Island County

Multi-Jurisdiction Hazard Mitigation Plan

Appendix B

HAZARD IDENTIFICATION AND VULNERABILITY ASSESSMENT

Foreword

The 2006 version of the ***Island County Hazard Identification and Vulnerability Assessment*** (HIVA) assesses only natural hazards in Island County and its surroundings. Technological hazards will be considered in a future document. Assessment is the initial step in the emergency management process that leads to mitigation of risk or impact, 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 county.

Hazard assessment helps emergency managers, jurisdictional leaders, businesses, and first responders determine vulnerability, rate the risk, and predict the adverse impact of disasters and emergencies. Emergency managers and others with good hazard assessments can effectively organize resources and develop comprehensive emergency management plans, resource requirements, and mitigation programs to reduce the impact of disasters and emergencies.

Acknowledgement

The Island County HIVA is built directly on the material and research of the Washington State HIVA. The format of the Island County HIVA also follows that of the state HIVA for ease of research and comparison. The HIVA contains information from federal, state, county, and local jurisdictions as well as from other published public sources. The Island County Department of Emergency Management is responsible for this document.

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ISLAND COUNTY
NATURAL HAZARD IDENTIFICATION AND VULNERABILITY ASSESSMENT

Purpose

This HIVA describes natural hazards, which can potentially impact the citizens, economy, environment, and property of Island County. It serves as a basis for county-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

Island County has experienced or could experience impacts from natural hazards including floods, storms, wildland fires, earthquakes, and volcanoes. Beyond natural hazards, the county faces technological hazards including urban fires, terrorism, and hazardous material spills. This HIVA only considers the nine natural hazards. All of these require assessment and further analysis by county and city officials in order to organize resources so impact and loss can be prevented or minimized.

From 1956 to 2006, Washington State qualified for 37 Presidential Major Disaster Declarations. County was identified in at least eight of these. These include the May 1980 eruption of Mount St. Helens, November 1990 flood, December 1990 Flood, November-December 1995 floods, the February 2001 earthquake, the June through October 2003 drought and floods, and the February 4, 2006 severe storm and tidal flooding. In addition to the Presidential Major Disaster Declarations, other events occur that result in severe localized impacts to the county, its towns, businesses, and environment.

Scope

This HIVA is applicable to all cities, towns, and unincorporated areas in the county. State law requires all political subdivisions to be part of an emergency management organization and 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 *Island County Comprehensive Emergency Management Plan (CEMP).*

The HIVA addresses natural hazards that are not present in all areas of the county but still require assessment and evaluation by the county. Examples are floods and tsunamis that are limited to specific geographical locations. On the other hand, a political subdivision may have a local hazard that the county has not assessed in this document. Unique or local hazards should be considered in the development of written local hazard assessments.

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 militate against, and recover from flooding. Mitigation may include building of dikes 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.

The scope of this document is to identify the county's hazards and then describe them in terms of definition, history, identification, assessment, and conclusion. As a minimum, incorporated political subdivisions need a HIVA or similar study product. Additional detailed hazard analysis may be required for specific hazards identified by local jurisdictions.

Political Subdivisions

Island County has only three incorporated towns all on Whidbey Island: Coupeville, Langley, and Oak Harbor. The county also has numerous special tax districts such as the hospital district, fire protection districts, dike and drainage districts, and others.

Geography and Transportation

Island County is one of the 39 counties of Washington State. The county seat is at Coupeville on Whidbey Island. The county consists of approximately 212 square miles on 8 islands in Puget Sound. These include: Baby, Ben Ure, Camano, Deception, Smith, and Whidbey Islands. The State Legislature recently recognized two other islands, Minor and Kalamut as being part of Island County. At low tide, Minor Island appears as an extension of Smith Island and Kalamut is actually a submerged sandbar just east of Maylor Point in Crescent Harbor, Whidbey Island. Island County ranks 38th in size among Washington counties with San Juan being the only county smaller in area. Whidbey and Camano Islands make up the majority of the land area. Ben Ure has only 19 residential lots; the other islands are uninhabited. Both Whidbey and Camano have flat to rolling terrain of mixed forest and farmland. There are several areas of significant flood plain that lie at sea level. High unstable banks and bluffs mark other coastal areas of both islands. Except in the vicinity of towns, other small residential areas, and along the few major roads, a large portion of Island County is agricultural land or second and third growth timber and brush. While there are no rivers in Island County, there are several small streams. On the south end of Whidbey Island there is Glendale and Maxwelton Creeks. On Camano Island are Kristofferson, Carp, and Cavalero Creeks. The flow rates of these streams range from 1 to 2 cubic feet per second (CFS) in the winter to fractional CFS in the summer. Whidbey and Camano Islands do have several small pothole lakes. The counties contiguous to Island County are Skagit County to the north and east and Snohomish County to the south and east. Jefferson County lies across the waters of Admiralty Inlet and Admiralty Bay on the west.

Whidbey Island is approximately 50 highway miles long with an irregular coastline. Camano Island is approximately 17 road miles long also with an extensive shoreline. Whidbey and Camano Islands lie adjacent to each other separated by the Saratoga Passage of Puget Sound.

The only major north-south road on Whidbey Island is State Highway 20. Highway 20 is a two-lane highway that connects Whidbey Island to Fidalgo Island and the mainland by bridge on the north at Deception Pass. Highway 20 ends on the island's west coast at the Washington State Ferry (WSF) terminal at Keystone near Fort Casey. This route connects to Port Townsend on the Olympic Peninsula. State Route 525 continues south to the WSF terminal at Clinton. This route connects Whidbey to the mainland at Mukilteo. Camano Island has one two-lane road, State Route 532 connecting its northeast coast by bridge to the mainland in the vicinity of Stanwood. There is no other bridge or ferry access to the Camano. Oak Harbor on Whidbey Island has commuter airline access to Seattle and other Puget Sound destinations by means of a commercial floatplane service. There 5 airfields on Whidbey Island including 2 military (Navy) and 3 private or commercial. Four of the airfields are on Whidbey Island and one is on northern Camano Island. The following table provides the name, identifier, category, and runway length. All are paved.

Table One
Island County Airfields

Name	Identifier	Category	Runway Length in Feet
Stanwood (Camano Island)	13W	4	1,750
Oak Harbor Air Park	76S	3	3,255
Whidbey Island NAS	NUW	1	8,000
OLF Coupeville		1	5400
Langley (Whidbey (Air Park)	WA31	3	2400

Data from USDA, Forest Service Airfield/Airstrip Directory, 1 May 2000

Climatology

Western Washington has a milder climate than any other region in the United States that is located as far north. Moist winds from the Pacific Ocean bring large amounts of precipitation to Western Washington. Island County at the east end of the Strait of Juan De Fuca is exposed to the marine air that blows through the strait and but is still in the rain shadow of the Olympic Peninsula. The surrounding waters have a moderating effect on temperatures in both summer and winter. Snow, while not rare, does not normally accumulate or remain on the ground long if it does. Prevailing wind direction varies with the season. Late autumn, winter, and early spring winds are generally southeasterly. The prevailing winds at Ault Field (NASWI) from October through March are southeasterly at 10 to 12 knots. Frontal winds from that direction can be strong, often reaching gale force (34-47 knots) and stronger gusts do occur.

Table Two Whidbey Island Climate					
Month	**Average High**	**Average Low**	**Warmest on Record**	**Coldest on Record**	**Average Precipitation**
JANUARY	45	35	65	-1	2.3
FEBRUARY	49	36	70	6	1.7
MARCH	51	38	72	16	1.6
APRIL	55	41	78	28	1.5
MAY	60	46	82	32	1.2
JUNE	63	50	93	37	1.2
JULY	66	52	86	41	.7
AUGUST	67	52	88	39	.9
SEPTEMBER	64	49	88	29	1.2
OCTOBER	57	44	75	22	1.8
NOVEMBER	50	39	69	9	2.7
DECEMBER	46	36	62	3	2.6

Data is from Whidbey Island Naval Air Station

Economy

Government employment makes up the largest part of the economy including Federal, state, county, city, and, public schools. Retired person's make-up a growing portion of the population, as do commuters who work in Skagit, Whatcom, Snohomish, and King Counties. A commercial muscle farming operation in Penn Cove has become a significant economic factor in the Coupeville area as has a growing boat building business at Freeland.

Demographics

Table Three Population - April 1, 1990 to April 1, 2000						
COUNTY	**1990**	**2000**	**Change**	**Percent Change**	**Natural Increase**	**Net Migration**
Island	60,195	74,200	14,005	23.27	5,219	8,786

Office of Financial Management, Forecasting Division

Island County Averages 343.3 persons per square mile
Island County's cultural base is 92% white, 4 % Filipino/Asian, 2% African American, 1% Native, and 1% other. Populations for Island County Towns and Areas follow:

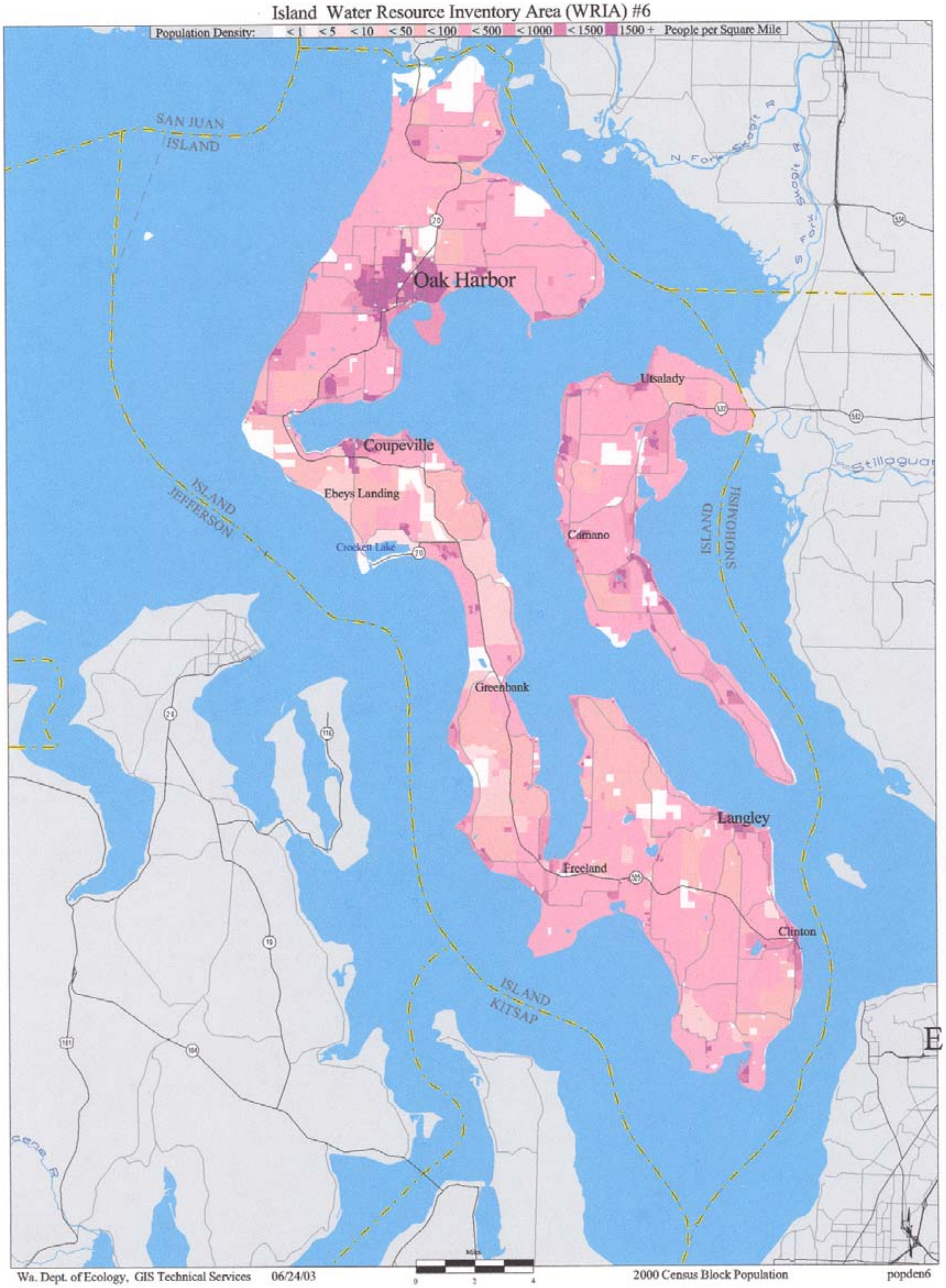
Whidbey Island	59,195
Camano Island	17,000
Oak Harbor	22,290
Coupeville	1,785
Langley	1055

Freeland (unincorporated)	615
Unincorporated	50,520

Housing Units, Single Family (% of total)	77.3
Housing units, multi-unit structures (%)	11.5
Housing units, mobile home (%)	10.9
Per capita income in 2000	$21,472

Since 1970, the county has grown faster than the state as a whole and is ranked as the fifth most densely populated county with approximately 343 persons per square mile.

The above data was taken from several sources including the Washington State HIVA Risk Assessment, Island County Economic Development Council, Washington State Office of Trade and Economic Development.



Island County Population Density Map

AVALANCHE

Definition

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

History

While traces of snow may fall in Island County, recorded accumulations have not reached a point that would result in an avalanche. Washington State does not consider any area in Island County at risk from avalanche.

Hazard Identification and Vulnerability Assessment

Island County is not vulnerable nor at risk from avalanche.

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

Island County has with the surrounding region been repeated affected by drought and near drought conditions. As discussed in the earlier Climatology Section, Island County is historically drier than much many of the counties to the east. When rainfall levels decrease, mild conditions quickly move toward drought. The county's lack of rivers, streams, and large lakes or reservoirs means that wells and the aquifers that supply them are impacted when rainfall does not replenish ground water. Finally, the island nature of the county also means that wells are subject to saltwater intrusion when aquifers are depleted.

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 Four for a list of drought occurrences in Washington State. Not on the chart was the summer of 2001 when the Governor declared a statewide Stage 2 drought in response to the worst dry spell since records began in 1929. Island County received only 66 percent of its normal precipitation and there were sporadic problems with saltwater intrusion into wells. Finally, in 2003 the state and the county were again in another drought when the county went for over 60 days without substantial rain. The office of the State Climatologist stated that this was the driest summer since records have been kept. As this analysis is being written, Island County was included in Presidential Disaster Declaration Number 1499 for summer of 2003 due to failure of several crops in the county and Western Washington

Drought is officially measured with a number of scales including the Palmer Drought Severity Index (PDSI) and the Keetch-Byram Drought Index (KDBI). The PDSC is more closely related to the economic effects of drought including agriculture while the KBDI was originally developed for wildfire potential assessment. During the summer of 2003, the U.S. Drought Monitor, sponsored by NOAA, listed Western Washington KDBI as in D2 or severe drought. The NOAA Palmer rating (PDSI) listed Western Washington as in –3.0 to –3.9 or severe drought.

Hazard Identification and Vulnerability Assessment

Nearly all areas of the state, including Island County are vulnerable to drought.
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 decreased Cascade hydroelectric generating capacity and raised electricity prices impacting Island County. There is also increased danger of wildland and interface fires.

Most areas of the county except Oak Harbor and NASWI depend on well water. Oak Harbor and NASWI obtain some 92% of their water by pipeline from the Anacortes water system that in turn gets it by pipeline from the Skagit River. Drought conditions increase pressure on aquifers and increased pumping can result in saltwater intrusion into fresh water aquifers and reductions in, or restrictions on economic growth and development.

History suggests a high probability of drought occurrence and reoccurrence with a probability of moderate drought conditions being present 5 to 10% of the time. Although the entire population of the county is vulnerable to the effects of drought, severity has historically been low, being more inconvenient than threatening. Locally, actual drought conditions have been limited to a few weeks or months even during extended dry periods.

Conclusion

Island County will remain vulnerable to the effects of a regional drought. The risk of a drought occurring is high while the impact to the county economy is probably limited.

As a result of past droughts, agriculture uses new techniques. Federal, state and local governments play an active role in developing new water projects and soil conservation programs. Active measures by community development and planning agencies can prevent or limit the impacts on existing well systems and prevent over commitment of existing fresh water aquifers. Better forest fire protection techniques decrease total acreage burned. Progress is being made in dealing with the impact of droughts through proper management of water resources.

RCW 43.83B.400-430 and Chapter 173-166 WAC pertain to drought relief.

Resources

Washington State Emergency Management Division, HIVA Risk Assessment
Washington State Department of Natural Resources
Office of the Washington State Climatologist
National Weather Service

Table Four
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.
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.
June-September 2003	Federal disaster number 1499 assigned to 15 counties including Island. The original disaster was for flooding but Island and several others were included because of previous drought conditions.

Data extracted from Washington State HIVA

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, only 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 Five for list of significant Earthquakes in Washington State.

Hazard Identification and Vulnerability Assessment

Washington is vulnerable to earthquakes originating from three sources: the subducting slab, 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.

In the northern Puget Sound region, seismic hazards are found on the Derrington–Devil's Mountain, Strawberry Point, Southern Whidbey, or Utsalady Point faults. These faults are considered as part of the North American (continental) plate). Evidence suggests that the Devil's Mountain fault and the Southern Whidbey Island Fault are capable of generating a quake of magnitude 7 or greater. The smaller Utsalady Point and Strawberry Point faults are capable of a quake of magnitude 6.7 or greater. Deep zone or Benioff zone quakes occur within the San De Fuca plate (1949, 1965, and 2001) and can be expected in the future.

Island County contains at least two faults, the North Whidbey Island Fault and the more significant South Whidbey. Smaller faults such as the Devil's Mountain, Utsalady Point, and Strawberry Point faults are thought to be parts of the North Whidbey fault. In addition to these there are several other suspected faults that may cross south Whidbey Island from south to north. Various sources and diagram indicate that parts of the North Whidbey fault probably run through a portion of Oak Harbor. One fault scarp is visible on NAS Ault Field at the Rocky Point area. Langley also sits very close to the plotted location of the South Whidbey Fault. Several neighborhoods on south Whidbey Island Clinton, Useless Bay, and Freeland are on or close to the South Whidbey Fault as it cuts the Island from the southeast to the northwest. Geologists have not determined likely earthquake occurrence intervals for these faults.

Earthquakes cause damage by strong ground shaking and by the secondary effects of ground failures, tsunamis, and sieches. 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 affect structures above or below them. Earthquakes can cause large and disastrous slides. 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 gravel 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. Numerous areas of Whidbey and Camano Islands are susceptible to liquefaction. These areas are primarily in low-lying marine or formerly tidal areas and filled areas. There are also extensive peat deposits on Whidbey and Camano Islands. Peat does not "liquefy" like fill soil or mud, but earthquake shaking and vibration can cause it to fail and slump away from piling, supports, and foundations. Examples of these types of land on Whidbey Island are: Dugualla Bay, Maple Valley, the Oak Harbor and Crescent Harbor shorelines and lowlands and the area roughly from Langley south across the island to Useless Bay. On Camano Island, these types of soils occur in the areas of West Pass and Livingston Bay, the west coast in the vicinity of Camano Cove, and the area south of the line of Wagner-Elger Bay Road. This is not meant to be a definitive or complete list but it does show the widespread potential for liquefaction and soil failure given a suitable earthquake.

Tsunamis are long-period waves that result from the water column being displaced by seafloor uplifting or subsiding or by landslides, submarine slides, or sometimes volcanic explosions in the water. Sieches 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. Historically, Washington has had minor damage from sieches. Tsunami deposits exist around Puget Sound and appear to be related to the Seattle Fault and the Cascadia Subduction Zone events. Low-lying parts of Island County are at risk from locally generated sieches and tsunamis. The west coast of Whidbey Island is also at some risk from tsunamis generated by more distant earthquakes given its exposure to the Straits of Juan De Fuca.

Conclusion

All of Island County, like all of western Washington, is vulnerable to damage and injuries from a large earthquake. The risk of an earthquake occurring and impacting Island County is high. Oak Harbor and Langley are both very close to known faults. 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. Due to its location and proximity to Seattle, Island County is likely to closely share Seattle's probability of a major quake and the resultant level of damage. Only Island County's more rural economy and lack of large buildings (more than two stories) and large population concentrations would militate against catastrophic damage.

The functionality of our critical facilities and lifelines such as hospitals, fire stations, schools, power, communications, transportation, and fuel delivery systems will be even more 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.

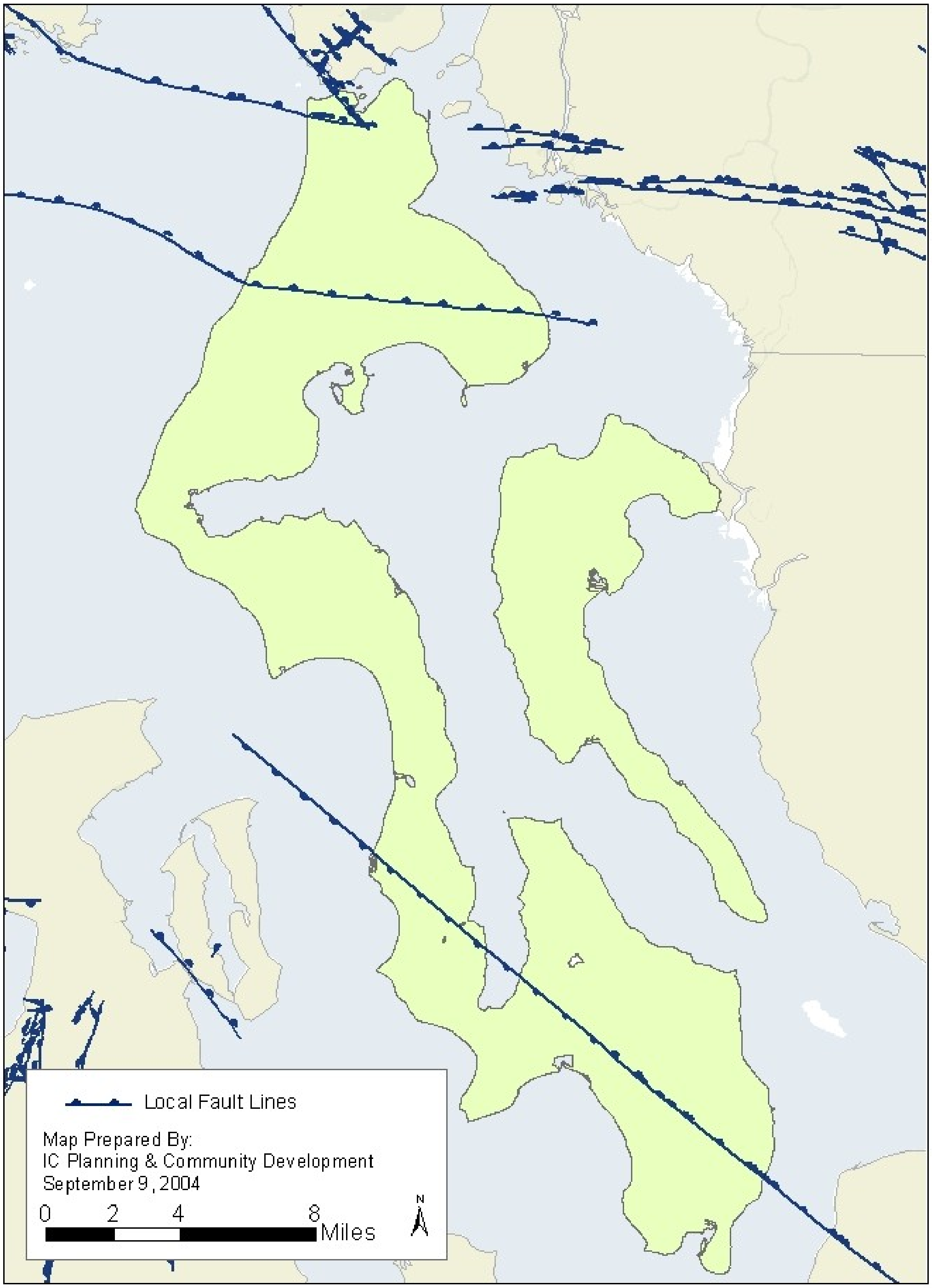
Resources

Washington State Emergency Management Division, HIVA and Hazard Mitigation Plan
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 Five 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
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

Data extracted from Washington State HIVA

**MAJOR EARTHQUAKE FAULTS
CROSSING ISLAND COUNTY**



FLOOD

Definition

A flood is an inundation of dry land with water.

History

From 1956 to 2006 there have been 29 Presidential Major Disaster Declarations in Washington State. Since 1971, every Washington State county has received a Presidential Disaster Declaration for flooding. See Table Six for list of floods in Washington State.

The SHELDUS (Spatial Hazard Events and Loss Database for the United States) database compiled and maintained by the Hazards Research Lab at the University of South Carolina is a county level dataset that lists a number of different hazard events where the total damage was over $50,000. In the period 1960 to 2002, the database lists 24 events for Island County. Of these flooding accounted for 5. While flooding made up only 21 percent of the listed events, the damage costs from flooding accounted for the majority of the property damage reported.

Hazard Identification and Vulnerability Assessment

Flooding is a natural feature of the climate, topography, and hydrology of western Washington State. Flooding in Island County results primarily from the rapid accumulation of runoff surface water and extremely high tides. Other possible causes of flooding in Island County include tsunamis, sieches, ponding, shoreline erosion, and the structural failure of dikes.

While there are a number of possible causes for floods in the county, the reality is that FEMA has rated the likelihood of flooding in most of the county as very small. The map at the end of this discussion shows in orange those areas where FEMA gives a 1% annual chance of flood (100 year flood). In almost all cases the cause of the flooding would be storm surge from Puget Sound driven by high winds. The areas indicated are those one would expect to have a greater chance of flood, i.e. those settled beach areas, dike and drainage district areas, and saltwater marshes. The reminder of the county falls into an area that FEMA rates as having a .2% chance of annual flooding (500 year flood). Flooding from rainfall and runoff ponding has occurred in limited areas in the past during exceptional rainstorms.

While flood likelihood is low in most areas, flood planning must still be a land use planning criteria. Two planning concerns are sudden onset of strong rain and drainage capacity in relation to topography and structures. Other factors contributing to flood damage are water velocity, water borne debris, duration of flood conditions, and ability of soil to absorb water. Flood danger is predominates during the winter and early spring due to storms with high winds, rain, and seasonally high tides.

In Western Washington 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.

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 economic 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 hazard 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. Island County has experienced continued growth that includes more residences on shorelines and tidal flood plains.

Island County has numerous beach level residential areas on both Whidbey and Camano Islands that are risk from tidal flooding. This in fact occurred as part of the severe storm that struck Island County on 4 February 2006. Currently there are four dike districts and three drainage districts in the county. They are:

District 1, Useless Bay	Drainage District 5, Livingston Bay
District 2, Langley	Drainage District 6, Admirals Cove/Lake Crockett
District 3, Dugualla Bay	Drainage District 7, Utsalady
District 4, Double Bluff	

Oak Harbor and the NASWI both have some residential and commercial property on the beach that is a risk from tidal surge. The Langley marina and the area of Sandy Hook south of Langley are exposed to tidal surge risk. 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 coastal areas of Island County are vulnerable to tidal flooding when conditions are right. The risk of a flood occurring in any one year is high while the magnitude of the flood will be restricted by the geography of the islands. 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. 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. The continued growth of Island County makes it imperative to enact and enforce strong building restrictions in likely flood areas.

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 materials, or debris that may be carried in tidal floodwaters.

The National Weather Service and National Ocean Survey have an extensive weather and tide monitoring system and provide flood and tidal flood watch and warning information to the public through a number of media sources.

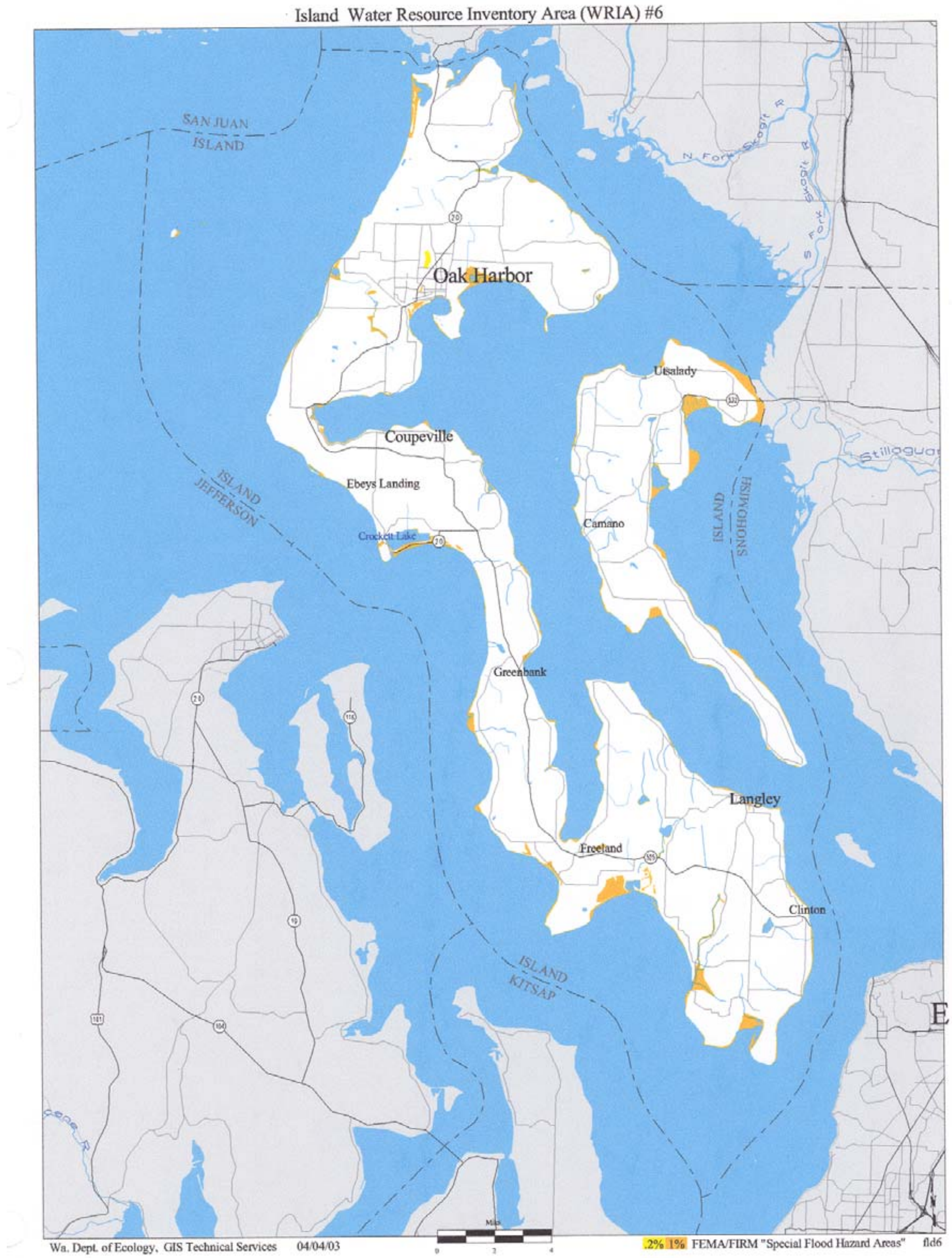
The United States Army Corps of Engineers, under PL 84-99, has the authority to assist public entities in flood fighting and rescue operations and to protect, repair, and restore federally constructed flood control works threatened, damaged, or destroyed by a flood.

Resources

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

Table Six Floods	
Date	**Occurrence**
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.
November – December 1995	Flooding and wind in the counties of Chelan, Clallam, Clark, Cowlitz, Grays Harbor, Island, Jefferson, King, Kittitas, Lewis, Mason, Pacific, Pierce, Skagit, Snohomish, Thurston, Wahkiakum, Whatcom, and Yakima. Federal Disaster Number 1079 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.
October 2003	Federal disaster number 1499 was assigned for counties of Chelan, Clallam, Grays Harbor, Island, Jefferson, KING, Kitsap, Mason, Okanogan, Pierce, San Juan, Skagit, Snohomish, Thurston, and Whatcom

Data extracted from Washington State HIVA



Island County Flood Rate Insurance Map (FIRM)

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

The county has approximately 200 miles of shoreline that includes bluffs as high as 300 feet. The map following this article shows the areas identified as having steep slopes. The erosion rates along Island County shores have been measured from as little as a fraction of an inch to more than 2 feet per year.

From November 1996 through March 1997, a series of wet winter storms delivered snow, freezing rain, and warm rain to Western Washington 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 and heavy rain brought soils to saturation. The lateral movement of ground water toward the free faces of bluffs and banks cause water pressures that trigger landslides. Mudslides were reported in several locations on Camano Island including: Cavalero County Park, Tyee Beach, Wilkes Gray Heights, Pebble Beach, Summerland Beach, and Woodland Beach. On Whidbey Island Slides were reported on Madrona Way, Harrington Road, Driftwood Beach, and Marshall Road. On the gentler plains, percolating water and the emergence of ground water from shallow aquifers caused ponding and flooding in low-lying areas.

Recent reviews of steep slope areas show continued slope movement on Whidbey Island at Driftwood Lane and onto Hidden Beach Drive. Other steep slope areas while covered with vegetation, show the bowing of tree trunks from what may be continued slope subsidence. Discussions with residents in several of these areas indicated that tree fall from these slopes are a continual problem after periods of heavy wind and rain. This presents a risk to persons, property and to access in and out of these mostly single road access areas. Finally, the Town of Coupeville, and City of Langley both share business area locations on bluffs or high banks that could slide under the right conditions. Oak Harbor has an area adjacent to the town where high bank subsidence has already claimed a portion of Scenic Heights Road (since rerouted).

Slope maps for many of the “at risk” areas of Island County are included with the profile and vulnerability data for that area.

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, interrupt transportation infrastructure, and damage utilities. Due to the growing 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.

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

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

Many coastal areas in Island County are vulnerable to landslides and subsidence. The risk of a landslide occurring in the county in any one year is high even if the size of most previous slides has been limited. 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 leave the property vulnerable to risk. 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. Engineering, design, or construction can mitigate some hazards so that risks are acceptable. When technology cannot reduce the risk to acceptable levels, building in hazardous areas should be avoided.

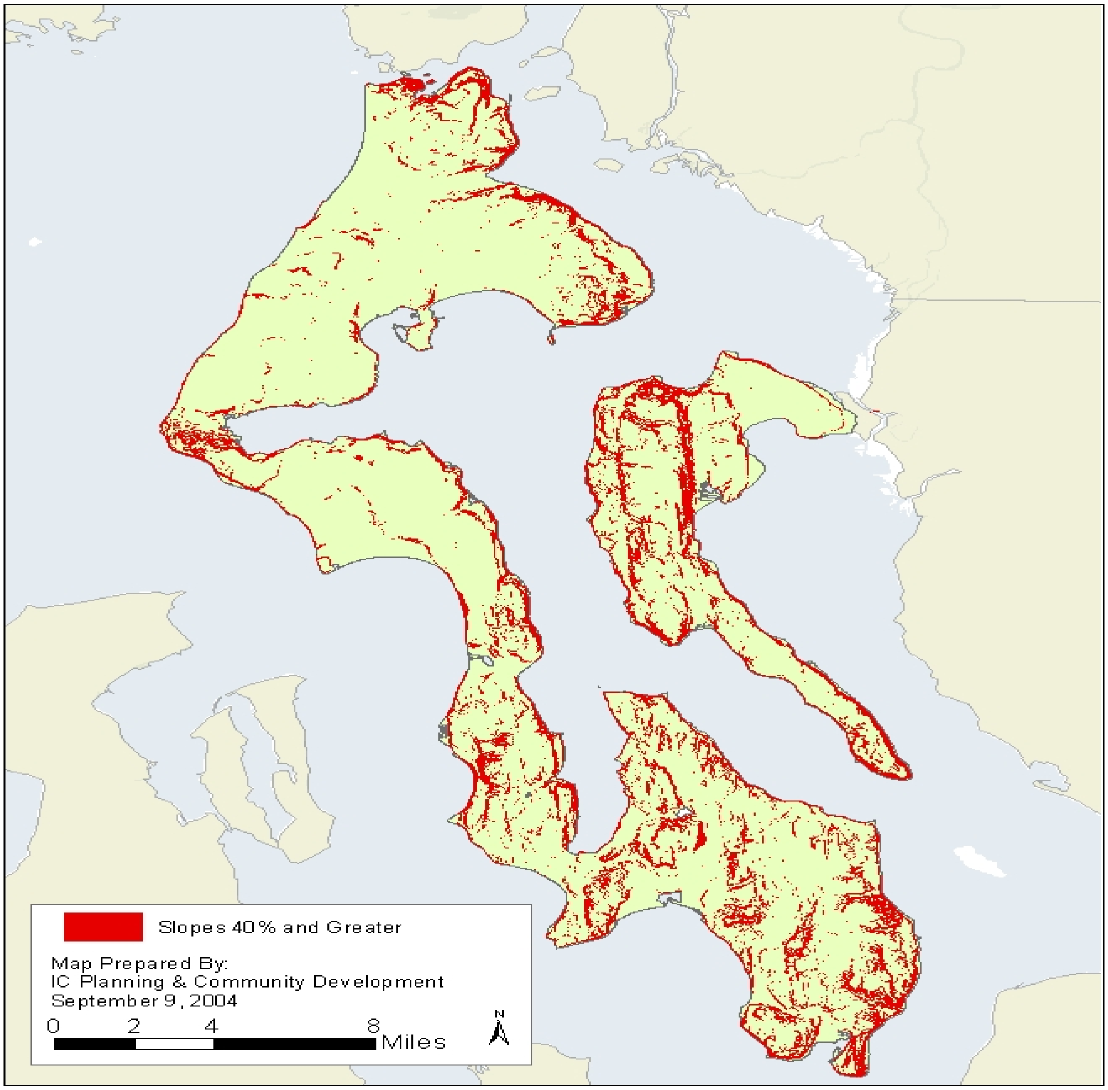
Ordinances identifying geological hazards are now in effect and information regarding steep slope hazards is available from county and city planning and building departments. Landslide losses are reduced 95-100 percent where the established ordinances are rigorously applied.

The least expensive and most effective landslide loss reduction measure is 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 Ecology, “Bluff Erosion Monitoring on Puget Sound, A guide for Volunteers,”1998
Federal Emergency Management Agency
United States Army Corps of Engineers
National Weather Service

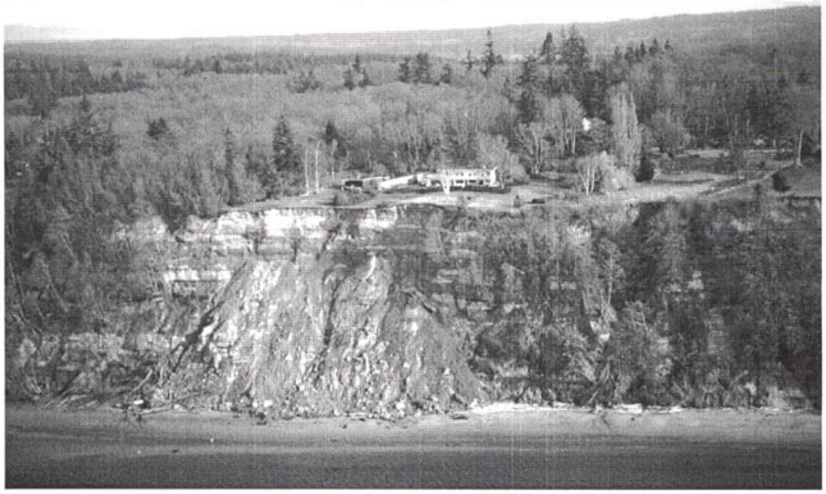
STEEP SLOPES IN ISLAND COUNTY



At Scatchet Head at the southern end of Whidbey Island, mudflows temporarily block access to these beach-level homes during wet winters. The upper bluff is porous glacial outwash sand that dries out in summer. The silt that forms the lower bluff (below dashed line) and perches ground water is damp and green year round. The top of the silt is approximately at the position of the dashed line. The scarp in the background and the partially forested bench are characteristic of such slide areas where percolating ground water is perched above the less permeable silts. The sands are weaker than the silts and slide readily when saturated. Similar situations are present north of Carkeek Park and in the Golden Gardens area of Seattle, among other places. (See Figs. 20, 21.)

FROM: "Puget Sound Bluffs: The Where, Why, and When of Landslides Following the Holiday 1996/97 Storms," Washington Geology, Vol 25, No 1, March 1997, Wndy J Gerstel, Mathew J. Brunengo, William S. Lingley Jr., Rober L. Logan, Hugh Shipman, Timothy J. Walsh.

Slide activity such as this in the Useless Bay area of Whidbey Island can cause periodic retreat of the bluff edge by as much as 20 feet or so in seconds. During this recent slide, a portion of the fence in front of the large house was lost. Such episodes commonly are preceded and followed by decades of little erosion, making estimates of average bluff retreat rates potentially meaningless. In this location there are multiple impermeable silt layers that perch water, in contrast to conditions like those at Scatchet Head (Fig. 14), where water is concentrated above one impermeable "perching" layer. Slides here can be triggered by an abundance of water (as in the December/January storms) or by wave erosion at the base of the bluff. A rainstorm may simply be the "last straw". In many locations around the sound, water from winter rains is accumulated inland of bluffs and may cause landslides to occur months later as it slowly migrates toward the bluff. In the mid-1970s in the Golden Gardens area of Seattle, slides occurred well into summer after a series of exceptionally wet winters.



FROM: "Puget Sound Bluffs: The Where, Why, and When of Landslides Following the Holiday 1996/97 Storms," Washington Geology, Vol 25, No 1, March 1997, Wndy J Gerstel, Mathew J. Brunengo, William S. Lingley Jr., Rober L. Logan, Hugh Shipman, Timothy J. Walsh.

SEVERE STORM

Definition

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

History

The SHELDUS (Spatial Hazard Events and Loss Database for the United States) database compiled and maintained by the Hazards Research Lab at the University of South Carolina is a county level dataset that lists a number of different hazard events where the total damage was over $50,000. In the period 1960 to 2002, the database lists 24 events for Island County. Of these, wind as a single factor accounted for 9 of the events and winter weather which included wind accounted for another 7, and thunderstorms which again included wind was another 3 for a total of 19 events.

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. High winds and ice contributed to the repeated and extended power outages to over 500,000 power customers during December 1996-February 1997.

The last major storm struck Island County on 4 February 2006. This combination of extreme wind (60 MPH) and seasonal extreme tides caused extensive tidal flooding, erosion and surf damage, and debris. In some areas of the county, power was out for two days.

Damage costs resulting from wind related events were generally low compared to flood damage, but as can be seen from the examples above, wind and storm effects a much wider area. The impacts of debris on roads and downed power and telephone lines can quickly overwhelm emergency services at least in the short term.

Hazard Identification and Vulnerability Assessment

All areas of Island County are vulnerable to the severe local storms. The affects are generally transportation problems and loss of utilities due to tree blow down. 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. All three towns on Whidbey Island have portions that are wooded and exposed to tree blow-damage. The majority of the critical facilities in Oak Harbor, Coupeville, and Langley are clear of direct damage from tree blow-down or flooding from ponded rainwater. However there still could be access problems due to blocked streets and roads.

Most storms move into Washington from the ocean with a southwest to northeast airflow. Windstorms with sustained winds of 50 miles per hour are powerful enough to cause significant damage and occur frequently. The National Weather Service issues a high wind warning when expected winds will average 40 miles and hour or more for at least one hour or wind gusts will be greater than 58 miles and hour - trees and power lines can be blown down. The most heavily affect areas in Island County are primarily at the edges of expanses of open water and the exposed edges of timber stands.

Conclusion

All of Island County remains vulnerable to severe rain, and high winds. Past severe storms have adversely impacted island services and the economy as well as causing large private property losses. Due to the yearly risk of severe storms, local jurisdiction emergency plans should address the 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 Seven Severe Storms		
Date	**Storm Type**	**Description**
Feb. 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.
Nov. 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.
Nov. 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.
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.
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.
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.
4 February 2006	Severe Storm	Severe storms, flooding, tidal surge, landslides, and mudslides. 11 Washington counties, including Island, FEMA number FEMA-1641-DR

Data extracted from Washington State HIVA and local records

TSUNAMI

Definition

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

History

In the early 1800's, possibly 1820 Snohomish Indian stories indicate that a large landslide at Camano Head caused a tsunami that swept across Saratoga Strait and hit Hat Island causing damage and drowning in an Indian village. (*The Fall of Camano Head…" Hugh Shipman, U of Washington Geology Dept., TsuInfo Alert, v.3, no. 6, December 2001*). During the 20th Century**,** there have been several tsunami events that have affected Puget Sound. On April 13, 1949:

> "An eleven million cubic yard landslide occurred on Point Defiance, at the Tacoma Narrows when a 400 foot high cliff gave way and slid into the water. "The water receded 20-25 feet from its normal tide line with an ominous sucking sound. Then an eight foot tidal wave rushed back against the beach smashing small boats, dock areas, a wooden boardwalk and other waterfront installations" (*Tacoma News-Tribune*, April 18, 1949, p. 1).

The Good Friday Alaskan earthquake of 1964 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.

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 tsunami 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. The west coast of Whidbey Island lies in a direct line with the ocean mouth of the Straits of Juan De Fuca making it vulnerable to any eastward moving tsunami.

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. Recent studies and projections for the west coast of Whidbey Island indicate the likely height of a locally caused tsunami would be in approximately 2 meters high or 6.5 feet. While this is not as high as might be expected, structures built at or close to sea level or on the beach will sustain significant damage. Bluff subsidence is also a real possibility.

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 scouring action. Ships moored in harbors may be swamped, sunk, or left stranded on shore. Oil and fuel tanks 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.

Coupeville, Langley, and Oak Harbor all have water front exposure and portions of their territory that are exposed to possible sieche damage. All three locations are shielded from ocean or open water (Puget Sound) tsunamis that have the potential to be much larger.

Conclusion

The west coast of Whidbey Island is vulnerable to an ocean or Puget Sound tsunami. Camano Island and the east coast of Whidbey are vulnerable to sieches. The risk or likelihood of a tsunami impacting on Island County is considered low. Some predictions indicate that a tsunami generated in Puget Sound would only produce a tsunami wave height of seven feet, impacting only the tidal portions of Island County.

Early warning, education, zoning, evacuation routes, and structural design will aid in reducing the disastrous effect of tsunamis. For tsunamis or sieches 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 or sieche. People in areas susceptible to tsunamis or sieches 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. Automobiles, RVs, and trucks can move inland.

Comprehensive educational programs are important to keep the public informed of the danger and protective measures. Paradoxically, a tsunami warning may cause people to endanger themselves by venturing to the shore out of curiosity.

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. 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. While Mount St. Helens is many miles south of Island County, the events described indicate some of the effects Island County might experience if a North Cascade volcano erupted.
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 and Mount Baker are active volcanoes. Even Glacier Peak has erupted as recently as a thousand years ago and possibly even as late as the 17th century. 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. In the future Island County can expect volcanoes to its east to erupt and generate mud and ash flows that will travel down the Skagit and other local rivers to Puget Sound with possible consequences for eastern areas of Island County. While winds over Island County are predominantly from southwest and west to east, Island County could still receive some ash from a Northern Cascade volcanic eruption. Areas downwind of a volcano eruption are vulnerable to reduced visibility, ash fall, and caustic gases. Two of the after effects of a volcanic eruption important to Island County are:

- Ash falls are harsh, acidic, gritty, smelly, and cause 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 affects river water quality and water supplies, strips and burns foliage, strips paint, corrodes machinery, and dissolves fabric. Heavy ash falls blot out light. Heavy demand for electric light and air conditioning cause a drain on power supplies. Ash clogs waterways, water system intakes, 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. All Washington State volcanoes are situated close shallow crustal fault zones.

Conclusion

Island County is vulnerable to volcanic induced hazards. The risk of a volcanic eruption in the Puget Sound area, while not zero, is considered low. Due to the relative locations of the Cascade volcanoes, Island County, and the prevailing winds, the impact on Island County from volcanic ash or other erupted material is considered to be low. However, ash and chemical products in the Skagit River would contaminate a main water supply to Oak Harbor and Whidbey Island Naval Air Station. Also of concern, would be volcanic related earthquakes or tsunamis. Volcanic eruption consequences to surrounding counties would also cause severe impacts in Island County. That is, transportation interruptions, power transmission interruptions, telecommunications outages, interruption of deliveries of essential foods, medical services, and police coverage would adversely impact Island County even if it was spared the direct damage of volcanic activity.

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.

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 mitigation. There are plans in existence for Mount St. Helens, Mount Rainier, and Mount Baker and in progress for Glacier Peak.

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 Eight Volcano Eruptions		
Volcano	*Years ago of Eruption* (Unless noted as A.D.)	**Type of Eruption**
Mount Baker	Postglacial-10,350	Sulfur Creek mudflows and tephra.
	6,000-10,350	Tephra and pyroclastic flows. Bolder Creek lava flows. Sulphur Creek mudflow and lava flow. Park Creek mudflow. Middle Fork Nooksack River mudflow.
	300-6,000	Tephra. Middle Fork Nooksack River and Park Creek mudflow.
	Within last few centuries	Bolder Creek mudflow and tephra. Rainbow Creek avalanche.
	1843 A.D.	Ash fall
	1958 A.D.	Bolder Glacier mudflow and avalanches.
	1975	Sherman Crater increased steam and gas activity.
Glacier Peak	11,000-13,000	Tephra, lahars, pyroclastic flows, and dome.
	5,100-6,600	Tephra, lahars, and pyroclastic flows.
	1,750-2,800	White Chuck dome.
	90-2,800	Tephra and ejecta.

Data extracted from Washington State HIVA

WILDLAND/INTERFACE FIRE

Definition

Wildland fires are the uncontrolled destruction of forests, brush, field crops and grasslands caused by nature or humans. Interface fires are those that move across the boundary from wildland to urban or urban to wildland.

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 firefighting training for the National Guard in the event federal, state, local and contracted fire-fighting 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.

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. Most wildland fires have human causes including cigarettes, fireworks, and outdoor burning. The effects of wildland fires vary with intensity, area, and time of year. Factors affecting the degree of risk of fire include rainfall, type of vegetation, and proximity to firefighting agencies.

Conclusion

Island County is vulnerable to wildland and interface fires. There is a yearly risk of wildland fire, but most fires that due occur are small and have little economic or safety impact to the county. However, the continued building of new residences in Island County, many of which are in forested areas with little or no separation from the surrounding forests, increases the probability of interface fire and loss of property.

All three towns on Whidbey Island have portions that are heavily wooded and remaining town portions of their boundaries are nearly all woodland interface. All are at risk from wildfire in the immediate area.

Often, structures are built with minimal awareness of the need for fire protection and surrounding vegetation clearance zones. 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 wildland/forested areas
- 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

HAZARD IMPACT ANALYSIS AND PRIORITIZATION

CRITERIA:

1. Frequency
2. Area Impacted
3. Magnitude

[All are based on a scale of from 1 (lowest) to 5 (highest)]

DEFINITION

1. FREQUENCY

1 Occurs < every 100 years.

2 Likely to occur at least every 100 years.

3 Likely to occur at least every 50 years.

4 Likely to occur every 10 years

5 Yearly

2. AREA IMPACTED

1 Point Target

2 1 – 10 Square miles

3 11- 50 Square miles

4 51 – 100 Square miles

5 > 100 Square Miles

3. MAGNITUDE

1 Slight property or infrastructure damage, no injuries.

2 Moderate property damage, one or more buildings damaged, possible infrastructure damage, but no services lost. Minor injuries, possibly one casualty.

3 Heavy property damage, several buildings damaged, one or more destroyed. Infrastructure damaged, some services temporarily disrupted for up to 24 hours in a limited area. Numerous injuries, 2-5 casualties possible.

4 Extensive property damage, several buildings destroyed. Infrastructure damaged, some services temporarily disrupted for periods over 24 –72 hours in a much wider area. Many injuries, 6-10 casualties possible.

5 Complete destruction of property in an extended area, wider spread damage to property and infrastructure. Infrastructure services disrupted for periods beyond 72 hours. Many injuries, more than 10 casualties.

4. IMPACT AND PRIORITY

(FREQUENCY + AREA IMPACTED) x MAGNITUDE = TOTAL SCORE

TOTAL SCORE + EXPERIENCE ESTABLISHES ROUGH PRIORITY FOR MITIGATION PLANNING

DEFINITIONS:

PROPERTY: Private and commercial property of all types.

INFRASTRUCTURE: Public buildings and facilities, public and private utilities and services.

HAZARD IDENTIFICATION AND RISK ASSESSMENT RANKINGS

WORKSHEET #1: HAZARD IDENTIFICATION AND RISK ASSESSMENT BY FORMULA

Hazard	**Frequency**	**Area Impacted**	**Magnitude**	*Hazard Index Score*
Avalanche	0	0	0	0
Drought	4	5	1	9
Earthquake	4	5	2	18
Flood	4	1.5	2	11
Landslide	4.5	1.5	2	12
Severe Storms	4.5	5	4	38
Tsunami	1	2	3	9
Volcano	1	5	2	12
Wildland/Interface Fire	5	1.5	2	13

WORKSHEET #1: HAZARD IDENTIFICATION AND RISK ASSESSMENT BY INTUITION				
Hazard	**Frequency**	**Area Impacted**	**Magnitude**	*Hazard Index Score*
Avalanche	0	0	0	0
Drought	4	5	2	18
Earthquake	1	5	3	18
Flood	3	2	2	12
Landslide	3	1	2	8
Severe Storms	5	5	3	30
Tsunami	1	2	2	6
Volcano	1	4	1	5
Wildland/Interface Fire	3	1	2	8

Rankings by Formula

1. **Severe Storm**
2. **Earthquake**
3. **Wildfire-Interface Fire**
4. **Volcano/Landslide**
5. **Flooding**
6. **Tsunami/Drought**
7. **Avalanche**

Intuitive Rankings

1. **Severe Storm**
2. **Drought/Earthquake**
3. **Flooding**
4. **Landslide/Interface Fire**
5. **Tsunami**
6. **Volcano**
7. **Avalanche**

ANALYSIS

The two ranking were done using the same 5 point scale with 1 being the low value.

The ranking by formula tried to specifically follow the frequency, area impact, and magnitude criteria. Scores using half points were allowed to better fit criteria to hazards. The intuitive ranking was simply an experienced based “gut feeling” as to how the criteria and the hazards fit.

The ranking above while not identical produced numerous similarities. Both lists placed Severe Storm as number 1 and included earthquake in a second position. The top five hazards on both lists included severe storm, earthquake, wildfire-interface fire, flooding, and landslide.

CONCLUSION

The hazard identification and risk assessment process produced a list of 7 prioritized hazards of the highest relative risk to the county. The risk is figure is not absolute and based on historical records, knowledge of how the various hazards may effect the county, and perception of the risk and impact. The hazards may in fact occur at any time or in almost any combination since they are all nearly independent events.