pipe bomb at the Valley Branch offices of *The Spokane-Review* newspaper on April 1, 1996, and robbed a branch of the US Bank in Spokane ten minutes later. The Phineas Priesthood repeated this mode of operation three months later when they placed a pipe bomb at a Planned Parenthood office in Spokane on July 12. They then robbed the same branch of the US Bank using an AK-47, a 12-gauge shotgun, a revolver, and a 25-pound propane tank bomb.

In addition to reported terrorist incidents, the FBI and Bellingham police prohibited a group of terrorists affiliated with the Washington State Militia from carrying out their plans in July 1996. The group planned to bomb various targets, including a radio tower, bridge, and a train tunnel, while the train was inside. More recently, the FBI and Seattle police and fire responded to a hoax, bioterrorism incident on September 19, 1999. The incident involved an Internet company that received a letter containing white power and claiming the powder was anthrax.

More recently, the spectrum of international terrorism surfaced in Washington State in December 1999 when a 33-year-old Algerian man was arrested by U.S. Customs officials while entering the United States in Port Angeles, Washington, aboard a ferry from Victoria, British Columbia. The man was charged with smuggling explosive material into the United States. A former chief of counter-terrorism at the Central Intelligence Agency said the timing devices and nitroglycerine in his possession were the "signature devices" of groups affiliated with Afghan-based Osama bin Laden, an Islamic militant. Because it was highly unlikely the explosive materials could be smuggled onto the commercial aircraft the suspect was scheduled to depart on the next day and he was booked into a motel blocks from Seattle Center, law-enforcement officials investigated the possibility of a terrorist bombing during the Year 2000 New Year's Eve celebration at the Space Needle. New Year's Eve celebrations at the Space Needle traditionally draw tens of thousands of revelers.

Hazard Identification and Vulnerability Assessment

Washington State is vulnerable to terrorist activity. Terrorism can be state sponsored or the outgrowth of a frustrated, extremist fringe of polarized and/or minority groups of people. Extremists have a different concept of morality than the mainstream society. They see issues in terms of black and white. Terrorists groups include:

- Ethnic, separatists, and political refugees

- Left wing radical organizations
- Right wing racists, anti-authority survivalist groups
- Extremist issue-oriented groups such as animal rights, environmental, religious, anti-abortionists

Communities are vulnerable to terrorist incidents and most have high visibility and vulnerable targets. These critical facilities, sites, systems, and special events in the community are usually located near routes with high transportation access. Examples include:

- Government office buildings, court houses, schools, hospitals, and shopping centers
- Dams, water supplies, power distribution systems
- Military installations
- Railheads, interstate highways, tunnels, airports, ferries, bridges, seaports, pipelines
- Recreational facilities such as sports stadiums, theaters, parks, casinos, concert halls
- Financial institutions and banks
- Sites of historical and symbolic significance
- Scientific research facilities, academic institutions, museums
- Telecommunications, newspapers, radio and television stations
- Chemical, industrial, and petroleum plants; business offices, and convention centers
- Law, fire, emergency medical services and responder facilities, and operations centers
- Special events, parades, religious services, festivals, celebrations
- Planned parenthood facilities and abortion clinics
- Residential properties

Critical facilities, sites, and special events become more appealing during visits by high profile personalities and dignitaries. Sporting events such as the Olympic Games and World Cup increase the probability of terrorist targeting. Additionally, international meetings and conventions provide terrorists an excellent environment in which to articulate their cause through violence. Terrorists have introduced two new wrinkles, which are of growing concern: targeting first responders with secondary devices and Weapons of Mass Destruction (WMD) hoaxes. Terrorists will go to great lengths to ensure an event produces the intended impact, even if it means destroying an entire structure or killing thousands. Commercially available materials agents can be developed into WMD. Science and the Internet have made information relating to WMD technology available to an ever-widening audience, and terrorists and other would-be criminals are using it for WMD experimentation. Experts generally agree that there are five categories of terrorist incidents: biological, chemical, nuclear, incendiary, and explosive.

Biological agents pose a serious threat because of their accessible nature and the rapid manner in which they spread. These agents are disseminated by the use of aerosols, contaminated food or water supplies, direct skin contact, or injection. Several biological agents can be adapted for use as weapons by terrorists. These agents include anthrax (sometimes found in sheep and cattle), tularemia (rabbit fever), cholera, the plague (sometimes found in prairie dog colonies), and botulism (found in improperly canned food). A biological incident will most likely be first recognized in the hospital emergency room, medical examiners office, or within the public health community long after the terrorist attack. The consequences of such an attack will present

communities with an unprecedented requirement to provide mass protective treatment to exposed populations, mass patient care, mass fatality management, and environmental health clean-up procedures and plans.

Chemical agents are compounds with unique chemical properties that can produce lethal or damaging effects in humans, animals, and plants. Chemical agents can exist as solids, liquids, or gases depending on temperature and pressure. Most chemical agents are liquid and can be introduced into an unprotected population relatively easily using aerosol generators, explosive devices, breaking containers, or other forms of covert dissemination. Dispersed as an aerosol, chemical agents have their greatest potential for inflicting mass casualties.

Nuclear threat is the use, threatened use, or threatened detonation of a nuclear bomb or device. At present, there is no known instance in which any non-governmental entity has been able to obtain or produce a nuclear weapon. The most likely scenario is the detonation of a large conventional explosive that incorporates nuclear material or detonation of an explosive in close proximity to nuclear materials in use, storage, or transit. Of concern is the increasing frequency of shipments of radiological materials throughout the world.

Incendiary devices are either mechanical, electrical, or chemical devices used to intentionally initiate combustion and start fires. Their purpose is to set fire to other materials or structures. These devices maybe used singularly or in combination.

Explosive incidents account for 70 percent of all terrorist attacks worldwide. Bombs are terrorist's weapon of choice. The Internet and local libraries provide ample information on the design and construction of explosive devices. The FBI reported that 3,163 bombing incidents occurred in the United States in 1994, 77 percent were due to explosives. Residential properties are the bombers' most common targets.

Cyberterrorism is a relatively new phenomenon used to potentially disrupt our society and exploit our increasing reliance on computers and telecommunication networks. Cyberterrorism threatens the electronic infrastructure supporting the social, health, and economic well being of Washington's citizens. Interlinked computer networks regulate the flow of power, water, financial services, medical care, telecommunication networks, and transportation systems. The public and private sectors' unprecedented dependence on information and communications systems, computers, and networks, demonstrate three realities:

- Our networks are vulnerable to attack from any source, whether it is a foreign intelligence agency or a teenager with a new Macintosh. The result of a youthful hacker could be as devastating as that of a sophisticated terrorist group seeking to intentionally disrupt our way of life. The ability to distinguish a singular hacker-type incident from a cyberterrorist attack may not be readily evident.
- The tools for conducting cyberterrorism are widely available, broadly advertised, and easily used. There are entire web sites devoted to the identification and use of hacking tools. Potential attackers only require access to a computer and a telecommunications network.

- Only with sophisticated methods and efforts can the source of the attack potentially be identified and tracked. As with any terrorist activity, the use of intelligence to uncover potential threats is the best means to avoid the disruption and chaos that could result from a cyber attack. Increased network security can significantly help users avoid less sophisticated attacks.

Conclusions

Terrorism is a deliberate strategy with persons' objectives obscured by the fact their acts seem random and indiscriminate. Terrorism is discriminate since it has a definite purpose, but indiscriminate in that the terrorist has neither sympathy nor hate for the randomly selected victim. Communities should use the existing processes and methodologies developed for the successful management of other hazards. Usually, the plans and systems developed for other problems can serve as templates for developing a comprehensive counter-terrorism program. Hazardous material emergency response plans and procedures are helpful in this arena. First responders must remember they are targets and that proactive steps need to be taken to protect the crime scene and the evidence.

Resources

Washington State Emergency Management Division
Ohio Emergency Management Agency
United States Department of Justice, Federal Bureau of Investigation
United States Attorney General
United States Department of State, Bureau of Diplomatic Security,
Overseas Security Advisory Council
National Infrastructure Protection Center
California Office of Emergency Services

TRANSPORTATION

Definition

Transportation systems in Washington State include road, air, rail, and maritime. Use of these systems and supporting transportation vehicles create the opportunity for accidents, emergencies, and disasters. Transportation hazards are natural or human caused.

History

Road: In 1996, two highway accidents were major emergencies. These accidents involved multiple car pileups that closed Interstate 5 (I-5) for hours; detoured traffic clogged other roadways, and overwhelmed local emergency response capabilities.

- January 1996: A 19-car pileup occurred in Whatcom County, near Ferndale, that closed northbound Interstate 5 for four hours. No one was injured.
- August 1996: A 42-car pileup occurred on Friday afternoon of Labor Day Weekend between Tacoma and Seattle on I-5. This accident closed southbound I-5 for four hours. Diverted traffic clogged most of the nearby highways and streets. The accident caused by rain, high speeds, and heavy traffic was responsible for 23 injuries and 1 death.

Air: Washington State has not experienced a major air accident, but the likelihood is increasing. A major air accident would almost certainly involve mass casualties. Several private plane crashes have resulted in injury and death.

Rail: Washington State experienced rail accidents in recent years.

- November 1993: A head on collision of a Union Pacific train and a Burlington Northern train near Kelso killed five-railroad crew. The crash caused an explosion and a fireball was fueled by 10,000 gallons of diesel on the trains. The area is one of the busiest rail corridors in the United States with 60 trains using the two sets of track daily. Amtrak uses these tracks 2 to 3 times per day.
- January 1997: A massive landslide in Snohomish County pushed five freight cars into Puget Sound and knocked out 100 yards of track. Amtrak and Burlington Northern use these tracks regularly.

Maritime: Washington State has not experienced a major accident involving a state ferry, but a series of incidents have occurred.

- Ferries:
  - 1981: The Klahowya collided with a Liberian freighter in heavy fog in Elliot Bay causing minor damage.
  - 1986: A freighter failed to respond to numerous attempts at passing arrangements and the ferry Chelan was forced to stop to avoid collision.

- 1986: The Hyak ran into a reef near the Anacortes ferry terminal, forcing the evacuation of 250 passengers.
- 1987: An inbound freighter nearly collided with the ferry Walla Walla, leaving Seattle Pier 52. The ferry turned hard right to avoid a collision.
- 1991: The ferries Sealth and Kitsap collided in heavy fog just north of Bremerton, injuring one woman.
- 1994: The ferry Nisqually went aground on Elwha Rock off of Orcas Island.
- 1994: The ferry Kitsap collided with a pleasure craft as it was proceeding to a Bremerton dock.
- 1994: The ferry Elwha crashed into the Anacortes dock causing $500,000 in damages.
- 1995: The ferry Nisqually lost power and rammed into the Lopez Island dock. Several passengers suffered minor injuries and the dock was seriously damaged.
- 1996: The ferry Elwha nearly runs aground in the San Juan Islands when the skipper goes for an unauthorized, 15-mile detour.
- 1999: The ferry Elwha crashed into the Orcas Island dock when the engines failed to reverse, causing $2.5 million in damages and disrupting vehicle traffic for days.

- Other Vessels
  - A Canadian study examined past collisions, accidents, and groundings in the Straits of Juan de Fuca and found that 56% involved bulk carriers, 12% involved container vessels, 12% involved passenger vessels, and 18% involved tankers. Tankers are currently the most heavily regulated. Washington State's strict regulations on tanker vessels were passed after the Exxon Valdez oil spill in Alaska.
  - On February 12, 1997 a sailboat sent a mayday distress call near the entrance to La Push Harbor after its mast was tore off in a storm. A standard 44-foot Coast Guard rescue lifeboat responded in 20-foot seas. The boat capsized several times and righted itself, as designed. Three of the four-crew lifeboat members were drowned after leaving the boat. The fourth member remaining on board survived. The rescue boat is capable of operating in 30-foot seas.
  - The New Carrisa cargo ship ran aground near Coos Bay, Oregon on February 4, 1999 with 150,000 gallons of fuel on board. On February 10 the spill response team decided to burn the fuel. The operation was a partial success but split the stern from the bow. Crews managed to pump 100,000 gallons of fluids to tanks on shore but most of it was water. On March 8, 1999, a tug pulled the bow to sea and a Navy submarine sinks the bow with a torpedo on March 11. On October 5 the crew attempted to pull the stern to sea unsuccessfully. Concerns were that the ship or onboard fuels would drift toward the Washington coast and cause a hazardous materials incident.

Hazard Identification and Vulnerability Assessment

- Road: Privately owned vehicles and buses provide transportation for individuals in Washington State using freeways, highways, and roads. Trucks and trailers carry interstate and intrastate cargo. Interstate pileups caused by fog, rain, high speeds, and heavy traffic are common on the west side of the Cascade Mountains.

- Air: A major airline crash will create a mass casualty incident with hundreds of injuries or deaths. Hazardous materials incidents are created with fuel spills and dangerous cargo, such as chemicals in a crop duster or an airplane carrying fire retardant. The crash of a military aircraft with munitions or classified material requires the support of explosive ordinance disposal or military security. An airplane crash in a remote area of the state creates a search and rescue situation.
- Rail: Major rail carriers in Washington State are Burlington Northern and the Union Pacific for freight, and Amtrak for passenger travel. North, south, east, and west travel is available. Other short haul carriers and local trains also exist. The greatest risk associated with freight trains is a spill of hazardous materials. An accident involving an Amtrak train traveling in Washington State could result in a mass casualty incident.
- Maritime: The Washington State ferry system is the primary means of marine passenger transport. During 1995, 22 ferries made 71,435 round trips in state waters. In 1995, 1,256 different ships made 3,619 calls to Puget Sound ports either through the Straits of Juan de Fuca or the Straits of Georgia. The Puget Sound, navigable rivers, and Pacific Ocean make Washington State vulnerable to shipping and boating accidents as well as ferry accidents. Ferry accidents could result in a mass casualty incident.

The United States Coast Guard has the primary responsibility for safety and rescue on the open waterways. Major emergencies associated with freight vessels are more likely to result from spills or collisions with passenger vessels.

Conclusion

Washington State is vulnerable to all types of transportation emergencies. The two major effects of transportation accidents are human injury and hazardous materials releases. Mass casualty incidents can be difficult because of location. Remote locations have limited resources, make response time slow, and delay treatment of the injured. Heavily populated locations have crowd control problems and slow response time due to congestion. The worst type of accident would involve mass casualties and a hazardous material release. The presence of hazardous materials slows response to the injured for fear of exposing emergency personnel. Mass casualty events quickly overwhelm local emergency personnel, hospitals, and blood banks. Areas typically plan for these events with mutual aid agreements.

The source and location of transportation accidents vary but the response is typically the same. Response is focused on determining the presence of hazardous materials and then assisting the injured.

Resources

Washington State Emergency Management Division
Washington State Department of Transportation
Washington State Continuous Airport System Plan Inventory and Forecasts
Washington State Utilities and Transportation Commission
Washington State Department of Ecology, Office of Marine Safety
National Transportation Safety Board

URBAN FIRE

Definition

Urban fire occur primarily in cities or towns with the potential to rapidly spread to adjoining structures. These fires damage and destroy homes, schools, commercial buildings, and vehicles.

History

There are over 5,900 career firefighters and 16,800 volunteer firefighters from over 600 fire departments who provide fire services to Washington State communities. These firefighters responded to more than 50,948 fire calls in 1998 that resulted in an estimated $206 million in property loss, with an average loss of $4,050 per call. More than 7,000 times each year, or 20 times a day, someone in Washington State suffers from a fire in their home. In 1998, there were 73 fire deaths; 75 percent of these fire deaths occurred in dwellings where people live. 1998 marked a second consecutive year of no line-of-duty firefighter deaths in Washington State, however, there were 237 injuries.

Fire deaths in 1998 reached a 14-year high and were more than double the 1997 figures. The five-year average for fire deaths was 55 per year. The ten-year average was 62 deaths per year. In Washington State, 75 percent of all fire deaths occurred in the home. Of great concern is the link of arson and suspected arson to fire deaths.

See Table Eleven for 1998 Fire Department Emergency Responses.

Hazard Identification and Vulnerability Assessment

In Washington State, 38 percent of identified structure fires occur where people live and 75 percent of all fire deaths occur in homes. People are more at risk from a fire where they feel safest, where they live. The leading causes of residential fires in Washington State are from heat from properly operating electrical equipment, matches or lighters, electrical short-circuit or arc, and heat from wood/paper fueled equipment.

Heat from properly operating electrical equipment includes electric stoves, electric heaters, and other electrical appliances. Cooking is a leading cause of residential fires and home heating is the second leading cause, as reported to the United States Fire Administration through the National Incident Reporting System. In Washington State, more than 24 percent of residential fires start in the kitchen cooking area. Fires caused by home heating are usually caused by portable space heaters. In Washington State, fires from wood or paper fueled equipment are also significant. The chimney is the third leading area of fire origin.

Of the homes where fire deaths occurred, 75 percent had smoke detectors. However, only 10 percent were known to be working. Despite the presence of working smoke detectors, ten fatalities occurred because elderly, disabled, mentally handicapped, and alcohol-impaired citizens were unable to escape fires in their homes.

Hotels, businesses, and educational buildings follow as the next leading buildings in which fires occur. These occupancy classes and others have special considerations that must be understood in order to protect citizens from fire dangers. Large assemblies, such as coliseums, retail facilities, and shopping malls are the types of buildings that make communities unique. Community activities often concentrate large numbers of people, creating the risk of large loss of life should a fire occur. To help these buildings be safe from fire, the Uniform Fire Code's international fire safety requirements have been adopted by Washington State.
Arson is a violent crime against people. Arson, when combined with suspected arson, was the leading cause of fire deaths in Washington State in 1998. Arson and suspected arson killed one of every eight people who died in a structure fire during that year. There were a total of 1,113 arson fires in Washington State in 1998.

Urban communities with newer industrial and business facilities are reasonably secure from potential conflagration. These buildings are generally constructed of fire resistive materials, protected with automatic sprinkler systems, and reasonably well separated. Although a major fire may occur in such facilities, it would most likely not spread into adjoining structures. This observation is based on the following:

- The Uniform Fire Code has required sprinklers in certain industrial and business buildings since 1985.
- Fire extinguishing and fire detection systems were installed during construction
- Fire stations are strategically located nearby

In Washington State, 7 percent of all fires involve vehicles, an increasingly large share of total fires. Fires occurring in the engine, running gear, and passenger areas account for 77 percent of vehicle fires. Vehicle fires start in engine compartments, brake systems, by driver or passenger smoking.

Conclusion

Prevention is a simple solution to reduce destructive fires. It is incumbent upon each citizen to take the responsibility for his or her family and individual safety and to practice fire and burn prevention. Citizens should insure that the following critical areas of preparedness and prevention are followed to reduce fire deaths and property losses:

- Matches and lighters out of the reach of children
- Heaters 36 inches from anything that can burn
- Cooking always attended
- Homes have a defensible space from wildfire
- Fire safety is practiced at home and work

Fire sprinklers are the most effective fire protection feature a home can have. Installation of home sprinklers must be aggressively pursued, especially for the vulnerable populations of the elderly and disabled. Good public education programs, conducted by fire departments and districts, on fire safety, fire alarms, and fire response are important and aid prevention.

Washington State adopts nationally recognized building and fire codes and rapidly changing fire and safety developments. Legislation is continually being developed and adopted to address specific fire-related problems.

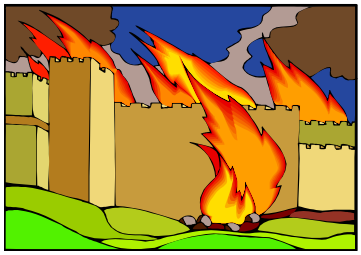
Resources

Washington State Department of Emergency Management
Washington State Patrol, Fire Protection Bureau
Federal Emergency Management Agency, United States Fire Administration

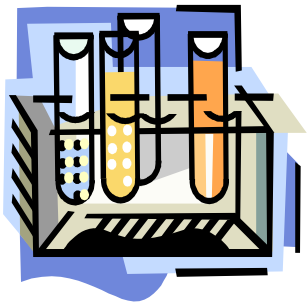
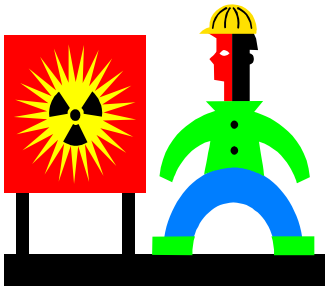
Table Eleven
Fire Department Emergency Responses

Type of Response	1998 Totals	Population Factor of 1.5*
All Fires	33,965	50,948
Structure	9,937	14,906
Residential	4,720	7,080
Wildland	4,466	6,699
Vehicle	4,705	7,058
Arson	1,113	1,670
Emergency Medical Service	224,716	337,074
Hazardous Material	4,448	6,672
Other	75,294	121,409
Mutual Aid	10,003	33,240
Rescue	14,273	21,410
Hazardous Condition	6,943	10,415
Service	22,160	33,240
Good Intent	18,350	27,525
False Calls	31,410	47,115
Dollar Loss	$137,482,231	$206,223,346

*The first column shows data submitted by the 149 fire departments that reported. The second column shows an extrapolated amount of what the figure would be if the other 70 percent of the departments reported. Data and calculations from Washington State Patrol, Fire Protection Bureau.


Hazard Matrixes & Definitions & Acronyms


HAZARD AND IMPACT MATRIX INSTRUCTIONS

Purpose

This Matrix is a tool to link hazards that may affect jurisdictions, agencies, and business and possible related adverse impacts to life, property, and the environment. Across the top are the major hazards present in Washington State. The left column is an alphabetical listing of adverse impacts that may affect jurisdictions, agencies, and business. With proper planning and action, communities can mitigate against, prepare for, respond to, and recover from adverse impacts of hazards.

Use

The Impact Matrix is a subjective estimate of the possible adverse effects on the community by a hazard based on historical experience. Marking the intersection of the hazard and the impact(s) with an "x" identifies these effects.

First identify a hazard on the top, or add a hazard if it is unique to your jurisdiction, agency, or business. Then move down and place an "x" in those blocks that indicate the impact expected as a result of the hazard. Each jurisdiction, agency, or business preparing a hazard identification and vulnerability assessment should identify the hazards that they are likely to experience and the impacts those hazards may bring. Then, for each hazard, identify the particular impact(s) by intersecting the matrix with an "x." In some instances, additional impacts may need to be added.

An unfilled matrix is provided as a start point for users to modify and fill in.

Hazard and Impact Matrix	Avalanche	Drought	Earthquake	Flood	Landslide	Severe Local Storm	Tsunami	Volcano	Wildland Fire	Abandoned Mine	Chemical	Civil Disturbance	Dam Failure	Hazardous Materials	Local Hazard	Pipeline	Radiological	Terrorism	Transportation	Urban Fire
Acid Rain																				
Ash Cloud																				
Communication loss																				
Contamination-air																				
Contamination-ground																				
Contamination-water																				
Evacuation																				
Fire-urban																				
Fire-wildland																				
Flood-urban																				
Flood-rural																				
Fuel																				
Hostage																				
Failure-bridges																				
Failure-buildings																				
Failure-road																				
Landslide																				
Medical emergency																				
Mud/rock flow																				
Riot/looting																				
Sabotage																				
Strikes																				
Transportation-air																				
Transportation-marine																				
Transportation-rail																				
Transportation-road																				
Utilities-electric																				
Utilities-natural gas																				
Utilities-sewer																				
Utilities-telephone																				
Utilities-water																				

HAZARD AND EMERGENCY SUPPORT FUNCTION MATRIX INSTRUCTIONS

Purpose

This Matrix is a tool to link hazards that may affect jurisdictions, agencies, and business and the related Emergency Support Functions (ESF). ESFs provide a functional approach to assistance and operational support necessary to mitigate against, prepare for, respond to, and recover from hazards that endanger life, property, and the environment. Across the top are the major hazards that may occur in Washington State. The left column is a listing of ESFs found in the *Washington State Comprehensive Emergency Management Plan* and the *Federal Response Plan.*

Use

The ESF Matrix is a subjective estimate of what assistance and operational support is necessary to deal with a historical hazard. Marking the intersection of the hazard and ESF(s) with an "x" identifies areas that may require assistance or operational support.

First identify a hazard from the top, or add a hazard if it is unique to your jurisdiction, agency, or business. Then move down and place an "x" in those blocks that indicate the ESF(s) you expect to activate as a result of the hazard. Each jurisdiction, agency, or business preparing an emergency management plan should identify the hazards that are likely to occur with the corresponding ESFs that apply.

An unfilled matrix is provided as a start point for users to modify.

Hazard and Emergency Support Function (ESF) Matrix	Avalanche	Drought	Earthquake	Flood	Landslide	Severe Local Storm	Tsunami	Volcano	Wildland Fire	Abandoned Mine	Chemical	Civil Disturbance	Dam Failure	Hazardous Materials	Local Hazard	Pipeline	Radiological	Terrorism	Transportation	Urban Fire
1-Transportation																				
2-Telecommunications																				
3-PublicWorks and Engineering																				
4-Firefighting																				
5-Information and Planning																				
6-Mass Care																				
7-Resource support																				
8-Health and Medical Services																				
9-Urban Search and Rescue																				
10-Hazardous Materials																				
11-Food																				
12-Energy																				
13-Federally Reserved																				
14-Federally Reserved																				
15-Federally Reserved																				
16-Federally Reserved																				
17-Federally Reserved																				
18-Federally Reserved																				
19-Federally Reserved																				
20-Military Support to Civil Authorities																				
21-Recovery																				
22-Law Enforcement																				
23-Damage Assessment																				
24-Evacuation and Movement																				
25-Foreign Animal Disease of Livestock																				

MITIGATION STRATEGY

Purpose

Hazard mitigation helps you develop a successful strategy to reduce vulnerability to hazards. Included in this section are worksheets for a local jurisdiction to complete. When you finish the worksheets, you will have an outline for mitigation strategy and for reducing your vulnerability to hazards. The worksheets will help you explore the current state of your jurisdiction, including identifying hazard areas and existing policies that affect those areas. The worksheets will help you define goals for increasing your hazard resilience, identify mitigation actions, and assign responsibility for action. For those wanting a greater, in-depth methodology for developing a mitigation strategy, more help is available on the Washington State Emergency Management Division website, www.wa.gov/wsem/www. On the website you find *Keeping Hazards From Becoming Disasters, A Mitigation Workbook for Local Governments.* This provides a step-by-step process and explanation to help jurisdictions complete the actions necessary for a comprehensive hazard mitigation strategy.

Use

Worksheet 1, Hazard Identification and Risk Assessment. This first step helps you decide on which hazards to focus your attention and resources.

Worksheet 2, Vulnerability Analysis. This step helps you determine who and what is vulnerable to hazards and determine the value of property that may be damaged or lost.

Worksheet 3, Mitigation Measures. This step helps you determine your current capability to address the threats posed by hazards. It helps you understand why certain policies may or may not be effective in mitigating hazards.

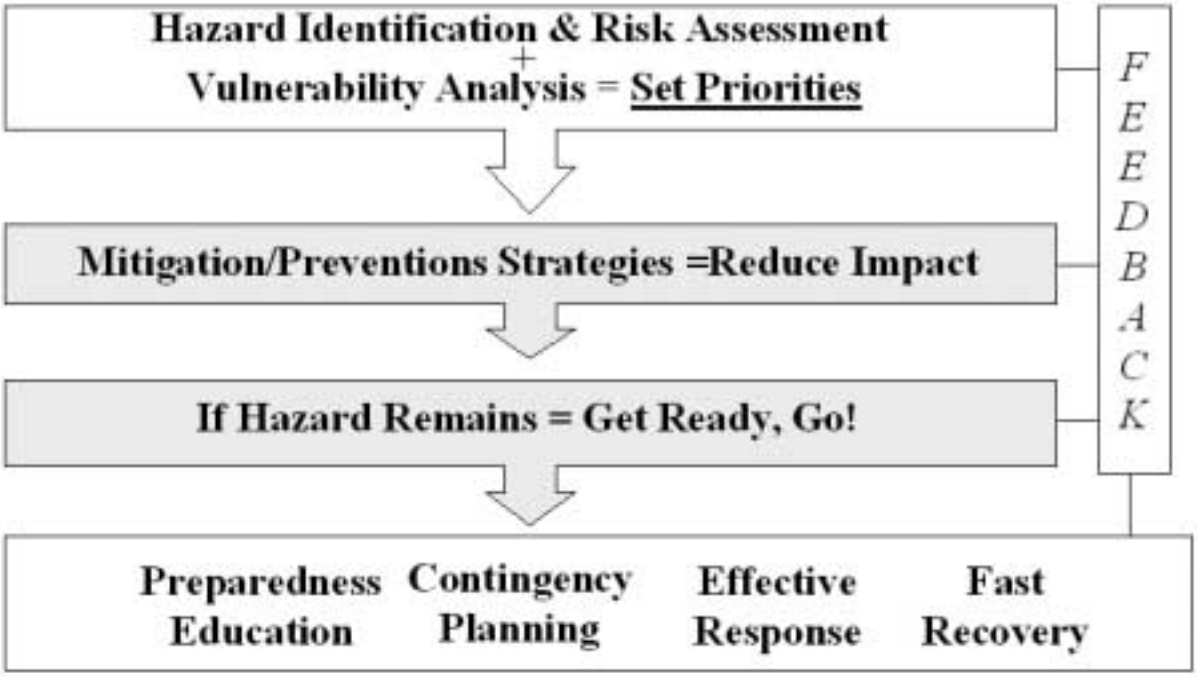
Worksheet 4, Mitigation Planning. This step helps you relate existing community goals to the goals you want to have in your mitigation strategy. It answers the question of how your goals fit with anticipated mitigation goals.

Worksheet 5, Mitigation Actions. This is the final step designed to help you develop your own actions to reduce vulnerability to hazards. The outcome will be the actions needed for a mitigation strategy.

Integrated Emergency Management Approach

When a mitigation strategy still does not satisfy all the concerns created by potential hazards, more must be done. Included in your emergency management program should be those other actions in the Integrated Emergency Management Approach chart. These are preparedness education, contingency planning, effective response, and an effective and expedient recovery.

An Integrated Emergency Management Approach



WORKSHEET #1: HAZARD IDENTIFICATION AND RISK ASSESSMENT				
Hazard	**Likelihood of Occurrence**	**Location**	**Impacts**	**Hazard Index**
Earthquake				
Landslide				
Flooding				
Wildland Fire				
Hazardous Materials				
Tornado				
Winter Storms				
Wind Storms				

WORKSHEET #2 VULNERABILITY ANALYSIS

Hazard Area Location _____
(Copy the form and complete for each hazard in your community)

	Developed Land			Undeveloped Land		
	Number of People	Number of Buildings	Approximate Value	Number of People	Number of Buildings	Approximate Value
Residential (use max. figures						
Commercial						
Industrial						
Public Buildings and Critical Facilities						
Sewage Treatment Plant						
Water Treatment Plant						
Hospitals						
Schools						
Roads						
Police						
Fire						
Hazardous Facilities						
Total						

WORKSHEET #3: MITIGATION MEASURES			
Policies and Programs	**Document Reference**	**Effectiveness for Mitigation**	**Rationale for Effectiveness**

WORKSHEET #4: MITIGATION PLANNING		
Source	**Existing Goal Statement**	**Effective Goal for Mitigation**
Comprehensive Emergency Management Plan		
Capital Improvement Plan		
Economic Development Plan		
Transportation Plan		
Storm Water Management Plan		
Parks and Open Space		
Other		

WORKSHEET #5: MITIGATION ACTIONS					
Hazard Area Location	**Type of Hazard(s)**	**New Initiative or Recommended Policy Changes**	**Goals Addressed**	**Responsible Party**	**Date Due**

DEFINITIONS

ABANDONED UNDERGROUND MINE - Any large excavation in the earth formerly used to extract ore, coal, or mineral, which is no longer in production.

ACCESS CONTROL POINTS - Road intersections or other logistically viable points on the relocation and food control boundaries which enable law enforcement and other emergency workers to maintain access control of the respective area(s). It involves the deployment of vehicles, barricades, or other measures to deny access to a particular area.

AVALANCHE - A mass of sliding snow, ice, earth, and rock that grows and collects additional material as it descends.

CHEMICAL AGENT (LETHAL) - A chemical substance that is intended for use in military operations to kill, seriously injure, or incapacitate a person through its physiological effects. Excluded from consideration are riot control agents, chemical herbicides, smoke, and flame.

CHEMICAL HAZARD - The release of toxic agents into the atmosphere that can harm population, animals, and food supplies.

CIVIL DISTURBANCE - Any incident that disrupts a community where intervention is required to maintain public safety.

DAM FAILURE - The uncontrolled release of impounded water resulting in downstream flooding, which can affect life and property.

DISASTER - An event expected or unexpected, in which a community's available, pertinent resources are expended; or the need for resources exceeds availability; and in which a community undergoes severe danger; incurring losses so that the social or economic structure of the community is disrupted; and the fulfillment of some or all of the community's essential functions are prevented.

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

EARTHQUAKE - The shaking of the ground caused by an abrupt shift of rock along a fracture in the earth, called a fault.

EMERGENCY - An event, expected or unexpected, involving shortages of time and resources; that places life, property, or the environment, in danger; that requires response beyond routine incident response resources.

EMERGENCY MANAGEMENT or COMPREHENSIVE EMERGENCY MANAGEMENT - The preparation for and the carrying out of all emergency functions, other than functions for

which the military forces are primarily responsible, to mitigate, prepare for, respond to, and recover from emergencies and disasters, and to aid victims suffering from injury or damage, resulting from disasters caused by all hazards, whether natural or technological, and to provide support for search and rescue operations for persons and property in distress.

EMERGENCY OPERATIONS CENTER (EOC) - A designated site from which government officials can coordinate emergency operations in support of on-scene responders.

EMERGENCY PLANNING ZONES (EPZs) - The areas for which emergency plans are made to assure that prompt and effective action can be taken to protect the public in the event of a radiological or chemical emergency. In Washington State the first zone is the plume exposure emergency planning zone with an approximate radius of ten miles from the nuclear power plant or chemical depot. The second zone is the ingestion exposure EPZ with an approximate radius of 50 miles. Immediate Response Zone (IRZ) and Protective Action Zone (PAZ) are zones associated with nuclear and chemical storage facilities.

FAULT - An abrupt shift of rock along a fracture in the earth.

FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA) - Agency created in 1979 to provide a single point of accountability for all federal activities related to disaster mitigation and emergency preparedness, response, and recovery. Federal Emergency Management Agency manages the President's Disaster Relief Fund and coordinates the disaster assistance activities of all federal agencies in the event of a Presidential Disaster Declaration.

FIXED NUCLEAR FACILITY (FNF) - One of a variety of complexes, in which fissionable fuel is stored or utilized for such functions as electrical power generation, or testing and manufacturing fuels and materials.

FLOOD - An inundation of dry land with water. Types of floods in Washington State are primarily river, surface water, flash, and tidal.

FOREST FIRE - The uncontrolled destruction of forested lands by wildfires caused by natural or human-made events. Wildfires occur primarily in undeveloped areas characterized by forest lands.

HANFORD SITE - A 560 square mile complex, located north of the city of Richland, Washington, under the direction of the U.S. Department of Energy.

HAZARDOUS MATERIALS - Materials, which, because of their chemical, physical, or biological nature, pose a potential risk to life, health, or property when released.

IMMEDIDATE RESPONSE ZONE – The six-mile area surrounding the chemical surrounding the chemical storage area at the Umatilla Chemical Depot.

INGESTION EXPOSURE PATHWAY - When human beings are exposed to radioactive or hazardous materials from a facility through consumption of water and food stuffs, including

dairy products. Emergency planning and protective actions are designed in part, to eliminate or reduce to the minimum exposures due to ingestion of contaminated materials in the area surrounding a facility.

LAHAR - Hot rock and gas melts snow and ice, creating surges of water that eroded and mixed with loose rock and debris, also known as a mudflow.

LANDSLIDE - Landslide is the sliding movement of masses of loosened rock and soil down a hillside or slope.

LAVA - Molten rock that flows onto the earth's surface.

LOCAL EMERGENCY PLANNING COMMITTEE (LEPC) - The planning body designated by the Superfund Amendments and Reauthorization Act, Title III legislation as the planning body for preparing local hazardous materials plans.

MAGMA - Molten material beneath or within the earth's crust from which igneous rock is formed.

MAJOR DISASTER - As defined in federal law, is any hurricane, tornado, storm, flood, high water, wind-driven water, tidal wave, tsunami, earthquake, volcanic eruption, landslide, mudslide, snowstorm, drought, fire, explosion, or other technological or human caused catastrophe in any part of the United States which, in the determination of the President, causes damage of sufficient severity and magnitude to warrant major disaster assistance… in alleviating the damage, loss, hardship, or suffering caused thereby.

MARINE SAFETY ZONE (MSZ) – A Chemical Stockpile Emergency Preparedness Program designated 12-mile stretch of the Columbia River.

MITIGATION - Actions taken to eliminate or reduce the degree of long-term risk to human life, property, and the environment from natural and technological hazards. Mitigation assumes our communities are exposed to risks whether or not an emergency occurs. Mitigation measures include, but are not limited to, building codes, disaster insurance, hazard information systems, land use management, hazard analysis, land acquisition, monitoring and inspection, public education, research, relocation, risk mapping, safety codes, statues and ordinances, tax incentives and disincentives, equipment or computer tie downs, and stocking emergency supplies.

PIPELINES - Transportation arteries carrying liquid and gaseous fuels.

PREPAREDNESS - Actions taken in advance of an emergency to develop operational capabilities and facilitate an effective response in the event an emergency occurs. Preparedness measures include, but are not limited to, continuity of government, emergency alert systems, emergency communications, emergency operations centers, emergency operations plans, emergency public information materials, exercise of plans, mutual aid agreements, resource management, training response personnel, and warning systems.

PRESIDENTIAL DECLARATION - Formal declaration by the President that an Emergency or Major Disaster exists, based upon the request for such a declaration by the Governor and with the verification of Federal Emergency Management Agency preliminary damage assessments.

PROTECTIVE ACTION ZONE (PAZ) – An area from the Immediate Response Zone to 20 miles from the Umatilla Chemical Depot.

PYROCLASTIC FLOW - Hot avalanches of lava fragments and gas formed by the collapse of thick lava flows and eruption columns.

RADIOLOGICAL HAZARD - The uncontrolled release of radioactive material that can harm people or damage the environment.

RECOVERY

a. Activity to return vital life support systems to minimum operating standards and long-term activity designed to return life to normal or improved levels, including some form of economic viability. Recovery measures include, but are not limited to, crisis counseling, damage assessment, debris clearance, decontamination, disaster application centers, disaster insurance payments, disaster loans and grants, disaster unemployment assistance, public information, reassessment of emergency plans, reconstruction, temporary housing, and full-scale business resumption.

b. The extrication, packaging, and transport of the body of a person killed in a search and rescue incident.

RESPONSE - Actions taken immediately before, during, or directly after an emergency occurs, to save lives, minimize damage to property and the environment, and enhance the effectiveness of recovery. Response measures include, but are not limited to, emergency plan activation, emergency alert system activation, emergency instructions to the public, emergency medical assistance, staffing the emergency operations center, public official alerting, reception and care, shelter and evacuation, search and rescue, resource mobilization, and warning systems activation.

SEICHE - Standing waves in an enclosed or partially enclosed body of water.

SEVERE STORM - An atmospheric disturbance manifested in strong winds, tornadoes, rain, snow, or other precipitation, and often accompanied by thunder or lightning.

SUBDUCTION ZONE - A convergent boundary between an oceanic plate and a continental plate.

TEPHRA - Clastic volcanic material.

TERRORISM - The unlawful use of force or violence against persons or property to intimidate or coerce a government or civilian population, in furtherance of political or social objectives.

TORNADO - A localized violently destructive windstorm occurring over land and characterized by a long funnel-shaped cloud that extends to the ground.

TSUNAMI - A series of traveling ocean waves of long length generated by earthquakes, volcanic eruptions, and landslides occurring below the ocean floor.
UMATILLA CHEMICAL DEPOT (UMCD) - A United States Army ordnance storage facility located in northeastern Oregon formerly known as Umatilla Depot Activity (UMDA). The Depot has been operated since 1942 as a storage site for conventional Army ammunition, bombs, artillery shells, and landmines. It is now a storage site for unitary and binary chemical weapons and agents.

URBAN FIRE - Urban fire occurs primarily in cities or towns with the potential to rapidly spread to adjoining structures.

VOLCANO - A vent in the earth's crust through which molten rock, rock fragments, gases, and ashes are ejected from the earth's interior.

WILDLAND FIRE - Uncontrolled destruction of forests, brush, field crops and grasslands caused by nature or humans.

ACRONYMS

ARC – American Red Cross

CEMP – Comprehensive Emergency Management Plan
CSEPP – Chemical Stockpile Emergency Preparedness Program

EMD – Washington Military Department, Emergency Management Division
EOC – Emergency Operations Center
EPZ – Emergency Planning Zone

FBI – Federal Bureau of Investigation
FEMA – Federal Emergency Management Agency
FNF – Fixed Nuclear Facility

HIVA – Hazard Identification and Vulnerability Assessment

IRZ – Immediate Response Zone

MSZ – Marine Safety Zone

PAZ – Protective Action Zone
PG&E – Puget Sound Gas and Electric
PZ – Precautionary Zone

ROW – Right of Way

TAR – Tone Alert Radio

UMCD – Umatilla Chemical Depot