Risk Assessment

The Risk Assessment of the Washington State Hazard Mitigation Plan provides the factual basis for the mitigation goals and activities proposed by the plan. This section examines the nine natural hazards the impact the state, determines which counties and populations are most vulnerable to each hazard, and estimates potential losses of state facilities for each hazard.

The Risk Assessment consists of two parts – profiles of nine natural hazards and socio-economic profiles of the nine regions of the state. Each Hazard Profile describes and documents the impact of past hazard events, identifies jurisdictions most at risk to that hazard, and identifies potential losses of state facilities caused by hazard events by region of the state. Each Regional Profile describes the setting of the region, its counties and its economy, examines potential at-risk populations, and identifies potential losses of state facilities by hazard within the region.

At this time, the Risk Assessment only includes information on facilities of the state agencies participating in this plan, and does not include risk information from local jurisdictions. This comes from a determination made by the Mitigation Section of the State Emergency Management Division that the number of approved local plans available at the time this plan was prepared (eight, but only two multi-jurisdictional plans as of December 31, 2003), did not provide adequate information to significantly influence the content of this plan's Hazard Profiles and Risk Assessment.

Review of approved local plans' Hazard Profiles and Risk Assessments by the Mitigation Section of the State Emergency Management Division revealed that the local jurisdictions evaluated hazards and risks in a similar manner and came to similar conclusions as those found in the state plan's Risk Assessment.

Hazard Profiles

The *Washington State 2001 State Hazard Identification and Vulnerability Assessment* identifies and describes nine natural hazards that have the greatest potential to affect the people, environment, economy, and property of the state. These natural hazards are:

Avalanche	Drought	Earthquake
Flood	Landslide	Severe Storm
Tsunami	Volcano	Wildland Fire

Identification of these natural hazards by the *State HIVA* provides the foundation for the Risk Assessment of the Washington State Hazard Mitigation Plan.

This Risk Assessment includes a profile of each of the nine hazards. Each profile provides a detailed description of the hazard and how it has affected the state; identifies jurisdictions most vulnerable to future hazard events; and provides a synopsis of state-owned and operated facilities and infrastructure that are most likely at-risk to the hazard.

Risk Assessment

Staff from the Mitigation Section of the State Emergency Management Division researched and wrote the Hazard Profiles, and prepared the synopsis of at-risk state facilities that appears at the end of each profile. State agencies provided information on potentially at risk-facilities. Subject-matter experts from various disciplines contributed to and reviewed the Hazard Profiles.

Information Sources

Information for the Hazard Profiles and at-risk facilities came from a variety of sources, including:

- *Washington State 2001 Hazard Identification and Vulnerability Assessment*.
- Historical disaster records and documents, including but not limited to Hazard Mitigation Survey Team reports and spreadsheets maintained by the State Emergency Management Division on assistance made available following disasters.
- Literature developed by state and national hazard experts containing best available science and most current knowledge of hazards.
- Current hazard zone maps, if available.
- Written and oral communication from state and national hazard experts.
- Facilities databases developed by state agencies participating in the development of this plan.

Information used in the Hazard Profiles came from a variety of organizations including:

- Cascades Volcano Observatory, U.S. Geological Survey.
- Federal Emergency Management Agency, U.S. Department of Homeland Security.
- Hazard Research Laboratory, Department of Geography, University of South Carolina.
- National Drought Mitigation Center, University of Nebraska-Lincoln.
- National Oceanic and Atmospheric Administration and its agencies/programs:
    - International Tsunami Information Center.
    - National Climatic Data Center.
    - National Tsunami Hazard Mitigation Program.
    - National Weather Service.
    - Northwest Weather and Avalanche Center.
    - Pacific Marine Environmental Laboratory.

- U.S. Forest Service, U.S. Department of Agriculture.
- U.S. Geological Survey, U.S. Department of the Interior.
- University of Washington and its departments/programs:
  - Nisqually Earthquake Clearinghouse, Department of Civil and Environmental Engineering (the State Emergency Management Division also is a partner in this project).
  - Pacific Northwest Seismic Network, Department of Earth and Space Sciences.
- Washington Department of Agriculture.
- Washington Department of Community Trade and Economic Development.
- Washington Military Department, Emergency Management Division.
- Washington Department of Natural Resources.
- Washington Department of Transportation.
- Western Regional Climate Center, Desert Research Institute.

A list of specific documents, resources, and experts consulted in the development of the Hazard Profiles appears at the end of each profile.

Profile Review

Each Hazard Profile was subject to a thorough review process directed and managed by the State Emergency Management Division's Mitigation Section. Staff from the division as well as members of the State Hazard Mitigation Advisory Team read and provided comments on early drafts of the profiles. Additionally, teams of hazard experts from a variety of state and federal organizations conducted a final review of each profile. The purpose of the expert review was to ensure the accuracy and currency of information presented, to validate the criteria used to identify local jurisdictions most vulnerable to the hazard, and to ensure conformity to federal requirements for this plan. Participating experts, by hazard:

<u>Avalanche</u>

- Mark Moore, Forecaster, Northwest Weather and Avalanche Center.

<u>Drought</u>:

- Linda Crerar, Natural Resource Policy Assistant to Director, Washington Department of Agriculture.
- Doug McChesney, Policy and Planning Manager, Water Resources Program, Washington Department of Ecology.

- Rebecca Inman, Environmental Specialist, Water Resources Program, Washington Department of Ecology.
- Mark Clark, Executive Director, Washington Conservation Commission.

Earthquakes

- George Crawford, Earthquake Program Manager, Emergency Management Division, Washington Military Department.
- Chris Jonientz-Trisler, Natural Hazard Program Specialist/Earthquake Program Manager, Region 10, Federal Emergency Management Agency, U.S. Department of Homeland Security.
- Tim Walsh, Chief Geologist, Division of Geology and Earth Resources, Washington Department of Natural Resources.
- Craig Weaver, Seismologist, U.S. Geological Survey.

Flood

- Dan Sokol, Floodplain Management Specialist and Acting National Flood Insurance Program State Coordinator, Washington Department of Ecology.
- Chuck Steele, Floodplain Management Specialist, Northwest Region, Washington Department of Ecology.
- Brent Bower, Hydrologist, National Weather Service, Seattle Forecast Office.
- Paul Komoroske, Emergency Management Coordinator, U.S. Army Corps of Engineers, Seattle District.

Landslide

- Tim Walsh, Chief Geologist, Division of Geology and Earth Resources, Washington Department of Natural Resources.
- Ed Harp, Geologist and Emergency Response Coordinator, National Landslide Hazard Program, U.S. Geological Survey.
- Dave Montgomery, Professor, Department of Earth and Space Sciences, University of Washington.

Severe Storm

- Ted Buehner, Warning Coordination Meteorologist, National Weather Service, Seattle Forecast Office.
- Jeff Rood, Meteorologist, National Weather Service, Seattle Forecast Office.
- Tyree Wilde, Warning Coordination Meteorologist, National Weather Service Portland, OR, Forecast Office.
- Ken Holmes, Warning Coordination Meteorologist, National Weather Service Spokane Forecast Office.
- Dennis Hull, Warning Coordination Meteorologist, National Weather Service Pendleton, OR, Forecast Office.

Tsunami

- Chris Jonientz-Trisler, Natural Hazard Program Specialist/Earthquake Program Manager, Region 10, Federal Emergency Management Agency, U.S. Department of Homeland Security.

- Tim Walsh, Chief Geologist, Division of Geology and Earth Resources, Washington Department of Natural Resources.
- Brain Atwater, Geologist, U.S. Geological Survey, and Affiliate Professor, Department of Earth and Space Sciences, University of Washington.
- Hal Mofjeld, Oceanographer, National Tsunami Hazard Mitigation Program, NOAA Pacific Marine Environmental Laboratory.
- Aggeliki Barberopoulou, Ph.D. candidate, Department of Earth and Space Sciences, University of Washington.

Volcano

- Chris Jonientz-Trisler, Natural Hazard Program Specialist/Earthquake Program Manager, Region 10, Federal Emergency Management Agency, U.S. Department of Homeland Security.
- William Scott, Scientist-in-Charge, Cascades Volcano Observatory, U.S. Geological Survey.
- Tim Walsh, Chief Geologist, Division of Geology and Earth Resources, Washington Department of Natural Resources.
- Wendy Bohrson, Associate Professor, Department of Geological Sciences, Central Washington University.

Wildland Fire

- Jennifer Flemister, Natural Resource Program Coordinator, Resource Protection Division, Washington Department of Natural Resources.
- Bob Bannon, Natural Resource Program Section Administrator, Resource Protection Division, Washington Department of Natural Resources.
- Barbara Kennedy, Cooperative Fire Specialist, U.S. Forest Service, Region 6.

Data Limitations

As described above, the Hazard Profiles are based on a wide range of information and data, including best available science and most current information, to describe each hazard and its impacts, and to determine jurisdictions most vulnerable. At the end of each profile is a list of information and data sources; each entry includes publication dates of information and data, as well as Internet URL, if available.

The depth of knowledge about the state's nine natural hazards varies greatly; ongoing research expands the scientific understanding for many of the hazards every year. Individual Hazard Profiles indicate areas where research is ongoing, if known, and describe limitations of information or data used in the development of the profile, as appropriate.

Each Hazard Profile describes in detail the data (and sources) used to determine which jurisdictions are most vulnerable to each hazard.

Maps that designate most vulnerable local jurisdictions generally illustrate vulnerability on a broad scale; maps that show specific hazard areas are provided if available (i.e., volcano hazard zones, tsunami inundation zones). When specific areas within a

jurisdiction are designated as most vulnerable, descriptions of those areas are in profile text.

Incorporating Local Hazard Information

As of December 31, 2003, the Federal Emergency Management Agency had approved only eight local hazard mitigation plans, two of which were multi-jurisdiction plans. Given this, the State Emergency Management Division determined that the number of approved local plans did not provide adequate information to influence significantly the state plan's Hazard Profiles. Review of approved local plans' Hazard Profiles by the Mitigation Section of the State Emergency Management Division revealed that the local jurisdictions evaluated hazards and risks in a similar manner and came to similar conclusions as those found in the state plan's Hazard Profiles.

For the second edition of the State Hazard Mitigation Plan (c. 2007), it is estimated that more than 30 local multi-jurisdiction hazard mitigation plans will be completed and approved. This number of plans, and the areas they represent, should provide adequate information to influence the Hazard Profiles and the Risk Assessment of the state plan.

The Mitigation Section of the State Emergency Management Division and members of the State Hazard Mitigation Advisory Team will review hazard profiles and risk assessments of local plans when preparing the next edition of the state plan. Information in local plans that supplements and improves the accuracy and depth of the state plan's Hazard Profiles will be added to the plan. Such information may include, but not be limited to, the following:

- Locations of hazard areas identified by the local jurisdiction. This includes the location of critical areas defined by the State's Growth Management Act (RCW 36.70A.050, RCW 36.70A.172(1),and Chapter 365-190 and 365-195 WAC). The act defines critical areas to include frequently flooded areas and geologically hazardous areas. Geologically hazardous areas are those subject to erosion, landslide, seismic hazard, mine hazard, volcanic hazard, and other geologic events including tsunamis, mass wasting, debris falls, rock falls, and differential settlement.

- Information on populations and structures located in or near local hazard areas/critical areas. Structures of concern include residential housing as well as critical facilities such as schools, fire and police stations, hospitals, water and sewage treatment facilities.

- Information on projected growth in or near identified local hazard areas/critical areas.

Local jurisdictions and hazard experts will review revised state Hazard Profiles and the revised Risk Assessment to ensure their accuracy and completeness after local information has been incorporated

Hazards of Greatest Concern

The State Hazard Mitigation Advisory Team determined that there are four natural hazards the state should be most concerned about – earthquake, flood, severe storm, and wildland fire. The team made this determination considering the likelihood of occurrence of each hazard and the magnitude of the impacts of likely hazard events. The team was most concerned with hazards with the greatest impacts that occur at least once every generation (about 20–30 years).

The team discussed a qualitative risk assessment to rank the hazards, based on a model developed by the British Columbia Provincial Emergency Preparedness program in Canada.

In ranking the hazards, the team examined seven consequences of hazard events – deaths and injuries, impact to critical facilities and lifelines, property damage, environmental, and economic and societal impacts – and the likelihood of occurrence of hazard events. Each consequence was ranked from very low (generating a score of 1) to very high (generating a score of 4). The likelihood of occurrence was ranked based on intervals ranging from 200-300 years (generating a score of 1) to 1-3 years (generating a score of 6). Table 1, on page 7, contains the scoring criteria.

The hazards with the highest total scores were considered the hazards of greatest concern for the state. Table 2, on page 8, shows the ranking of the nine natural hazards, with the priority hazards scoring highest and appearing in the shaded rows.

Table 1. Qualitative Risk Assessment Criteria

	Very Low	Low	High	Very High		
Deaths	0-4	4-10	10-50	50+		
Injuries	0-4	4-50	50-2,000	2,000+		
Critical Facilities	Temporary Relocation	Closed Few Days	Loss of 50% Capacity	Long-Term Disruption		
Lifelines	Temporary Interruption	Few Day Interruption	Week-Long Interruption	Long-Term Interruption		
Property Damage	Minimal	Localized	Localized, Severe	Widespread, Severe		
Environ. Impact	Minimal	Localized	Localized, Severe	Widespread, Severe		
Econ/Social Impact	Temporary	Temporary, Widespread	Extended, Widespread	Long-Term Disruption		
Likelihood of Occurrence	200-300 Years	100-200 Years	30-100 Years	10-30 years	3-10 Years	1-3 Years
Score	**1**	**2**	**3**	**4**	**5**	**6**

Table 2. Natural Hazards Qualitative Risk Assessment

	Deaths	Injuries	Critical Facility	Lifelines	Property Damage	Environmental Impact	Economic Impact	Likely	Total
Earthquake	3	3	3	4	4	3	4	3	**27**
Flood	2	2	2	2	3	3	2	5	**21**
Severe Storm	2	2	2	2	3	2	2	6	**20**
Wildland Fire	1	2	2	2	3	2	2	6	**20**
Tsunami	4	3	2	2	3	2	2	1	**19**
Volcano	3	3	2	2	3	2	3	1	**19**
Landslide	1	1	2	2	2	2	2	4	**16**
Avalanche	1	2	1	1	1	1	1	6	**14**
Drought	1	1	1	1	1	1	2	5	**13**

Legend

	Priority Hazard
	Secondary Hazard

Regional Profiles

To understand the vulnerability of local jurisdictions to various hazards, profiles of the socioeconomic characteristics for nine geographic regions of the state were developed. The Washington Department of Health originally developed the regional structure in 2002 for bio-terrorism planning; it has been adopted by the State Emergency Management Division for homeland security planning purposes. The regional structure organized the 39 counties of the state as follows:

Region 1
Island
San Juan
Skagit
Snohomish
Whatcom

Region 2
Clallam
Jefferson
Kitsap

Region 3
Grays Harbor
Lewis
Mason
Pacific
Thurston

Region 4
Clark
Cowlitz
Skamania
Wahkiakum

Region 5
Pierce

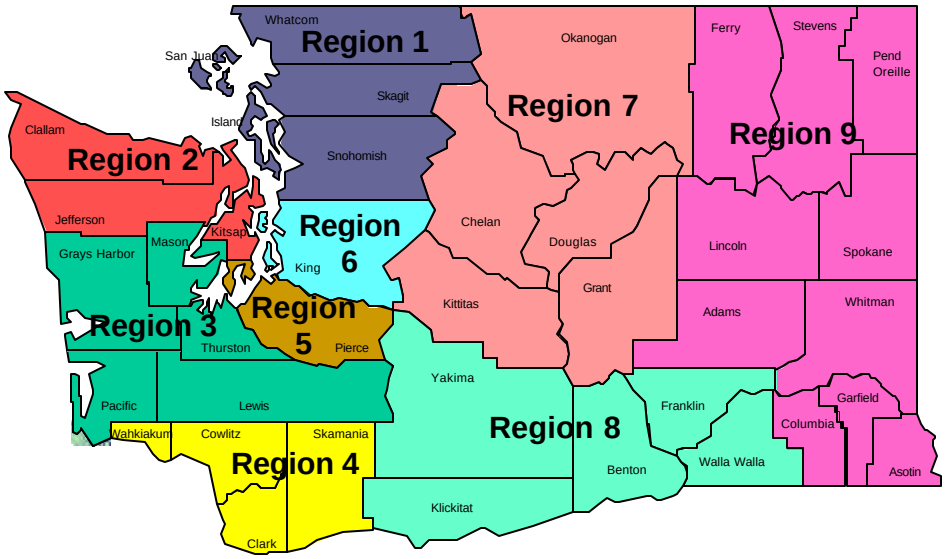
Region 6
King

Region 7
Chelan
Douglas
Grant
Kittitas
Okanogan

Region 8
Benton
Franklin
Klickitat
Walla Walla
Yakima

Region 9
Adams
Asotin
Columbia
Ferry
Garfield
Lincoln
Pend Oreille
Spokane
Stevens
Whitman

Planning Regions



Risk Assessment

The Regional Profiles used information from the Washington Office of Financial Management's Forecasting Division, the Washington Department of Employment Security's Labor Market and Economic Analysis Branch, the Washington Department of Transportation, and the U.S. Census Bureau's 2000 Census. Specific source documents used in the development of each Regional Profile are referenced in each profile.

Each Regional Profile is divided into two distinct sections: the first provides a description of the region and its counties, and the second provides a synopsis of each natural hazard and how it impacts the region, and the state facilities identified as being at risk in that region.

Description of the region: This section provides details on the geographic setting and economy of the region and each county, as well as a synopsis of a number of characteristics of potentially at-risk populations that live there, including:

- Population of urban and rural areas.
- Population of ethnic groups.
- Primary language spoken, if other than English.
- Population of non-institutionalized disabled people.
- Population of senior citizens.
- Population of people living in poverty.
- Population of school-age children, kindergarten through 12th grade.

Information on the mix of housing between single-family homes and other housing types, the age of housing, median household income, and commuting patterns of the region's workers is provided.

Regional hazard descriptions: The one-page synopsis of each natural hazard provides information on the characteristics of that hazard, identifies sources of the hazard or vulnerable areas the within the region, provides history of hazard events in the region, if known, and describes probability of future events in that region, if known.

Information in each hazard description came from the Hazard Profiles and the documents used to develop those profiles as listed at the end of each profile. If other sources were used to develop a regional hazard description, they are listed at the end of the appropriate Regional Profile.

At-risk state facilities: The one-page synopsis of state facilities was developed by analyzing information provided by state agencies that are participating partners in this plan.

State Facility Information

The Washington Office of Financial Management maintains and annually updates an inventory of state owned or leased buildings used for official state business. The inventory identifies more than 11,500 structures ranging from comfort stations (i.e., bathrooms) at state parks to the Legislative Building (the state's Capitol building). This inventory became the database used to identify facilities potentially at risk for the Risk Assessment of this plan.

A multi-step process determined which facilities are potentially at risk to one or more of the natural hazards that affect the state. It started in the fall of 2002, when the State Emergency Management Division asked state agencies to review and confirm the inventory of buildings they owned or occupied. Next, division staff updated the building inventory and restructured the database to meet the needs of this plan and the agency annexes that are part of this plan.

Each agency participating in development of this plan was then sent a new facility database and asked to provide additional information needed for the Risk Assessment of the state plan and for their agency annexes. Agencies were asked to provide information on each building, including:

- Whether the building was owned by the agency or the state, or whether it was leased.
- Whether the building is potentially of historic significance.
- The size of the building.
- The numbers of people that work, visit and/or live in the building. Agencies were asked to estimate the number based on the peak use of the facility, regardless of the time of day; most agencies used maximum building capacity.
- The estimated replacement cost of the structure, if owned or the responsibility of the agency.
- The estimated cost of the contents.
- The hazards to which the building is potentially at risk.

State agencies used a planning guide developed by the Mitigation Section of the State Emergency Management Division to determine the hazards to which their buildings might be at risk. This planning guide requested state agencies to use the following tools and methodologies to make a preliminary determination on whether their facilities are in identified hazard areas; these were used, unless otherwise noted in agency annexes, see Tab 11. In all cases, agencies were asked to identify buildings that have been damaged by hazards in the past.

- Avalanche – Agencies identified buildings along mountain highways and passes prone to avalanche; a list of specific highways and passes in the state was provided. (Note: Most avalanches that damage property in Washington occur in the backcountry, where state facilities are rare.)

- Drought – Agencies identified buildings in counties with a medium or high risk of drought. (Note: Most damage caused by drought is economic, financial and environmental rather than physical.)

- Earthquake – Agencies identified buildings in listed high hazard counties; these counties were identified based on an October 2002 peak horizontal ground shaking map developed by the U.S. Geological Survey for a 1,000 year earthquake [Peak Acceleration (% gravity) with 2 percent Probability of Exceedance in 50 years]. Additionally, agencies determined whether the buildings they owned met current seismic code or needed an assessment by a structural engineer.

- Flood – Agencies used the Geographical Information System-based website HazardMaps.Gov to determine if their buildings were in the 100-year or 500-year floodplain. They also used a list of high-risk communities and counties, based on previous flood disasters, in their assessment.

- Landslide – Agencies identified buildings in listed high-risk counties and used HazardMaps.Gov to determine whether buildings were in areas susceptible to landslide. Agencies consulted Coastal Zone Atlas maps available online through the Washington Department of Ecology for Pacific Coast, Strait of Juan de Fuca and Puget Sound shorelines, and the online landslide map for the City of Seattle available through the city's website.

- Severe Storm – Agencies identified buildings in listed at-risk counties as well as those buildings previously damaged in severe storm events, and to use high wind information available through the HazardMaps.Gov website.

- Tsunami – Agencies identified buildings on or near at-risk shorelines of the Pacific Coast, Strait of Juan de Fuca or Puget Sound, and then used HazardMaps.Gov to determine if their buildings are in areas subject to previous tsunamis (1788-2001).

- Volcano – Agencies used hazard zone maps available through the U.S. Geological Survey's Cascades Volcano Observatory to determine if their buildings are in lahar or ash fall zones for any of the state's five volcanoes. Additionally, the agencies used a list of communities built on previous lahar deposits in their analysis.

- Wildland fire – Agencies determined whether their buildings are in any of the 181 communities in the state designated by the State Forester as being at high risk to an urban interface wildland fire.

Then, State Emergency Management Division staff built tables to display a synopsis of at-risk facilities by region and by hazard. These tables have information on the number of at-risk facilities and their uses, the number of people in those facilities, their replacement cost, if owned, and the replacement cost of their contents. A second part of the table provided similar information for buildings identified as critical facilities. Additionally, the tables include narratives that provide a general description of potentially at-risk facilities. These tables were placed into the Hazard Profiles and the Regional Profiles.

Notes about state facilities:

- Most state facilities used for general office purposes are leased from private property owners. In general, facilities owned by the state include the Capitol Campus in Olympia, buildings on college and university campuses, buildings on health care or residential campuses, such as Western State Hospital or the State School for the Deaf, and facilities of the communications network of the Washington State Patrol (this is not an exhaustive list, but a representative sample). Data on at-risk state facilities does not include a dollar value for buildings the state leases and therefore is not responsible; however, the dollar value of contents of those buildings is included in the data presented.

- GIS databases and maps were not used to determine which state facilities are at-risk to various hazards because databases and maps are lacking for many of the nine hazards, or this information is currently being compiled; it is anticipated that GIS will be used extensively in the development of the Risk Assessment for the 2007 edition of this plan.

A note about transportation facilities: The Washington Department of Transportation is not participating formally in the development of this plan. Therefore, only information on routes considered as essential corridors or of statewide significance to the state's economy is provided within each Regional Profile. An analysis of state transportation routes and facilities potentially at risk to various natural hazards is not available nor is it part of the plan at this time. It is hoped the transportation department will participate more fully in the 2007 edition of the plan.