Flood

Flood

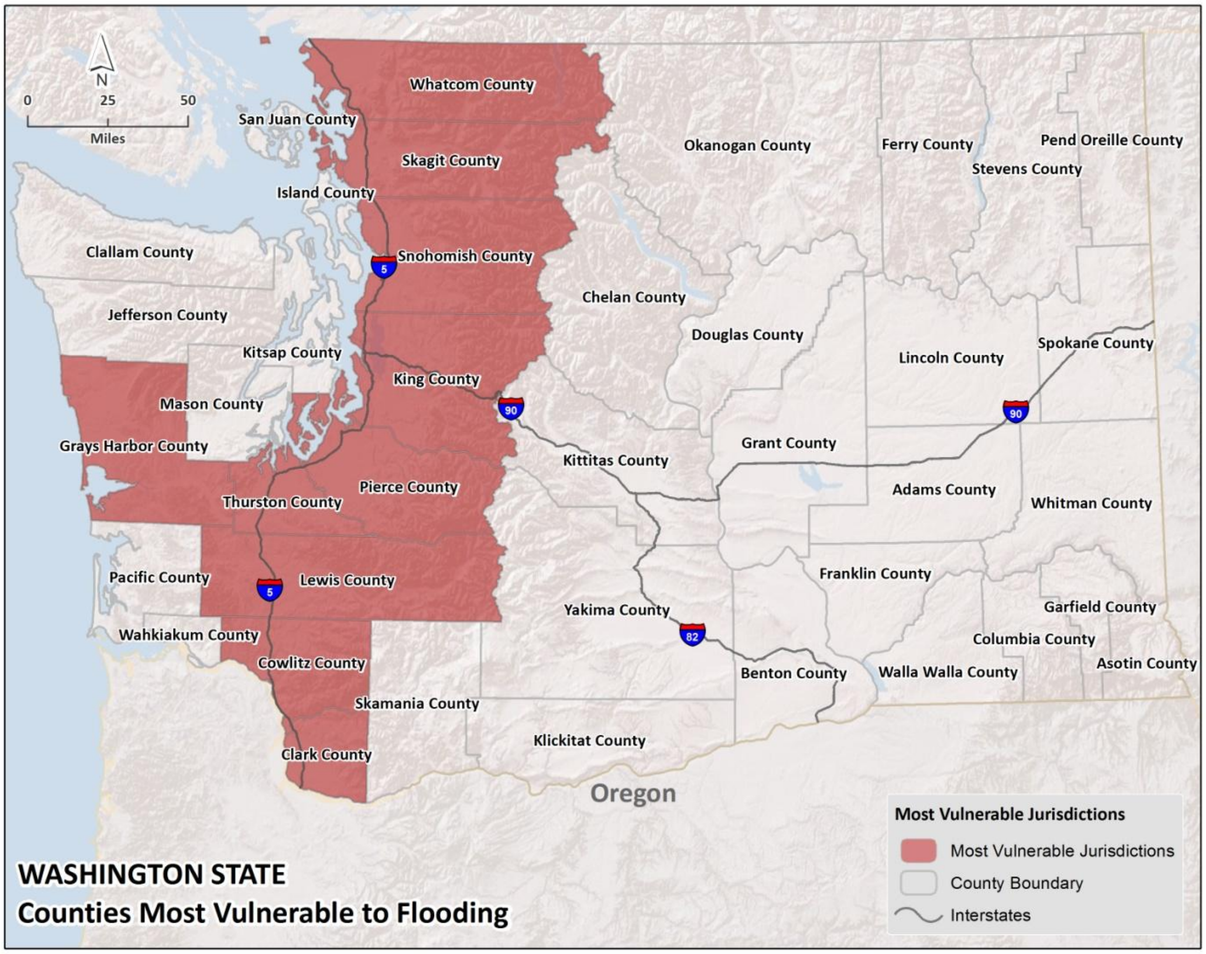
Frequency	50+ yrs	10-50 yrs	1-10 yrs	Annually
People	<1,000	1,000-10,000	10,000-50,000	50,000+
Economy	1% GDP	1-2% GDP	2-3% GDP	3%+ GDP
Environment	<10%	10-15%	15%-20%	20%+
Property	<$100M	$100M-$500M	$500M-$1B	$1B+
Hazard scale	< Low to High >			

Risk Level

- Frequency – Flooding occurs in Washington on an annual basis.
- People – Several U.S. floods have claimed lives, averaging 95 fatalities per year over a 30-year average.[1]
- Economy – During a flooding event the local economy can suffer severely, which in turn can result in an impact to the overall economy in the state of Washington.
- Environment – Although the environment can suffer irreversible damage due to a flooding event, the type of damage does not meet the threshold for this category.
- Property – Disaster assistance for the 2012 floods in Washington were over an estimated $40 million dollars. Between 2004 and 2011 (as of January 31, 2012) Washington State had received $352 million in federal disaster assistance (combined hazards).[2] With continued growth of industry and towns in and around these areas, property damage is estimated to rise with each subsequent flood.
- Overview –The State of Washington Department of Ecology created a document titled, "Washington State Watershed Risk Assessment," that provides risk ranking for each watershed in the State where FEMA Flood Insurance Rate Map data were available. The report analysis considers population density, NFIP policies and claims, and floodplain area. The Lower Skagit, Puget Sound, and Strait of Georgia watersheds ranked highest in risk. The complete document can be found in Appendix B.

Summary

- The Hazard – Flooding, the overflow of water onto normally dry land (usually a river's floodplain) due to abnormal or excessive rainfall and associated runoff, is the most prevalent natural hazard facing Washington State residents.
- Previous Occurrences – Washington State has a long history of damaging floods, including the 1948 (Vanport) flood; the November 1990 back-to-back floods (Veterans Day and Thanksgiving); and February 1996 event- the most widespread flooding in the State's history, and the January 2012 event – the flood of record on some rivers. These three floods are included in the National Weather Service's list of the Top Ten Washington State Weather Events in the 20th Century. Since 1956, Washington State has received 32 Presidential Disaster Declarations for flooding with each county in the State receiving at least one declaration during this period.
- Probability of Future Events – Based on presidential disaster declarations, the approximated recurrence interval for the state is a major flood event every two years. County level estimates ranged from 2 year to 11-year intervals.
- Jurisdictions at Greatest Risk – Western Washington is at the greatest risk for flooding, encompassing 10 counties within the Puget Sound Basin and along the Pacific Coast as shown in the figure below (also Figure 16 at the end of this document).



The Hazard[3, 4]

The National Flood Insurance Program defines flood as, "A general and temporary condition of partial or complete inundation of two or more acres of normally dry land area or of two or more properties (at least one of which is the policyholder's property) from:

- Overflow of inland or tidal waters; or
- Unusual and rapid accumulation or runoff of surface waters from any source; or
- Mudflow (liquid and flowing mud moving across surface); or
- Collapse or subsidence of land along the shore of a lake or similar body of water as a result of erosion or undermining caused by waves or currents of water exceeding anticipated cyclical levels that result in a flood as defined above."

Floods cause loss of life and damage to structures, crops, land, flood control structures, transportation infrastructure (roads and bridges) and utilities. Floods also cause erosion and landslides (including mudslides or mudflows), and can transport debris and toxic products that cause secondary damage. Flood damage in Washington State exceeds damage by all other natural hazards.

There have been 32 Presidential Major Disaster Declarations for floods in Washington State from 1956 through July 2012. Every county has received a Presidential Disaster Declaration for flooding. While not every flood creates enough damage to merit a declaration, most are severe enough to warrant intervention by local, state or federal authorities.

Between 1978 and January 2013, FEMA has paid out over $37 billion in losses on significant flood events (one with more than 1,500 losses). These funds are used repair public facilities, help individuals recover from flood disasters, and pay for measures to prevent future flood damage.[5] This equates to over a billion dollars annually. Overall flood losses would far exceed this figure. A University of Colorado study found that average annual flood damages in the U.S. are $2.41 billion.[6] The National Flood Insurance Program found that flood insurance claims alone totaled over $2.9 billion annually from 2002 to 2011. While money is made available for mitigation, the amount varies annually and does not rival the amount spent annually on disaster relief. Some studies have shown that for every $1 spent on mitigation, over $3 is saved on disaster relief assistance.

The magnitude of most floods in Washington depend on the particular combinations of intensity and duration of rainfall, pre-existing soil conditions (e.g., was the ground wet or frozen before the storm), the size of the watershed, elevation of the rain or snow level, and amount of snow pack. Man-made changes to a basin also can affect the severity of floods.

Although floods can happen at any time during the year, there are typical seasonal patterns for flooding in Washington State, based on the variety of natural processes that cause floods:

- Heavy rainfall on wet or frozen ground, before a snow pack has accumulated, typically cause fall and early winter floods.
- Rainfall combined with melting of the low-elevation snow pack typically cause winter and early spring floods. Of particular concern is the so-called Pineapple Express, a warm and wet flow of subtropical air originating near Hawaii which can produce multi-day storms with copious rain and very high freezing levels.
- Late spring floods in Eastern Washington result primarily from melting of the snow pack.
- Thunderstorms typically cause flash floods during the summer in Eastern Washington; on rare occasions, thunderstorms embedded in winter-like rainstorms cause flash floods in Western Washington.

Washington State is subject to flooding from several different flood sources:

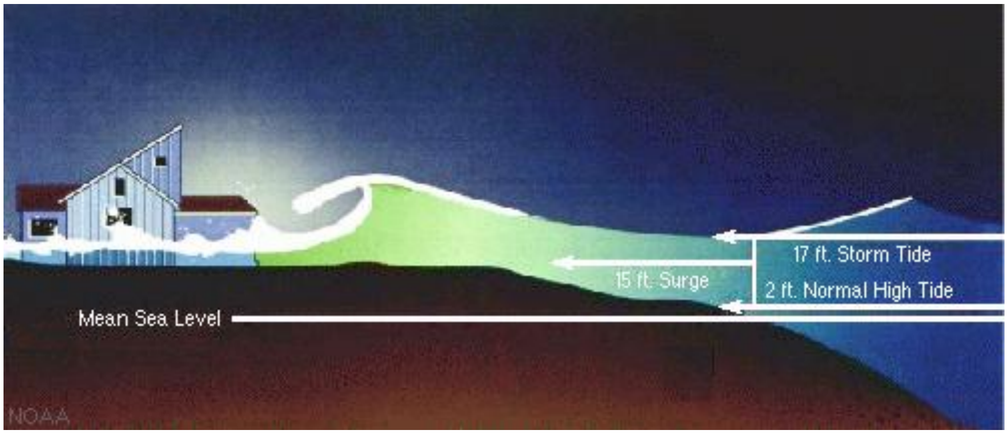
1) Overbank flooding from rivers and streams,
2) Coastal storm surge flooding,
3) Local stormwater drainage flooding, and
4) Flooding from failures of dams, reservoirs or levees.
5) Other flood source - subsidence, tsunamis and seiches

Overbank flooding from rivers and stream occurs throughout Washington, most commonly from winter storms with heavy rainfall from November to February. Flood events with significant contributions from snowmelt are may also occur during the spring snowmelt season. Snowmelt may be an important contribution to flooding for watersheds with high enough elevations to have significant snowfalls. Although less common, overbank flooding can also occur at any time of the year. The severity of overbank flooding depends primarily on flood depth. However, other factors such as flood duration, flow velocity, debris loads, and contamination with hazardous materials also significantly impact the severity of any given flood event. Overbank flooding can be very severe and affect broad geographic areas. Figure 1 below shows flooding along the Chehalis River in 2007.

Figure 1 Flood Event in Centralia and the Unincorporated Areas Surrounding Centralia, Washington – December 2007[7]

Coastal storm surge flooding affects low elevation areas along the coasts of the Pacific Ocean, Puget Sound and Strait of Juan de Fuca and is most common from winter storm events, generally from November through February. Coastal flooding results from the combination of storm-driven surges and daily tides. Maximum flooding occurs when the peaks of storm-driven surges coincide with high tides. The severity of coastal flooding depends not only on flood depths but also on wave effects and debris impacts. Wave pounding exerts substantial forces on structures and extended ponding by frequent waves may destroy structures not designed to withstand wave forces. Wave action may also destroy structures by erosion scour that undermine foundations. Debris impacts may greatly increase damages for a given flood depth. Figure 2 illustrates storm surge effects.

Figure 2 Storm Surge Effects



Source: NOAA

Coastal flood events are expected to become more frequent and more severe in the future because of global warming and sea level rise. Current consensus estimates[8] by climate scientists are that sea level may gradually rise by about 1.4 to 2.0 meters (4.6 to 6.2 feet) over the next hundred years. Sea level rise is also expected to exacerbate beach erosion which may further increase flooding potential in coastal areas.

Storm water drainage flooding, which is sometimes referred to as urban flooding, occurs when inflows of storm water exceed the conveyance capacity of a local storm water drainage system. The drainage system overflows, resulting in water ponding in low lying areas. This type of flooding is generally localized, with flood depths than may range from a few inches to several feet.

Failures of dams, reservoirs for potable water systems or levees results in flooding areas downstream of dams and reservoirs or behind levees. Failures of major dams operated and regulated by state or federal agencies are possible, but unlikely because these dams are generally well-designed and well-maintained. However, failures of smaller dams maintained by local governments, special districts or private owners are more common.

Failures of reservoirs for potable water systems occur, especially from earthquakes. These reservoirs typically have much smaller storage volumes than dams, so flooding from failures is generally localized. Similar flooding may occur from failures of large diameter water pipes.

Levee failures before overtopping may occur at any time, not only during high water events but also under normal non-flood conditions. There are numerous causes for such failures, including scour, foundation failures, under-seepage, through-seepage, animal burrows, and others. Failures of major levees, such as those along the Columbia River are possible, but unlikely because such levees are generally well-designed and well-maintained. Failures of smaller levees maintained by local governments, drainage districts, irrigation districts or private owners are more common.

Flooding from other sources may also occur, including subsidence, tsunamis and seiches. Major earthquakes on the Cascadia Subduction Zone are expected to result in coastal subsidence of several feet. This subsidence will result in flooding of low elevation areas. Further details about earthquakes on the Cascadia Subduction Zone are provided in Tab 5.4 Earthquakes.

Cascadia Subduction Zone earthquakes will also generate tsunamis which will cause widespread inundation and heavy damage for low-elevation areas along in coastal areas on the Pacific Ocean and Puget Sound. Tsunamis within Puget Sound may also be generated by earthquakes on the Seattle Fault Zone or the Tacoma Fault Zone. Earthquakes may also generate seiches in inland bodies of water. Seiches, which are waves from sloshing of water, may result in inundation and significant damages to harbor and dock facilities as well as buildings at low elevations near the shoreline. Further details about tsunamis and seiches are provided in Tab 5.8 Tsunamis.

Location of Flooding

Many rivers in Western Washington typically flood every two to five years; damaging flood events occur less frequently. These include rivers flowing off the west slopes of the Cascade Mountains (Cowlitz, Green, Cedar, Snoqualmie, Skykomish, Snohomish, Stillaguamish, Skagit, Nisqually, Puyallup, Lewis, and Nooksack); out of the Olympic Mountains (Satsop, Elwha, Dungeness, and Skokomish); and out of the hills of southwest Washington (Chehalis, Naselle, and Willapa). Long periods of rainfall and mild temperatures are normally the cause of flooding on these streams.

Several rivers in Eastern Washington also flood every two to five years, including the Spokane, Okanogan, Methow, Yakima, Walla Walla, and Klickitat; again, damaging events occur less frequently. Flooding on rivers east of the Cascades usually results from periods of heavy rainfall on wet or frozen ground, mild temperatures, or from the spring runoff of mountain snow pack.

Eastern Washington is prone to flash flooding. Thunderstorms, combined with steep ravines, alluvial fans, dry or frozen ground, and lightly vegetated ground that does not absorb water can result in flash flooding.

All of the Pacific coastal counties, Puget Sound and Strait of Juan de Fuca coastal counties, and counties at the mouth of the Columbia River, are susceptible to wind and barometric tidal flooding.

Occasionally, communities experience surface water flooding due to high groundwater tables. This occurred dramatically during the 1996-97 winter storms. In many communities, residents outside of identified or mapped flood plains had several inches of water in basements due to groundwater seepage. These 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.

Urban areas across the state have also experienced urban or small stream flooding when a developed community's stormwater drainage system is overwhelmed by excessive rainfall and runoff from impervious surfaces such as roads and parking lots. While normally not life-threatening, such urban flooding can be very disruptive for residents. These events may increase as urban areas develop rapidly without commensurate improvements in urban drainage infrastructure.

Riverine Floodplains make up about 4.5 percent of the state's total land area based on the 1.0-percent annual chance flood modeled for this plan. These areas contain an estimated 430,000 households based on census blocks showing flooding and the population within.[1] All the homes and people who live in them are vulnerable to flood damage. Only about 25 to 35 percent of the homes in floodplains have insurance for flood losses. Uninsured homeowners face greater financial liability than they realize. For example, for a $50,000 federal disaster assistance loan at 4% interest, your monthly payment would be around $240 a month ($2,880 a year) for 30 years. Compare that to a $100,000 flood insurance premium, which is about $400 a year ($33 a month).[9] During a typical 30-year mortgage period, a home in a mapped floodplain has 26 percent chance of damage by a 100-year flood event. The same structure only has about a 1 percent chance of damage by fire.

State Floodplain Management Program

The Washington State Department of Ecology (Ecology) Floodplain Management Program plays an important role in state mitigation with respect to flooding events. Program staff assists communities in administering their local floodplain management programs, make substantial damage determinations after a flood and ensure that communities are in compliance with their local ordinances. In addition, they work to provide assistance to non-participating communities that wish to enter the National Flood Insurance Program (NFIP) and provide technical assistance to participating communities interested in enrolling in the Community Rating System (CRS). Floodplain Management staff provides technical assistance to the Washington State Hazard Mitigation Advisory Team (SHMAT) as well as mitigation staff in administering the mitigation programs and developing a repetitive loss strategy for the state. Floodplain Management staff provides training to local government and emergency management officials on floodplain management and mitigation. Ecology also developed the Floodplain Management Guidebook, which provided additional planning guidance for local jurisdictions to meet FMA planning requirements with respect to NFIP, floodplain management and mitigation planning.

In addition to the above, Ecology supports ongoing updates to existing FEMA floodplain mapping and risk reduction programs. Ecology's Floodplain Management Program has partnered with FEMA under two FEMA programs - Map Modernization and Risk MAP - in support of effective implementation of floodplain regulations and flood hazard reduction. Both of these mapping programs are discussed in detail below.

National Flood Insurance Program (NFIP)[10]

The U.S. Congress established the National Flood Insurance Program (NFIP) with the passage of the National Flood Insurance Act of 1968. NFIP allows property owners in participating communities to purchase insurance as a protection against flood losses in exchange for State and community floodplain management regulations that reduce future flood damages. Participation in the NFIP is optional, and is based on an agreement between communities and the Federal Government. If a community adopts and enforces a floodplain management ordinance to reduce future flood risk to new construction in floodplains, the Federal Government will make flood insurance available within the community as a financial protection against flood losses. This insurance is designed to provide an insurance alternative to disaster assistance to reduce the escalating costs of repairing damage to buildings and their contents caused by floods.

The emphasis of the NFIP floodplain management requirements is directed toward reducing threats to lives and the potential for damages to property in flood-prone areas. One key component in the Act is the restriction in place which prohibits FEMA from providing flood insurance to any individual unless the

[1] Not that all households may be not be subject to flooding. A value of 2.5 persons per household was utilized to determine number of household from the approximate population.

community within which the intended insured resides has adopted and enforces floodplain management regulations that meet or exceed the floodplain management criteria established within 44 Code of Federal Regulations (CFR) Part 60, *Criteria for Land Management and Use.*

As part of the NFIP, various funding opportunities are available for mitigation efforts. These funding opportunities are discussed in greater detail within the *Enhanced* portion of the SHMPH, Tab 7.

Two elements which must be met by all jurisdictions within the local mitigation plan is the issue of Repetitive Loss Properties and Severe Repetitive Loss properties as they relate to floods only. These are defined as:

- *Repetitive Loss Properties*
  A repetitive loss property is one for which two or more losses of at least $1,000 each have been paid by the National Flood Insurance Program (NFIP) over a rolling 10-year period.
- *Severe Repetitive Loss*
  An SRL property is a residential property that is covered under an NFIP flood insurance policy and:
  (1) That has at least four NFIP claim payments (including building and contents) over $5,000 each, and the cumulative amount of such claims payments exceeds $20,000; or
  (2) For which at least two separate claims payments (building payments only) have been made with the cumulative amount of the building portion of such claims exceeding the market value of the building.
  (3) For both (a) and (b) above, at least two of the referenced claims must have occurred within any 10-year period, and must be greater than 10 days apart.

In addition to providing flood insurance and reducing flood damages through floodplain management regulations, the NFIP identifies and maps the Nation's floodplains. Mapping flood hazards creates broad-based awareness of the flood hazards and provides the data needed for floodplain management programs and to actuarially rate new construction for flood insurance. Recently, this mapping initiative has taken a new step toward providing a more reliable mapping system with the creation of Risk MAP (discussed in greater detail below).

The Biggert-Waters Flood Insurance Reform Act of 2012 extends the National Flood Insurance Program (NFIP) through 2017 and included several reforms included eliminating subsidized insurance rate of repetitive loss properties. Some of the changes to be implemented include[11]:

- Owners of **non-primary/secondary** residences in a Special Flood Hazard Area (SFHA) will see 25 percent increase annually until rates reflect true risk – began January 1, 2013.
- Owners of **property which has experienced severe or repeated flooding** will see 25 percent rate increase annually until rates reflect true risk – beginning October 1, 2013.
- Owners of **business properties in a Special Flood Hazard Area** will see 25 percent rate increase annually until rates reflect true risk -- beginning October 1, 2013.
- Owners of **primary residences** in SFHAs **will be able to keep their subsidized rates** unless or until:
  - You sell your property;
  - You allow your policy to lapse;
  - You suffer severe, repeated, flood losses; or
  - You purchase a new policy.
- Grandfathered rates will be phased over five years

Community Rating System[12]

The National Flood Insurance Program's Community Rating System (CRS) was implemented in 1990 as a voluntary program, which recognizes and encourages community floodplain management activities that exceed the minimum NFIP standards. The National Flood Insurance Reform Act of 1994 codified the Community Rating System in the NFIP.

As a result of CRS, flood insurance premium rates are discounted to reflect the reduced flood risk resulting from the community actions meeting the three goals of the CRS:

- Reduce flood losses
- Facilitate accurate insurance rating
- Promote the awareness of flood insurance

The more a jurisdiction does in excess of NFIP standards, the more points they earn. These points are then utilized to establish the jurisdictions CRS class. There are ten CRS classes. Class one (1) requires the most credit points and gives the largest premium reduction; class 10 receives no premium reduction. For CRS participating communities, flood insurance premium rates are discounted in increments of 5%; i.e., a Class 1 community would receive a 45% premium discount, while a Class 9 community would receive a 5% discount, and as indicated above, a Class 10 is not participating in the CRS and receives no discount.

The CRS classes for local communities are based on 18 creditable activities, organized under four categories:

1. Public Information
2. Mapping and Regulations
3. Flood Damage Reduction
4. Flood Preparedness.

More information on the CRS program is available at on FEMA's website at: http://www.fema.gov/business/nfip/crs.shtm

The table below describes the credit points earned, classification awarded and premium reductions given for Washington communities in the National Flood Insurance Program Community Rating System.

Table 1. Communities Participating in the CRS and Associated CRS Class

COMMUNITY NUMBER	COMMUNITY NAME	CRS ENTRY DATE	CURRENT CLASS	% DISCOUNT FOR SFHA
530073	Auburn, City of	10/1/92	5	25
530074	Bellevue, City of	10/1/92	5	25
530153	Burlington, City of	10/1/94	5	25
530103	Centralia, City of	10/1/94	5	25
530104	Chehalis, City of	10/1/94	5	25
530024	Clark County	10/1/04	5	25
530051	Ephrata, City of	10/1/00	7	15
530200	Everson, City of	10/1/94	7	15
530140	Fife, City of	05/1/06	5	25
530166	Index, Town of	04/1/98	6	20
530079	Issaquah, City of	10/1/92	5	25

Table 1. Communities Participating in the CRS and Associated CRS Class

COMMUNITY NUMBER	COMMUNITY NAME	CRS ENTRY DATE	CURRENT CLASS	% DISCOUNT FOR SFHA
530080	Kent, City of	05/1/10	6	20
530071	King County	10/1/91	2	40
530156	La Conner, Town of	10/1/96	7	15
530102	Lewis County	10/1/94	7	15
530316	Lower Elwha Klallam Tribe	10/1/00	8	10
530331	Lummi Nation	05/1/10	8	10
530169	Monroe, City of	10/1/91	5	25
530158	Mount Vernon, City of	05/1/97	6	20
530085	North Bend, City of	10/1/95	6	20
530143	Orting, City of	05/1/08	6	20
530138	Pierce County	10/1/95	2	40
530088	Renton, City of	10/1/94	6	20
530151	Skagit County	04/1/98	4	30
535534	Snohomish County	05/1/06	4	30
530090	Snoqualmie, City of	10/1/92	5	25
530173	Sultan, City of	10/1/03	7	15
530204	Sumas, City of	10/1/93	7	15
530188	Thurston County	10/1/00	5	25
530193	Wahkiakum County	10/1/07	8	10
530067	Westport, City of	10/1/09	6	20
530198	Whatcom County	10/1/96	6	20
530217	Yakima County	10/1/07	8	10

In addition to the CRS community status provided above, data pertaining to the NFIP statistics (including policies and claims) can be found in Appendix A. The information providing above and in Appendix A provides statistical data as it relates to Washington's involvement in the NFIP during the 2013 plan update process. Information is always changing, and therefore, as local jurisdiction plans are updated, the most current data should be gathered to meet planning requirements from the Emergency Management Division, Department of Ecology, or FEMA. At present time, the facts below demonstrate the overall importance of the NFIP to the State and demonstrate the level of flooding concern. The information represents the most currently available data as of the dates referenced within each section.

Risk MAP (Risk Mapping Assessment and Planning)[13]

Risk MAP replaced the Flood Map Modernization program in 2010. Flood Map Modernization was established in 1997 to digitally update FEMA flood maps. Under the Map Moderations Program, several counties in the state were mapped, providing countywide Digital Flood Insurance Rate Maps (DFIRMs). These include:

• Adams	• Grays Harbor	• Skagit
• Clallam	• Island	• Snohomish
• Clark	• King	• Spokane
• Cowlitz	• Kitsap	• Thurston
• Ferry	• Lewis	• Whatcom

• Grant	• Pierce	• Yakima

FEMA's Risk MAP program takes a holistic, community-wide approach to floodplain planning activities. The purpose behind FEMA's Risk MAP Strategy is to constantly reduce losses to life and property. Flood mapping is used for risk assessments which are incorporated into mitigation plans where risk reduction measures are identified for future action. Risk MAP will identify, assess, and communicate multi-hazard risks with non-regulatory products and assessments. Washington State Department of Ecology is partnering with FEMA to implement the four fundamental strategies to Risk MAP in Washington State. The four strategies include Identify Risk, Assess Risk, Communicate Risk, and Mitigate Risk. The Risk MAP program further enhances mapping by involving communities during the assessment and planning stages, and guides and encourages communities to communicate risk to their constituents.

Ecology has developed two new floodplain management tools for open use by the public, communities, agencies, and stakeholders in the floodplains. The Washington State Coastal Atlas delivers flood hazard maps in an internet mapping application using the latest orthophotos to view floodplain at the property level. Several websites are available for more information on these references:

- Coastal Atlas for Washington State: https://fortress.wa.gov/ecy/coastalatlas/
- Risk MAP program in Washington State: http://www.ecy.wa.gov/programs/sea/floods/index.html
- The official FEMA Risk MAP website: http://www.fema.gov/risk-mapping-assessment-planning

Previous Occurrences

The following is a synopsis of damaging floods that occurred in this half-century from 1948 to 2012. It is not a complete history of flood events, but a sample for which documentation is readily available that shows the breadth of the flood problem in Washington.

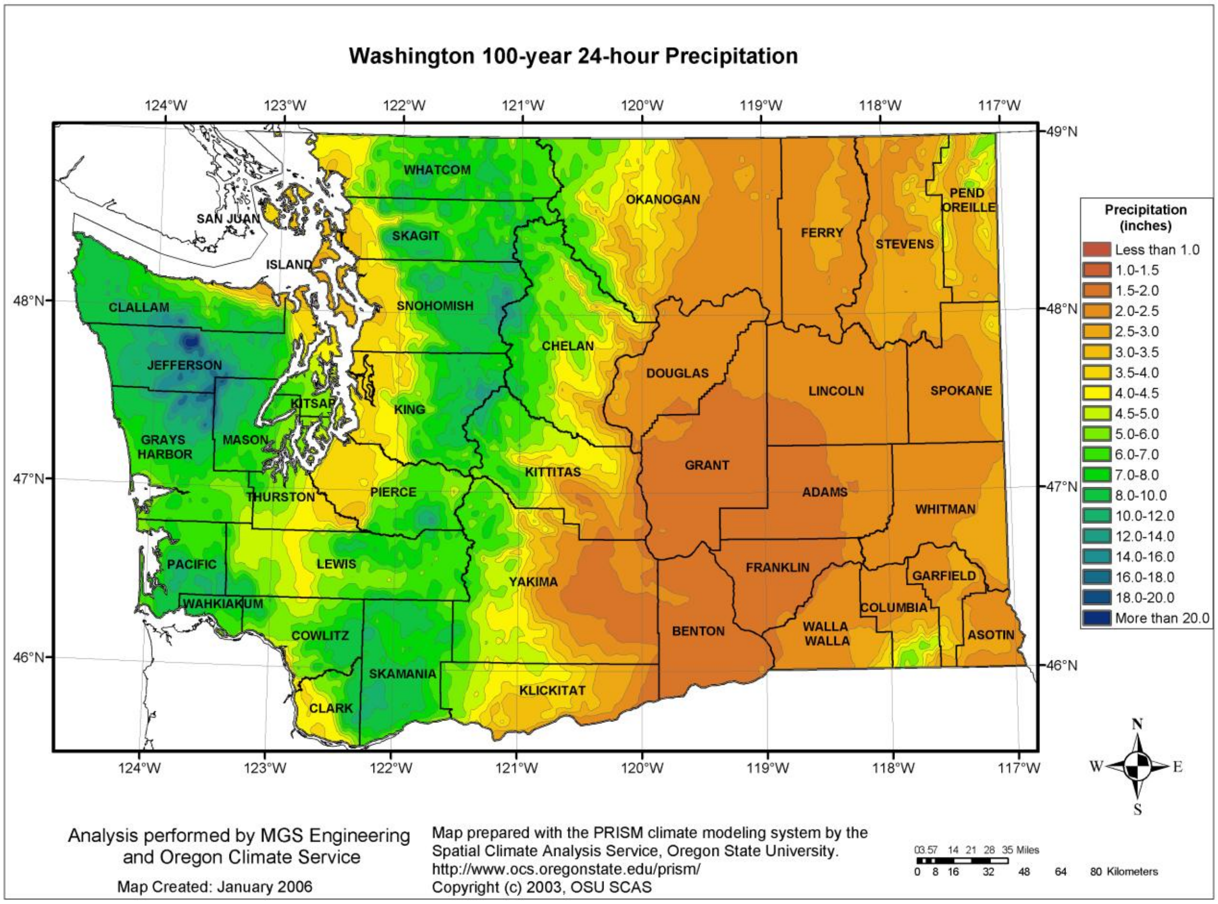
Several flood disasters described below include narratives or tables that depict projected recurrence rates for floods of the magnitude observed; information is for events and selected rivers, streams and lakes for which data is available. The probability of a flood event occurring is expressed as a percent chance that a flood of a specific magnitude will occur in any given year. For example, a flood with a 10-year recurrence rate has a 10 percent chance of occurring in any one year.

The table below demonstrates how recurrence rate translates to the chance of occurrence for the types of floods the state has experienced.

Flood Return Intervals	Chance of Occurrence In Any Given Year
10 Years	10%
20 Years	5%
25 Years	4%
50 Years	2%
100 Years	1%
500 Years	0.2%

Map of 24-hour precipitation totals that would qualify as a 100 year event (from MGS Engineering Consultants).[14] The frequency of major flooding is well-correlated with precipitation levels. Figure 3 on the following page shows 100-year 24-hour precipitation data. The high precipitation areas, shown in blue, green and yellow on Figure 3 include all of the counties with a history of frequent major flood events.

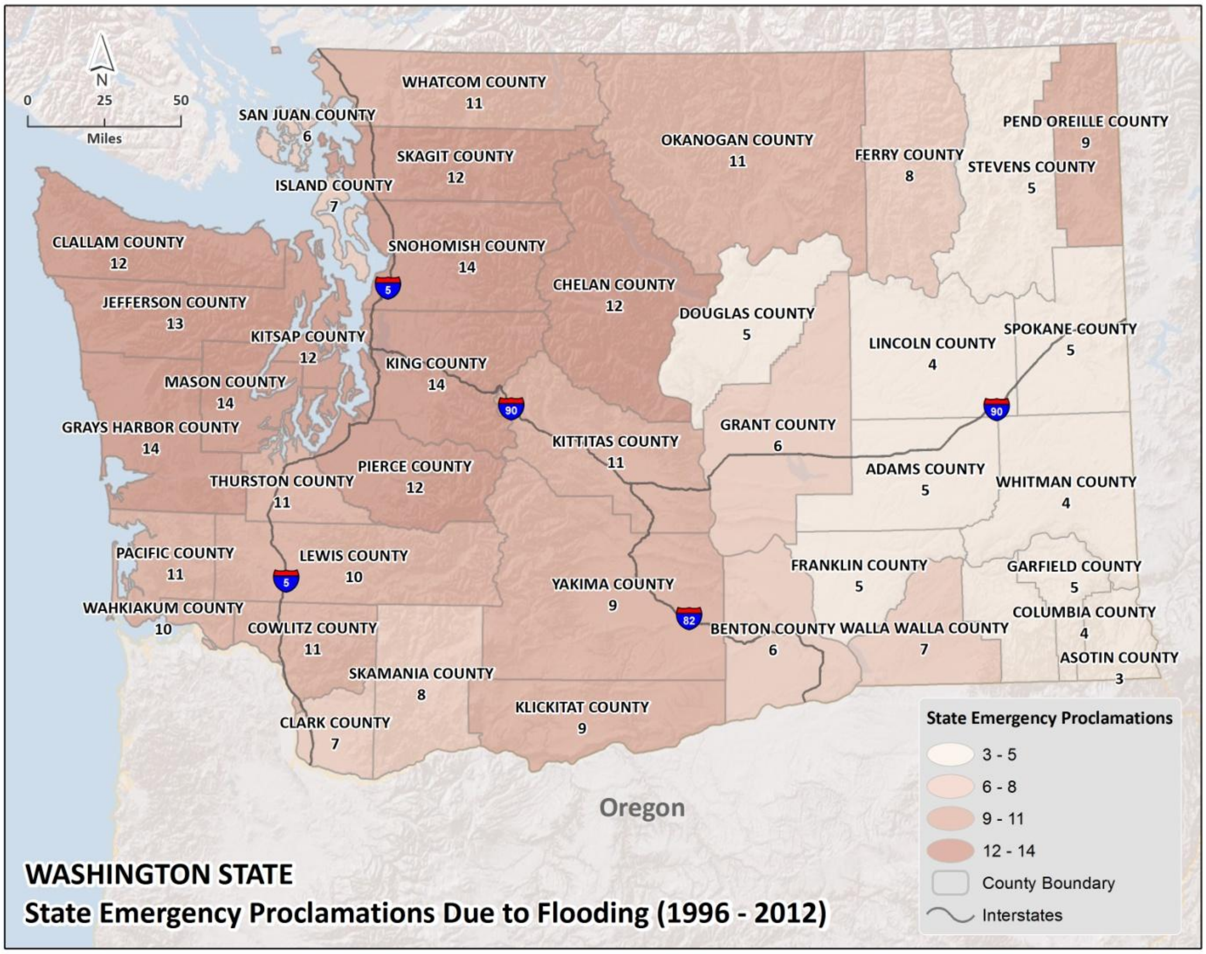
Figure 3 Washington Map of 1.0-percent Annual Chance Flood 24-hour Precipitation



For some tables below, recurrence intervals determined using data in *Magnitude and Frequency of Floods in Washington*, Department of Interior, United States Geological Survey Water-Resources Investigations Report 97-4277, 1998.

The hazard area map of Washington depicts the number of emergency declarations for each county due to flooding. Governor's Emergency Proclamations from 1996 to December 2012 were gathered, the number of declarations for each county was compiled for each year and then all declarations were totaled to generate Figure 4 below. A total of 57 state proclamations were issued including four statewide proclamations.

Figure 4 State Emergency Proclamations (1996-2012)



The following text relays several historic occurrence events including federal disaster declarations.

May-June 1948 [15]
Vanport Flood (One of the top 10 weather events in Washington during the 20th Century, according to National Weather Service, Seattle Forecast Office). Snowmelt flooding broke lake and river records in Eastern Washington and along the Columbia River to the Pacific Ocean. The Columbia River below Priest Rapids, WA, established a new flood of record at 458.65 feet (flood stage 432.0 feet). The Methow River at Pateros, WA, established a new flood of record at 12.30 feet (flood stage 10.0 feet). The flood lasted 45 days. Vancouver, Camas, Kalama, and Longview suffered flood damage. This flood is most notable for wiping out the community of Vanport in North Portland in less than one hour as dikes along the Columbia River gave way. Vanport, America's largest wartime housing project was not rebuilt.

Recurrence interval of this Columbia River flood is projected at 30 years.[16] A number of hydroelectric dams constructed on the Columbia after this event also control flooding, reducing the probability of flooding along much of the length of the river in Washington.

January 1971
Federal Disaster (DR-314)
Snow melt in the counties of Columbia, Garfield, Grays Harbor, Lewis, Skagit, Whatcom and Yakima, combined with heavy rains, produced major flooding throughout the region.

January 1972
Federal Disaster (DR-322)
Severe storms in the counties of Asotin, Cowlitz, Grays Harbor, Lewis, Pacific, Skamania, Thurston, Wahkiakum and Whitman counties caused flooding throughout the region.

February 1972
Federal Disaster (DR-328)
Heavy rains in the counties of King, Pierce and Thurston produced major flooding throughout the area.

May-June 1972
Federal Disaster (DR – 334)
Snow melt in north-central Washington counties of Chelan, Douglas, and Okanogan, combined with heavy rains, produced major flooding on the Okanogan and Methow Rivers in Okanogan County and the Entiat River in Chelan County. All three rivers reached record flood stages. Recurrence intervals for flood levels are not available for this disaster.

January 1974
Federal Disaster (DR – 414)
Unseasonably warm temperatures (+/- 65 degrees), along with monsoon-like rains caused extensive flooding within three states: Washington, Oregon and Idaho. The counties of Asotin, Benton, Columbia, Ferry, Kitsap, Klickitat, Lewis, Mason, Pend Oreille, Stevens, Thurston, Whitman, and Yakima were declared within the state of Washington.

December 1975
Federal Disaster (DR-492)
Unusually heavy and warm rains, together with warm, strong winds, caused flooding mainly within western Washington – Cowlitz, Grays Harbor, King, Lewis, Mason, Pierce, Skagit, Snohomish, Whatcom and Thurston Counties, but also impacted a number of eastern Washington counties: Benton, Kittitas and Yakima. This disaster was considered a statewide event. On the Snohomish River, though the discharge at Monroe was only the fifth largest (the November 25 1990 flood discharge being the largest on record), the 1975 flood produced the highest flood stage ever recorded on the Snohomish at the City of Snohomish; this stage was 34 feet, which is higher than both the January 2009 and November 2006 floods. Snohomish River flooding in the 1975 flood was (in) famous for the drowning of over 2,000 head of cattle, which spurred the concept of establishing “critter pads” in many western Washington floodplains.

According to estimates of the Federal Disaster Assistance Administration of HUD (FEMA not being created until 1979), there was $35 million in losses during this flood. These losses were estimated to include $17 million in public losses, $13 million in agricultural losses and $5 million in private property losses (later estimates ranged up to $70 million in damages).

December 1977[17]
Federal Disaster (DR-545)

Severe storms, mudslides, high tides and flooding categorized this event as a very large Statewide flood that included a record 16 counties, both in western (10 counties) and eastern (6 counties) Washington. Impacted were: Benton, Clark, Cowlitz, Garfield, Grays Harbor, King, Kittitas, Klickitat, Lewis, Pacific, Pierce, Snohomish, Thurston, Wahkiakum, Whitman and Yakima Counties.

This event closed both I-90 and I-5 due to slides and high water on the road surface, trapped two freight trains due to washout of the tracks, caused four deaths and left thousands homeless. Every major western Washington river experienced some flooding, and there was serious flooding on the Naches and Yakima Rivers in eastern Washington.

Estimates indicated damages to be in the tens of millions of dollars. According to a December 4, 1977 news article in the Seattle Times, Senator Henry Jackson was quoted as saying “this year’s flood is clearly more severe than the floods of 1975, which caused $70 million in damage”.

December 1979
Federal Disaster (DR-612)
Storms, high tides, mudslides and flooding impacted the counties of Clallam, Grays Harbor, Jefferson, King, Mason, Skagit, Snohomish and Whatcom. This event produced a record rainfall of 12.7 inches; normal rainfall for the same time of year at SeaTac was 5.94 inches. The flood event started on December 15th, with most rivers peaking between December 17 and 20, 1979.

Although most of the damages were on streams that flowed out of the Cascades, flooding on these streams were mostly 5-10 year floods. Flooding was much more severe on the Olympic Peninsula, though damages were less severe because there were no large populations along these rivers. The Bogachiel, Calawah, and Hoh Rivers were 50-year floods or greater. Total damage figures for this event were approximately $8 million, and the declaration was only for individual assistance.

December 1982 [18]
Federal Disaster (DR-676)
Disaster assistance provided – $1.7 million. Small Business Administration loaned $1 million to home and business owners for damages. Flooding, severe storm, and high tide affected Whatcom County. Four persons injured, 122 people evacuated; 129 homes and 113 businesses damaged; $1.7 million in public facility damage. Recurrence intervals for flood levels are not available for this disaster.

January 1986 [19]
Federal Disaster (DR-757)
Flooding and severe storms in Clallam, Jefferson, and King Counties caused $5 million in damage to public facilities. Recurrence intervals for flood levels are not available for this disaster.

February 1986 [20]
Federal Disaster (DR-762)
Flooding, heavy rainfall, and mudslides in Cowlitz County caused $5 million in damage to public facilities and private property. Recurrence interval of the Cowlitz River flood at Castle Rock projected at 2 years.

November 1986 [21]
Federal Disaster (DR-784)

Stafford Act disaster assistance provided – $1.9 million.

Heavy rainfall, mild temperatures, and low-elevation snowmelt generated major floods on the Chehalis, Skookumchuck, Skykomish, Snoqualmie, and Snohomish Rivers. Less severe flooding occurred on the Satsop, Skokomish, Cedar, Stillaguamish, Skagit, and Nooksack Rivers. Flooding occurred in Cowlitz, King, Lewis, Pacific, Snohomish, and Wahkiakum Counties resulting in two deaths, $11 million in private property damage, and $6 million in public facility damage. One-hundred twenty homes in the City of Snoqualmie were evacuated. Two-hundred eighty homes and businesses were flooded in Lewis County; impacts included a major hazardous materials spill (pentachlorophenol) from an underground storage tank and Lewis County had fairgrounds under nine feet of water. Numerous levees overtopped and damaged throughout flooded counties.

Disaster #784, Flood Recurrence Interval This Event, Selected Rivers

River (County)	Flood Recurrence Interval	Chance of Annual Occurrence
Snoqualmie (King County)	15 – 20 Years	4 – 6%
Skykomish (Snohomish County)	10 – 25 Years	4 – 10%
Snohomish (Snohomish County)	5 – 15 Years	6 – 20%
Puyallup (Pierce County)	40 – 45 Years	~2%
Chehalis (Grays Harbor County)	45 – 50 Years	~2%

March 1989 [22]
Federal Disaster (DR-822)

Stafford Act disaster assistance provided – $3.8 million. Flooding and heavy rainfall affected Douglas, Okanogan, Stevens, and Whitman Counties. Roads and utilities heavily damaged in four rural counties. Mud from flooding impaired the city of Bridgeport's sewage treatment facility for months. Total damage to public facilities was $2 million. Recurrence intervals for flood levels are not available for this disaster.

January 1990 [23]
Federal Disaster (DR-852)

Stafford Act disaster assistance provided – $17.8 million. Flooding occurred on the Chehalis, Skookumchuck, and Deschutes Rivers as heavy rainfall and severe storms affected Benton, Grays Harbor, King, Lewis, Pierce, Thurston, and Wahkiakum Counties resulting in four deaths; $16 million in damages to public facilities and $6 million private property damage. Hundreds of people evacuated, several hundred homes and businesses damaged or destroyed. Chehalis hospital isolated by floodwaters; several nursing homes evacuated. Interstate 5 in Chehalis closed for several days, covered by 3 to 5 feet of water. Recurrence intervals for flood levels are not available for this disaster.

November 1990[24, 25]
Federal Disaster (DR-883).

Stafford Act disaster assistance provided – $57 million. This was one of the top 10 weather events in Washington during the 20th Century, according to National Weather Service, Seattle Forecast Office.

Severe storms and flooding occurred during Veteran's Day and Thanksgiving weekend holidays in Chelan, Clallam, Grays Harbor, Island, Jefferson, King, Kitsap, Kittitas, Lewis, Mason, Pacific, Pierce, San Juan, Skagit, Snohomish, Thurston, Wahkiakum, Whatcom, and Yakima counties. Widespread, major flooding occurred in both Western and Eastern Washington. Rivers with major flooding were the Skagit and Nooksack Rivers. The Thanksgiving weekend floods set record flood stages on the Naselle, Willapa, Hoh, Calawah, Dungeness, Skokomish, Cedar, Skykomish, Snoqualmie, Snohomish, Stillaguamish, Chiwawa, Wenatchee, Elwha, and Klickitat Rivers. Two people died; more than 500 cattle perished. Damage estimated at $250 million. Many levees overtopped and damaged. Hundreds of homes evacuated; much of the city of Snoqualmie evacuated. Thousands of acres of farmland flooded and evacuated; on Fir Island, Skagit County, 167 homes were flooded by 8 feet of water; on Eby Island, Snohomish County, only people with elevated homes stayed.

Disaster #883, Flood Recurrence Interval This Event, Selected Rivers

River (County)	Flood Recurrence Interval	Chance of Annual Occurrence
Skagit (Skagit County)	50 Years	2%
Snohomish (Snohomish County)	50 – 100 Years	1 – 2%
Nooksack (Whatcom County)	100 Years	1%

December 1990
Federal Disaster (DR-896).

Stafford Act disaster assistance provided – $5.1 million. Floods, storms, and high winds affected the counties of Island, Jefferson, King, Kitsap, Lewis, Pierce, San Juan, Skagit, Snohomish, and Whatcom. Recurrence intervals for flood levels are not available for this disaster.

November – December 1995 [26]
Federal Disaster (DR-1079).

Stafford Act disaster assistance provided – $45.9 million. Small Business Administration disaster loans approved - $4.3 million.

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. More than 850 homes damaged or destroyed; one death reported.

Disaster #1079, Flood Recurrence Interval This Event, Selected Rivers[27]

River (County)	Flood Recurrence Interval	Chance of Annual Occurrence
Naselle near Naselle (Pacific County)	10 Years	10%
Quinault at Quinault Lake (Grays Harbor County)	10 Years	10%
American River near Nile (Yakima County)	10 Years	10%
Snoqualmie, multiple locations (King County)	10 – 25 Years	4 – 10%
Willapa near Willapa (Pacific County)	15 Years	7%
Snohomish (Snohomish County)	20 Years	5%
Cedar, multiple locations (King County)	20 – 40 Years	~2 – 5%
Nooksack near Ferndale (Whatcom County)	25 Years	4%
Sauk near Sauk (Skagit County)	25 Years	4%
Skagit, multiple locations (Skagit County)	50 – 75 Years	~2%
Cowlitz, multiple locations (Cowlitz County)	50 – 100 Years	1 – 2%
Nisqually at LaGrande (Thurston County)	50 Years	2%

Disaster #1079, Flood Recurrence Interval This Event, Selected Rivers[27]

River (County)	Flood Recurrence Interval	Chance of Annual Occurrence
Puyallup at Alderton (Pierce County)	100 Years	1%
Stehekin at Stehekin (Chelan County)	100 Years	1%
Wenatchee, multiple locations (Chelan County)	100 Years	1%

February 1996 [28, 29]
Federal Disaster (DR-1100).

Stafford Act disaster assistance provided – $113 million. Small Business Administration disaster loans approved - $61.2 million. This was one of the top 10 weather events in Washington during the 20th Century, according to National Weather Service, Seattle Forecast Office.

Heavy rainfall, mild temperatures and low-elevation snowmelt caused flooding in Adams, Asotin, Benton, Clark, Columbia, Cowlitz, Garfield, Grays Harbor, King, Kitsap, Kittitas, Klickitat, Lewis, Lincoln, Pierce, Skagit, Skamania, Snohomish, Spokane, Thurston, Wahkiakum, Walla Walla, Whitman and Yakima counties, and the Yakima Indian Reservation. Record floods occurred on the Columbia, Snoqualmie, Cedar, Chehalis, Nisqually, Skookumchuck, Klickitat, Skokomish, Cowlitz, Yakima, Naches, Palouse and Walla Walla Rivers, and Latah Creek. The table below shows how frequently flooding of the magnitude observed in this event will occur on selected rivers and streams for which data is available.

Disaster #1100, Flood Recurrence Interval This Event, Selected Rivers and Streams[30]

River / Stream (County)	Flood Recurrence Interval	Chance of Annual Occurrence
Ahtanum Creek (Yakima County)	20 Years	5%
Deschutes River (Thurston County)	25 Years	4%
South Prairie Creek (Pierce County)	37 Years	3%
Newaukum River (Lewis County)	90 Years	~1%
Chehalis River (Thurston, Lewis Counties)	90 – 100 Years	1%
Newaukum Creek (King County)	100 Years	1%
Puyallup River (Pierce County)	100 Years	1%

Mudslides occurred throughout the state causing significant impacts to transportation infrastructure including highways and rail corridors. Three deaths, 10 people injured. Nearly 8,000 homes damaged or destroyed. Traffic shut down for several days both east and west, and north and south, along major state highways. Snow avalanches closed Interstate 90 at Snoqualmie Pass. Mudslides in Cowlitz County and flooding in Lewis County closed Interstate 5. Damage throughout the Pacific Northwest estimated at $800 million.

December 1996 - January 1997 [31]
Federal Disaster (DR-1159).

Stafford Act disaster assistance provided – $83 million. Small Business Administration loans approved – $31.7 million.

Saturated ground combined with snow, freezing rain, rain, rapid warming and high winds within a five-day period to cause flooding. Impacted counties – 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, Whitman, and Yakima. Significant urban flooding occurred north of Pierce County; significant river flooding occurred south of Pierce County; severe groundwater flooding took place in Pierce and Thurston Counties. The table below shows how frequently flooding of the magnitude observed in this event will occur on selected rivers and lakes for which data is available.

Disaster #1159, Flood Recurrence Interval, Selected Rivers and Lakes[32]

River / Lake (County)	Flood Recurrence Interval	Chance of Annual Occurrence
Chehalis River (Grays Harbor County)	10 Years	10%
Klickitat River (Klickitat County	10 Years	10%
Palouse River (Whitman County)	10 Years	10%
Skookumchuck River (Lewis County)	10 Years	10%
White Salmon River (Skamania County)	10 Years	10%
Black Lake (Thurston County)	40 Years (lake elevation)	~2%
Scott Lake (Thurston County)	40 Years (lake elevation)	~2%
Deschutes River (Thurston County)	45 Years	~2%
Lake Sammamish (King County)	70 Years (lake elevation)	~1.5%
Newaukum River (Lewis County)	100 Years	1%

Twenty-four deaths; $140 million (est.) in insured losses; 250,000 people lost power. More than 130 landslides occurred between Seattle and Everett, primarily along shorelines. Interstate 90 at Snoqualmie pass closed due to avalanche.

March 1997
Federal Disaster (DR-1172)

Stafford Act disaster assistance provided – $6.5 million. Small Business Administration disaster loans approved – $2.9 million.

Heavy rainfall and low-elevation mountain snowmelt caused flooding in counties of Grays Harbor, Jefferson, King, Kitsap, Lincoln, Mason, Pacific, Pierce, Pend Oreille, and Stevens. The table below shows how frequently flooding of the magnitude observed in this event will occur on selected rivers for which data is available.

Disaster #1172, Projected Flood Recurrence Interval This Event, Selected Rivers

River (County)	Flood Recurrence Interval	Chance of Annual Occurrence
Naselle River (Pacific County)	100 Years	1%
Satsop River (Grays Harbor County)	200 Years	0.5%
Wynoochee River (Grays Harbor County)	200 Years	0.5%

May 1998

Federal Disaster (DR-1252)

Stafford Act disaster assistance provided – $3.6 million.

Heavy rainfall caused flooding in Ferry and Stevens Counties. Recurrence intervals for flood levels are not available for this disaster.

October 2003[33]
Federal Disaster (DR-1499)

Stafford Act disaster assistance provided to date –$5.8 million. Small Business Administration disaster loans approved – $2.1 million.

Heavy rainfall caused severe flooding in Chelan, Clallam, Grays Harbor, Island, Jefferson, King, Kitsap, Mason, Okanogan, Pierce, San Juan, Skagit, Snohomish, Thurston and Whatcom counties. Most severe flooding took place along the Skagit River. Record flood levels were set on the Skagit River at Concrete, Sauk River, and Stehekin River. More than 3,400 people were evacuated. Thirty-three homes were destroyed, 112 homes had major damage, with property damage estimated at $30 million. Numerous federal, state and county roads were damaged by landslides and floodwaters.

Disaster #1499, Projected Flood Recurrence Interval This Event, Selected Rivers

River (County)	**Flood Recurrence Interval**	**Chance of Annual Occurrence**
Nooksack at Deming (Whatcom County)	25 Years	4%
Skagit near Mount Vernon (Skagit County)	40 Years	~2%
Sauk near Sauk (Skagit County)	100 Years	1%
Stillaguamish at Arlington (Snohomish County)	100 Years	1%
Skokomish near Potlatch (Mason County)	100 – 200 Years	0.5 – 1%
Stehekin at Stehekin (Chelan County)	100 – 200 Years	0.5 – 1%

January 2006
Federal Disaster (DR-1641)
Declared by Governor Gregoire on 12 January 2006, this event was the climax of a month of steady rainfall beginning in mid-December. Initially involving counties in the Puget Sound Basin and Spokane, the declaration eventually was extended to all 39 counties. Flooding, landslides and mudflows seriously impacted state and local transportation infrastructure across the state as well as damaging homes and businesses.

November 2006
Federal Disaster (DR-1671)
A total of 2,388 people applied to FEMA for assistance. Stafford Act disaster assistance provided in excess of $38 million. This storm was one of Washington's worst, making it onto the list of *Washington 2006 Top 10 Weather and Climate Events*. [34]

A powerful series of moist subtropical rainstorms battered much of the state from 2-11 November 2006. The Governor proclaimed an initial emergency on 6 November and on 9 November expanded her Proclamation to cover 24 of the state's 39 counties. A number of streams reached record flood levels including the Cowlitz River at Randle; the Snoqualmie River at Carnation; and the Carbon River near

Fairfax. Mt. Rainier National Park was severely impacted with damage totals exceeding $30 million to park infrastructure. During the period from November 2 to 7, 24.1 inches of rain fell at the Paradise visitor center, resulting in unprecedented destruction to roads, bridges, campgrounds, trails and other Park facilities.

Washington November 2006 Precipitation Totals[35]

City	Nov. 2006	Nov. Normal	Nov. Record	Monthly Record	Graphs & Data
Bellingham	8.10"	5.44"	11.60" (1990)	11.60" (11/1990)	1 Data
Chelan/Lakeside**	2.94"	1.61"	6.20" (1983)	6.20" (11/1983)	1 Data
Forks**	29.28"	17.72"	32.52" (1983)	41.70" (01/1953)	1 Data
Hoquiam*	**21.38"**	10.30"	18.03 (1990)	19.64" (12/1996)	1 Data
Olympia	19.68"	8.13"	15.51" (1962)	19.84" (01/1953)	1 Data
Quillayute*	30.76"	14.82"	29.14" (1983)	29.14" (11/1983)	1 2 Data
Quinault	51.91"	N/A	N/A	N/A	1 Data
Seattle	**15.63"**	5.90"	11.62" (1998)	12.92 (01/1953)	1 2 Data
Spokane	4.38"	2.24"	5.85" (1897)	5.85" (11/1897)	1 2 Data
Stampede Pass*	**28.03"**	12.84"	25.43" (1958)	29.06" (12/1953)	1 Data
Yakima	1.14"	1.05"	2.83" (1973)	5.59" (12/1996)	1 2 Data
Vancouver	13.31"	6.29"	12.92" (1942)	15.04" (12/1933)	1 Data
Denotes new record November rain total * Includes estimated totals for missing data			**Denotes new record monthly rain total** ** Missing Data		

December 2006
Federal Disaster (DR-1682)

Stafford Act disaster assistance provided in excess of $37 million.

A series of severe winter storms during the time period 14-15 December 2006 caused flooding, landslides and mudslides for 19 Washington counties. High winds reached speeds of 113 mph in the cascades. Saturated soils brought down trees and power lines. A total of 15 fatalities were reported; one woman became trapped in her basement as water rushed into the room and jammed the door shut, 8 were due to carbon monoxide poisoning from generators. The President issued a major disaster declaration as a result of those storms. Under this declaration, the Public Assistance (PA) program of the Federal Emergency Management Agency (FEMA) was made available to entities in Chelan, Clallam, Clark, Grant, Grays Harbor, Island, King, Klickitat, Lewis, Mason, Pacific, Pend Oreille, Pierce, San Juan, Skagit, Skamania, Snohomish, Thurston and Wahkiakum counties. Recurrence intervals for flood levels are not available for this disaster. Additional information on this disaster is available at: http://www.fema.gov/news/event.fema?published=1&id=7565

December 2007[36]
Federal Disaster (DR-1734)

During the time period December 1-3, 2007, three storms moved over the Pacific Northwest. December 1st marked the first in the series, producing heavy snow in the mountains and low-land snow throughout western Washington. Snow fall levels ranged from a trace to 1" in Seattle, to many areas away from Puget Sound receiving over 4". On December 2nd, the snow changed over to rain as temperatures increased, accompanied by strong winds. As a low pressure system moved over the Olympic Peninsula, wind gusts of over 80 mph were observed along much of the coast (Hoquiam 81, Destruction Island 93, Tatoosh Island 86) and 40 to 50+ mph inland (Olympia 44, Seattle 48, Bellingham 53).

The most significant of the three storms arrived December 3rd, with near record high temperatures (59°F for Seattle) and moist tropical air which led to record rainfall and flooding around western Washington. Reports indicate that 6-hour and 24-hour precipitation amounts were at or near 100-year rain frequency levels. For Sea-Tac Airport, December 3, 2007 became the 2nd wettest day on record with 3.77" (first is 4.93" recorded on October 20, 2003) and the wettest day on record for Bremerton which received 7.50" of rain, breaking the old record of 5.62" set December 10, 1921.

Several sites reached all time record high river flows and set all-time record high flood stage levels, including the Chehalis, which reached nearly 75 ft (10 feet over flood stage), breaking the previous record set in the floods of February 1996. The flooding of the Chehalis River led to widespread flooding throughout western Lewis County, including a stretch of I-5, forcing 20 miles of the interstate to be closed for 4 days. The Coast Guard rescued more than 300 people from the flood areas, and the flooding and mudslides resulted in at least 5 deaths.

A major disaster declaration was issued for 10 counties for Individual Assistance and 12 counties for Public Assistance, comprised of Clallam, Grays Harbor, Jefferson, King, Kitsap, Lewis, Mason, Pacific, Skagit, Snohomish, Thurston and Wahkiakum counties. Individuals Assistance (IA), SBA low-interest disaster loans and Public Assistance programs were made available to those jurisdictions impacted

As of March 2008, the breakdowns of losses were as follows: [37]

County	Housing Assistance (HA)	Other Needs Assistance (ONA)	Small Business Administration (SBA)	Public Assistance (PA)
Clallam	$219,359	$11,623	$251,400	$277,978
Grays Harbor	$1,556,046	$234,918	$3,867,600	$2,326,407
Jefferson	N/A	N/A	N/A	$201,216

King	$1,370,211	$160,353	$1,594,700	$1,845,386
Kitsap	$1,401,024	$59,419	$1,255,500	$1,195,046
Lewis	$9,583,635	$2,266,483	$19,615,500	$8,034,990
Mason	$1,202,781	$58,506	$1,984,700	$1,997,304
Pacific	$475,217	$49,697	$1,340,100	$231,576
Skagit	N/A	N/A	N/A	$21,050
Snohomish	$494,205	$37,233	$724,700	$1,398,783
Thurston	$726,581	$4,180	$823,400	$1,117,943
Wahkiakum	$128,659	$28,531	$85,800	$160,561
Statewide (PA)	N/A	N/A	N/A	$2,104,756
TOTAL	$17,157,718	$2,910,943	$31,543,400	$20,912,996
Legend: **HA** = Housing Assistance**; ONA** = Other Needs Assistance; **SBA** = Small Business Administration Disaster loans; **PA** = Public Assistance for state and local governments, tribes and non-profits (the 75% federal share of completed Project Worksheets); **N/A** = These counties were not designated for Individual Assistance. Additional information on this event is available at: http://www.fema.gov/news/event.fema?published=1&id=9126 and http://www.climate.washington.edu/events/dec2007floods/				

January 2009
Federal Disaster (DR-1817)[38].

Stafford Act disaster assistance provided approximately $10 million.

A strong, warm and very wet Pacific weather system brought copious amounts of rainfall to Washington during the period 6-8 January, 2009, with subsequent major flooding extending through January 11, 2009, as well as minor flooding that continued through most of January. The storm involved a strong westerly flow aloft with embedded sub-tropical moisture, known as an *atmospheric river* of moisture. Snow levels rose from low levels to between 6,000 and 8,000 feet, with strong westerly winds enhancing precipitation amounts in the mountains. Antecedent conditions from a mid-December through early January region-wide cold snap and associated heavy snow helped set the stage for the flooding. This event also produced avalanches in the mountains, and caused more than an estimated 1,500 land/mudslides across the state, and resulted in structural damage to buildings from added snow load, compounded by heavy rains.

All counties of Western Washington lowlands received 3-8 inches of rain, while east of the Cascades, amounts ranged from 2 to 7.5 inches. On January 7, 2009, Olympia set a daily record with 4.82 inches. The National Weather Service issued flood warnings for 49 flood warning points across the state. Some daily rainfall records were broken (but not all-time) on January 7th at airports: Sea-Tac saw 2.29 inches that broke 1.33 inches on January 7th in 1996, Olympia saw 4.82 inches breaking 1.95 set on January 7, 2002, and Quillayute saw 2.88 inches breaking 2.39 set on January 7, 1983 (from NWS).

Emergency Alert System was activated by NWS Seattle and Portland as 22 Western Washington rivers exceeded *major* flood category. Two rivers, the Naselle in Pacific County and the Snoqualmie reached all-time record crests. Six rivers had near-record crests, while Mud Mountain Dam and How Hanson Dam had record levels of inflows. The State's primary north-south rail line was also closed and ice jam flooding was also a problem. Interstate-5 was closed from milepost 68 to 89 for 43 hours due to water over the roadway around Chehalis. The economic impact of this closure is estimated at $12 million per day. Public Assistance was provided to 22 counties, while Individual Assistance was provided to 15 counties. 3,465 homeowners and renters applied for federal disaster assistance.

January 2011
Federal Disaster (DR-1963)

The weeks leading up to the flood event featured a number of weather systems that left much of western Washington with saturated soils, healthy snow packs, and rivers that were at high levels. The series of Pacific weather systems brought large amounts of precipitation to Washington State during January 11-21, 2011, causing flooding, landslides, and mudslides. Widespread flooding was experienced across the Pacific Northwest that was initiated by warm, heavy precipitation and strong winds that produced rainfall and snowmelt. Flood damage resulted in numerous road closures, home evacuations, and the inundation of low-lying lands. This event included King, Kittitas, Klickitat, Lewis, Skagit, Skamania, and Wahkiakum counties. Flooding in the Spokane River Basin was estimated at $255,000 dollars. The Preliminary Data Assessment estimated $8.6 million in total public assistance needed.[39]

January 2012
Federal Disaster (DR- 4056)

A severe winter storm pummeled the Pacific Northwest in late January 2012, icing roads, downing power lines, and prompting avalanche warnings. The period of January 14-19 featured some heavy snowfall and significant freezing rain in the lowlands of western Washington. Precipitation continued on January 19, and much of it fell as freezing rain or snow. The series of Pacific weather systems brought severe winter storms, flooding, landslides, and mudslides to Western Washington State. This snow and ice storm was one of the highest impact weather events for western Washington in a few years. However, it should be recognized that these impacts were minimized by timely warnings from NWS and relatively effective and rapid response by transportation departments and utilities.[40] On January 20, more than 250,000 customers were without electricity.[41] The Preliminary Data Assessment estimated $32 million in total public assistance needed.

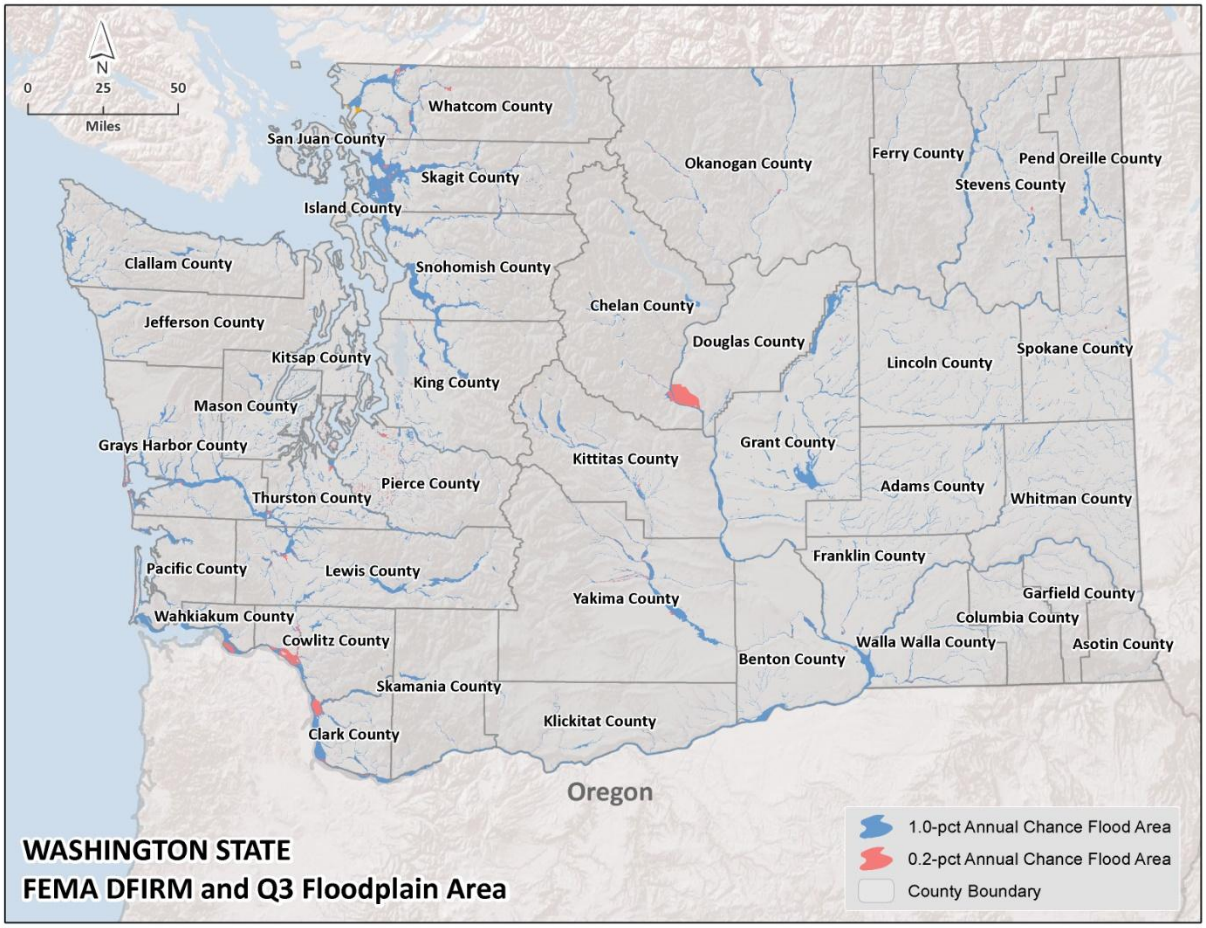
July 2012
Federal Disaster (DR-4083)

On July 20, 2012, a severe thunderstorm hit the region, resulting in flash flooding and significant damage to residential and commercial property. Strong winds of up to 90 miles-per-hour knocked out power and phone service and a damaged storm sewer system prevented local access to clean water for several days. The storm significantly impacted timber, resulting in a $1 million loss for the Washington State Department of Natural Resources and a $2 million loss for the Colville Tribe. One person was also killed in Ferry County as a result of the storm in the Colville National Forest during the thunderstorm and high-intensity winds).[42] In Nespelem and Spring Canyon on Lake Roosevelt, wind gusts peaked at 66 mph and were reported in excess of 50 miles-per-hour. More than 200 trees were knocked down at Daroga State Park in Wenatchee and 80 to 100 mph winds on Daroga Park's island.[43]

Probability of Flooding

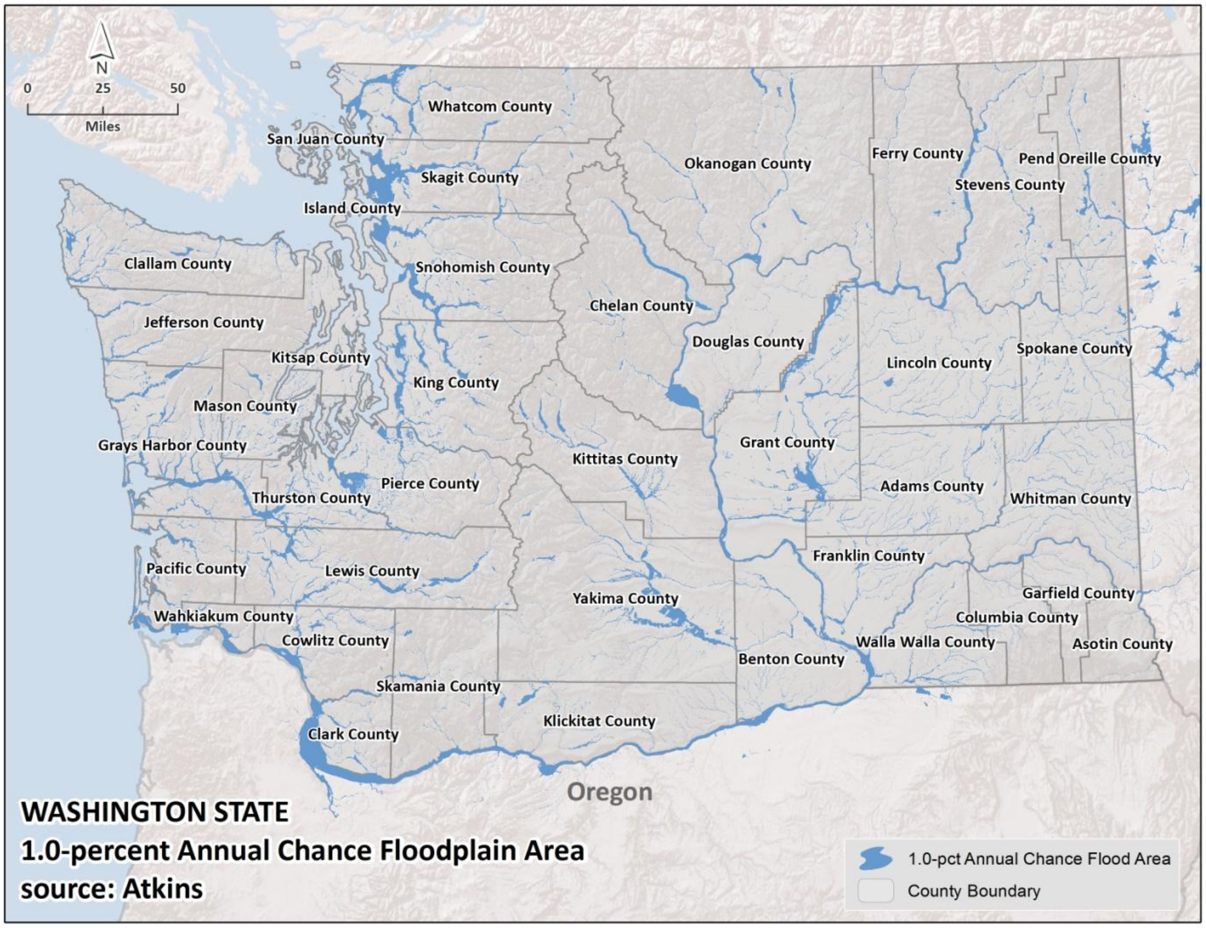
As previously noted, every county in the state has had a Disaster Declaration due to flood. Based on historical records, damaging flood events in Washington State's most flood prone counties will occur every two to eleven years. FEMA regulatory maps are often used to depict these areas, though not all areas in the state are mapped. Where maps are available, the 1.0-percent annual chance and 0.2-percent annual floodplain areas are shown below in Figure 5. It should also be noted that some V zone areas are present in Island, Skagit, Thurston, and Whatcom Counties.

Figure 5 FEMA Regulatory Floodplain Area



For this project, the 1.0-percent annual chance flood was also modeled for this project by Atkins, the contractor responsible for the plan update. Shown in Figure 6 below, these areas indicate a 1.0-percent chance of flooding in any given year based on modeling. However, it should be noted that these areas are not regulatory floodplains.

Figure 6 Modeled 1.0-percent Annual Chance Floodplain



Although floods can happen at any time during the year, there are typical seasonal patterns for flooding in Washington State, based on the variety of natural processes that cause floods:

- Heavy rainfall on wet or frozen ground, before a snow pack has accumulated, typically cause fall and early winter floods.
- Rainfall combined with melting of the low-elevation snow pack typically cause winter and early spring floods. Of particular concern is the phenomenon known as the Pineapple Express, a warm and wet flow of subtropical air originating near Hawaii which can produce multi-day storms with copious rain and very high freezing levels.
- Late spring floods in Eastern Washington result primarily from melting of the snow pack.
- Thunderstorms typically cause flash floods during the summer in Eastern Washington; on rare occasions, thunderstorms embedded in winter-like rainstorms cause flash floods in Western Washington.

Development in or near floodplains increases the likelihood of flood damage in two ways. First, new developments on or adjacent to a flood plain add structures and people in flood areas. Secondly, new construction alters surface water flows by diverting water to new courses or increases the amount of water that runs off impervious pavement and roof surfaces. This second effect diverts waters to places previously safe from flooding.

Hazus-MH Flood Methodology and Results

Hazus-MH 2.1 was used to determine losses with an externally created floodplain. In order to generate this floodplain, Atkins has created an automated tool to run large areas of floodplain analysis using industry accepted techniques. The output generated is consistent with national floodplain standards and is generally of a better quality than what is generated with Hazus' hydrologic and hydraulic (H&H) models.

Flood discharges are derived from published flood gage information and processed through industry-standard statistical analyses to determine values for each return period (i.e., - the 1.0-percent annual chance flood or 0.2-percent annual chance flood). Where available, data indicating special conditions, such as flow regulation, are used to refine the analyses. Flow rates at each modeled cross-section are then extrapolated and interpolated using drainage area as the primary variable. The standard error of prediction is computed at each gage and can be estimated at any other point. The floodplain data was developed using nationally available data sets. The terrain data used for the analysis was the United State Geological Survey 10-meter DEM.

Hydrologic and hydraulic modeling techniques employed with this analysis significantly exceed the minimum standards set by the United States Federal Emergency Management Agency (FEMA) for approximate regulatory flood maps, and include creation of model cross-sections approximately every 300 feet along stream centerlines. A full 1-D steady flow model is developed using this data, and run for specified return periods. For each stream segment, a separate 1-D model is created. The modeling assumes non-coincident peaks as a default, in accordance with FEMA guidelines.

The modeling analysis was run for the 1.0-percent annual chance flood. Depth grids were created using the water surface elevations from the modeling and the USGS 10-meter DEM. These depth grids were imported into Hazus to model the flood losses.

Floodplain data was created at the HUC8 watershed level, which enabled the depth grids to be brought into Hazus with study regions based on HUC8 extents. There are 72 HUC8 watersheds that intersect the State of Washington, and in order to ensure full coverage of the flood data, all but one HUC was included in the analysis. The San Juan Islands watershed (comprised of several islands in the Pacific Ocean) was not included in the Atkins Flood data since there is not enough data to create an automated hydrologic and hydraulic model with the same level of quality as the contiguous portion of the state.[2] Although several return periods could be generated, only the 1.0-percent annual chance return period was used for the Washington State Hazard Mitigation Plan analysis. This was primarily due to time constraints though additional return periods may be explored in future updates of this plan.

FEMA Region 10 supplied the Hazus inventory data that was used for the Hazus General Building Stock (GBS) analysis. The Region 10 data, which has been recently updated, replaced the default Hazus inventory data that is largely based on the 2000 Census.

As previously noted, these floodplains may not be used for regulatory flood determinations in the United States, unless a formal Best Available Data Letter (BADL) has been obtained for the area of interest.

[2] Riverine level losses were not available for San Juan County. However, as discussed in detail below, coastal flood losses were available.

In addition to floodplain generation and Hazus-MH analysis, inflation was accounted for in order to estimate approximate 2012 value of losses. The Consumer Price Index (CPI) is a common measure of inflation and was used herein. State CPI's are not determined but national and metropolitan-level (with populations over 1.5 million) values are calculated. According to the Washington Office of Financial Management, the Seattle Metropolitan Statistical Area CPI (including Seattle, Tacoma, and Bremerton) is the closest representative to a state CPI. It should also be noted that the CPI at the metropolitan level is subject to measurement errors and can be more volatile given the smaller area. According to the Seattle CPI, the cumulative rate of inflation between 2000 and 2012 was calculated to be 29.9 percent. In other words, $1.00 in 2000 would be $1.29 in 2012.[44] The national rate of inflation during this time was 33.3 percent. The results are shown in Table 2 and Figure 7 below.

Hazus-MH 2.1 Flood Results

Table 2. Hazus-MH 2.1 General Building Stock (GBS) Total Losses for 1.0-percent Annual Chance Riverine Flood

	GBS Total Losses*	GBS Building Losses	GBS Contents Losses	GBS Inventory Losses	GBS Total Losses Inflated to 2012 dollars
Adams	$8,787,000	$3,553,000	$4,906,000	$304,000	$11,413,538
Asotin	$82,724,000	$36,484,000	$44,469,000	$1,292,000	$107,451,182
Benton	$1,288,925,000	$575,302,000	$693,503,000	$11,013,000	$1,674,199,931
Chelan	$1,232,147,000	$586,471,000	$616,600,000	$23,612,000	$1,600,450,315
Clallam	$79,133,000	$39,367,000	$38,652,000	$941,000	$102,786,790
Clark	$1,945,812,000	$979,262,000	$906,534,000	$54,834,000	$2,527,438,226
Columbia	$39,833,000	$19,881,000	$19,401,000	$445,000	$51,739,555
Cowlitz	$3,347,993,000	$1,296,265,000	$1,626,579,000	$356,100,000	$4,348,747,716
Douglas	$239,999,000	$134,343,000	$101,650,000	$3,251,000	$311,737,540
Ferry	$18,151,000	$10,087,000	$7,958,000	$91,000	$23,576,549
Franklin	$189,014,000	$89,818,000	$94,709,000	$3,934,000	$245,512,521
Garfield	$7,897,000	$3,885,000	$3,929,000	$64,000	$10,257,507
Grant	$189,431,000	$103,564,000	$83,068,000	$2,128,000	$246,054,167
Grays Harbor	$1,205,714,000	$457,984,000	$578,992,000	$158,010,000	$1,566,116,179
Island	$20,491,000	$12,190,000	$8,249,000	$30,000	$26,616,002
Jefferson	$19,695,000	$10,189,000	$9,145,000	$246,000	$25,582,068
King	$9,765,188,000	$3,892,642,000	$5,524,413,000	$301,348,000	$12,684,118,219
Kitsap	$2,111,000	$1,139,000	$961,000	$11,000	$2,742,003

Table 2. Hazus-MH 2.1 General Building Stock (GBS) Total Losses for 1.0-percent Annual Chance Riverine Flood

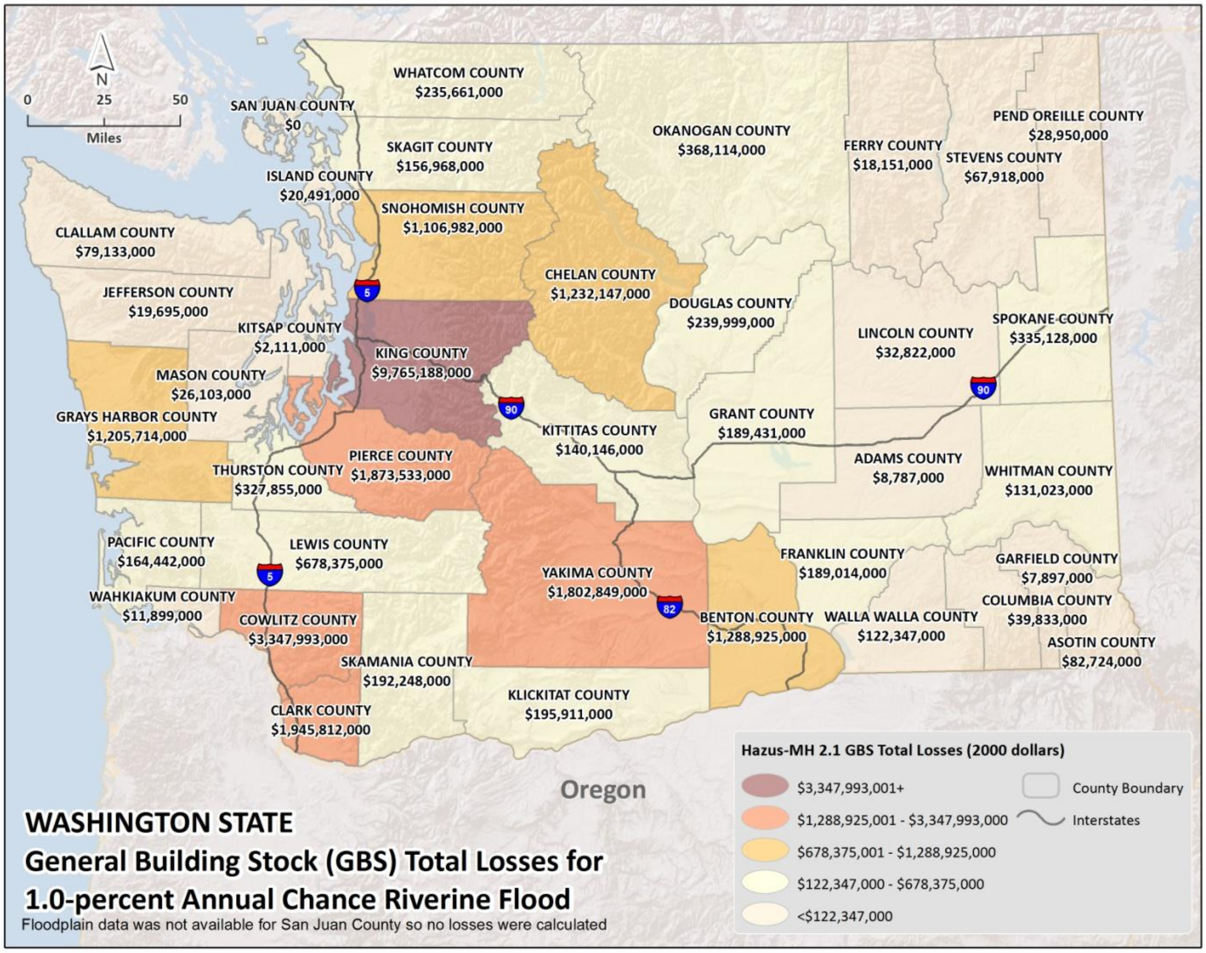
	GBS Total Losses*	GBS Building Losses	GBS Contents Losses	GBS Inventory Losses	GBS Total Losses Inflated to 2012 dollars
Kittitas	$140,146,000	$68,107,000	$69,379,000	$2,085,000	$182,037,297
Klickitat	$195,911,000	$111,391,000	$81,342,000	$2,792,000	$254,471,116
Lewis	$678,375,000	$273,524,000	$384,014,000	$17,449,000	$881,149,313
Lincoln	$32,822,000	$13,883,000	$18,272,000	$463,000	$42,632,884
Mason	$26,103,000	$13,753,000	$12,047,000	$268,000	$33,905,496
Okanogan	$368,114,000	$186,032,000	$175,684,000	$5,342,000	$478,147,630
Pacific	$164,442,000	$70,068,000	$90,120,000	$2,637,000	$213,595,659
Pend Oreille	$28,950,000	$17,034,000	$11,732,000	$159,000	$37,603,497
Pierce	$1,873,533,000	$810,092,000	$1,001,038,000	$55,027,000	$2,433,554,178
San Juan**	--	--	--	--	--
Skagit	$156,968,000	$86,625,000	$68,727,000	$1,331,000	$203,887,592
Skamania	$192,248,000	$111,727,000	$78,733,000	$897,000	$249,713,202
Snohomish	$1,106,982,000	$508,734,000	$575,668,000	$19,691,000	$1,437,872,016
Spokane	$335,128,000	$154,680,000	$175,142,000	$4,042,000	$435,301,724
Stevens	$67,918,000	$34,396,000	$32,033,000	$1,084,000	$88,219,494
Thurston	$327,855,000	$165,139,000	$158,197,000	$3,438,000	$425,854,738
Wahkiakum	$11,899,000	$5,399,000	$6,190,000	$125,000	$15,455,752
Walla Walla	$122,347,000	$46,211,000	$72,978,000	$2,168,000	$158,917,966
Whatcom	$235,661,000	$111,648,000	$120,026,000	$3,298,000	$306,102,861
Whitman	$131,023,000	$51,832,000	$77,057,000	$1,511,000	$170,187,325
Yakima	$1,802,849,000	$579,565,000	$898,129,000	$303,246,000	$2,341,741,894
Washington State	$27,725,131,000	$11,695,290,000	$14,470,226,000	$1,344,707,000	$35,956,891,641

* Total loss includes building, contents, inventory, relocation, income, rental income, wage, direct output, and employments losses determined by the scenario as a result of riverine flooding.

**The necessary National Hydrography Data (NHD) data required for automated modeling does not exist for this county so a riverine floodplain could not be generated.

Source: Hazus-MH 2.1, Level 2 (enhanced) hazard run

Figure 7 Hazus-MH 2.1 General Building Stock Loss Estimates for the 1.0-percent Annual Chance Riverine Flood



In order to present a complete picture of risk and losses due to flooding, coastal losses were also garnered. Coastal losses were derived from the results of the nationwide Hazus Average Annualized Loss (AAL) Usability Analysis which concluded in 2010. The study used Hazus-MH MR 4 with a 30-meter digital elevation model (DEM) to complete a Level 1 (basic) flood boundary. Coastal Still Water Elevations were used from the available regulatory Flood Insurance Study reports for counties where coastal flood data was created. Conclusions of the study noted that the AAL Usability Analysis provided reasonable results though lack of detail in the DEM was attributed to larger than expected losses in some areas. For the purpose of showing coastal flood losses in this plan, the coastal AAL results were added to the riverine flood results (as presented above). Table 3 and Figure 8 below shows the combined riverine and coastal flood losses due to the 1.0-percent annual chance flood.

Table 3. Hazus-MH 2.1 General Building Stock (GBS) Total Losses for 1.0-percent Annual Chance Riverine and Coastal Flood

	GBS Total Losses*	GBS Building Losses	GBS Contents Losses	GBS Inventory Losses	GBS Total Losses Inflated to 2012 dollars
Adams	$8,787,000	$3,553,000	$4,906,000	$304,000	$11,413,538
Asotin	$82,724,000	$36,484,000	$44,469,000	$1,292,000	$107,451,182
Benton	$1,288,925,000	$575,302,000	$693,503,000	$11,013,000	$1,674,199,931
Chelan	$1,232,147,000	$586,471,000	$616,600,000	$23,612,000	$1,600,450,315
Clallam	$169,162,000	$77,588,000	$86,519,000	$941,000	$219,726,523
Clark	$1,945,812,000	$979,262,000	$906,534,000	$54,834,000	$2,527,438,226
Columbia	$39,833,000	$19,881,000	$19,401,000	$445,000	$51,739,555
Cowlitz	$3,347,993,000	$1,296,265,000	$1,626,579,000	$356,100,000	$4,348,747,716
Douglas	$239,999,000	$134,343,000	$101,650,000	$3,251,000	$311,737,540
Ferry	$18,151,000	$10,087,000	$7,958,000	$91,000	$23,576,549
Franklin	$189,014,000	$89,818,000	$94,709,000	$3,934,000	$245,512,521
Garfield	$7,897,000	$3,885,000	$3,929,000	$64,000	$10,257,507
Grant	$189,431,000	$103,564,000	$83,068,000	$2,128,000	$246,054,167
Grays Harbor	$1,366,001,000	$538,209,000	$654,318,000	$158,010,000	$1,774,314,859
Island	$181,456,000	$102,191,000	$77,998,000	$30,000	$235,695,345
Jefferson	$89,670,000	$42,462,000	$44,672,000	$246,000	$116,473,424
King	$13,512,333,000	$5,209,259,000	$7,763,768,000	$301,348,000	$17,551,329,189
Kitsap	$428,506,000	$195,887,000	$226,230,000	$11,000	$556,591,513
Kittitas	$140,146,000	$68,107,000	$69,379,000	$2,085,000	$182,037,297
Klickitat	$195,911,000	$111,391,000	$81,342,000	$2,792,000	$254,471,116
Lewis	$678,375,000	$273,524,000	$384,014,000	$17,449,000	$881,149,313
Lincoln	$32,822,000	$13,883,000	$18,272,000	$463,000	$42,632,884
Mason	$206,078,000	$103,124,000	$99,455,000	$268,000	$267,677,152
Okanogan	$368,114,000	$186,032,000	$175,684,000	$5,342,000	$478,147,630
Pacific	$584,626,000	$243,519,000	$324,617,000	$2,637,000	$759,377,628
Pend Oreille	$28,950,000	$17,034,000	$11,732,000	$159,000	$37,603,497
Pierce	$3,610,980,000	$1,450,117,000	$2,008,640,000	$55,027,000	$4,690,344,641

Table 3. Hazus-MH 2.1 General Building Stock (GBS) Total Losses for 1.0-percent Annual Chance Riverine and Coastal Flood

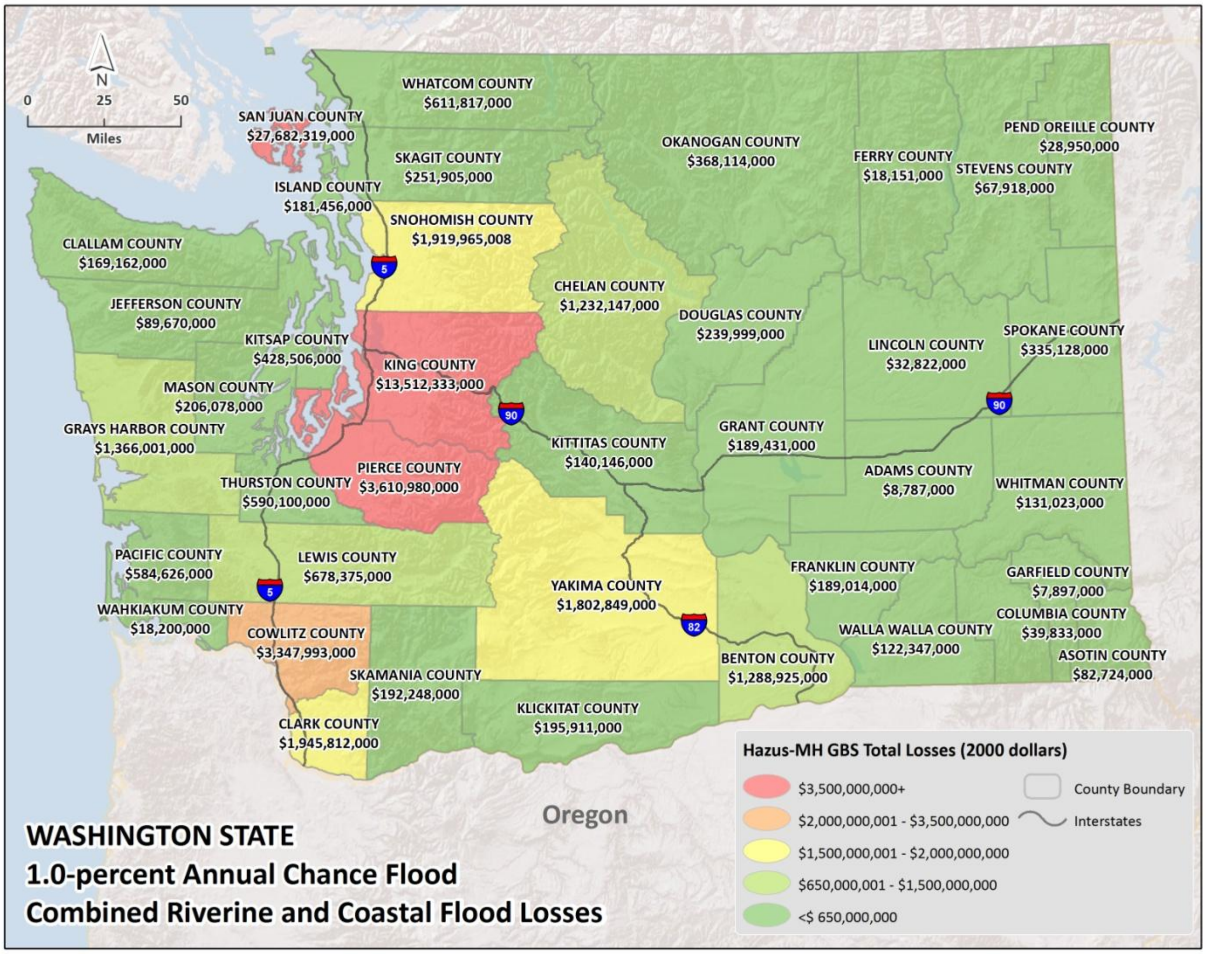
	GBS Total Losses*	GBS Building Losses	GBS Contents Losses	GBS Inventory Losses	GBS Total Losses Inflated to 2012 dollars
San Juan**	$27,682,319,000	$11,672,266,000	$14,470,226,000	$0	$35,956,891,641
Skagit	$251,905,000	$133,550,000	$113,451,000	$1,331,000	$327,202,385
Skamania	$192,248,000	$111,727,000	$78,733,000	$897,000	$249,713,202
Snohomish	$1,919,965,008	$850,119,000	$1,025,052,000	$19,691,000	$2,493,865,263
Spokane	$335,128,000	$154,680,000	$175,142,000	$4,042,000	$435,301,724
Stevens	$67,918,000	$34,396,000	$32,033,000	$1,084,000	$88,219,494
Thurston	$590,100,000	$273,291,000	$298,872,000	$3,438,000	$766,487,871
Wahkiakum	$18,200,000	$8,364,000	$9,304,000	$125,000	$23,640,195
Walla Walla	$122,347,000	$46,211,000	$72,978,000	$2,168,000	$158,917,966
Whatcom	$611,817,000	$271,165,000	$323,013,000	$3,298,000	$794,696,339
Whitman	$131,023,000	$51,832,000	$77,057,000	$1,511,000	$170,187,325
Yakima	$1,802,849,000	$579,565,000	$898,129,000	$303,246,000	$2,341,741,894
Washington State	$63,909,662,008	$26,658,408,000	$33,803,936,000	$1,344,707,000	$83,013,016,056

* Total loss includes building, contents, inventory, relocation, income, rental income, wage, direct output, and employments losses determined by the scenario as a result of riverine flooding.

** The necessary National Hydrography Data (NHD) data required for automated modeling does not exist for this county so a riverine floodplain could not be generated. Therefore, only Hazus-MH MR4 coastal model flood and associated results were utilized.

Source: Hazus-MH 2.1, Level 2 (enhanced) hazard run

Figure 8 Hazus-MH 2.1 General Building Stock Loss Estimates for the 1.0-percent Annual Chance Riverine and Coastal Flood Impacts



Jurisdictions Most Vulnerable to Flooding

The factors used to determine which counties are most vulnerable to future flooding are:

- Frequency of flooding that causes major damage, based on the number of Presidential Disaster Declarations since 1956 as an indicator of how often serious, damaging flood events occur (top 20 counties). An approximated reoccurrence interval was also estimated using this data.
- Percentage of the County in Floodplain (land area only minus water bodies) (2 percent of more of the area of the county) – a measure of the size of the area within a county at-risk to flooding.
- Counties with the top 20 highest total General Building Stock Losses in Hazus-MH 2.1 from the 1.0-percent annual chance flood scenario.
- Number of Flood Insurance Policies Currently in Effect (top 20 counties) – a measure of the built environment in the floodplain.
- Number of Flood Insurance Claims Paid Since 1978 (top 20 counties) – another measure of the built environment in the floodplain.
- Number of Repetitive Flood Loss Properties (measured by county) – a measure of how often serious, damaging flood events occur.
- Number of Severe Repetitive Loss Properties (measured by county) – a measure of how often serious, damaging flood events occur.

Based on these factors, the following counties are at ten with the greatest risk and most vulnerable to flooding:

Jurisdictions Most Vulnerable to Flooding	
• Clark	• Pierce
• Cowlitz	• Skagit
• Grays Harbor	• Snohomish
• King	• Thurston
• Lewis	• Whatcom

Frequency of Major Flood Occurrence

Presidential Disaster Declarations provide a good indicator of major damage caused by a hazard event. There have been 32 Presidential Disaster Declarations for flooding since 1956. Each county has received at least five disaster declarations for flooding since 1956.[45]

The counties in Table 4 below are those that have experienced the most frequent flooding resulting in major damages and a Presidential Disaster Declaration since 1956. The approximated reoccurrence interval using this data is found in the table below for the top twenty counties. Occurrence rates are approximate, and rounded to the nearest year. This information also depicted in Figure 9.

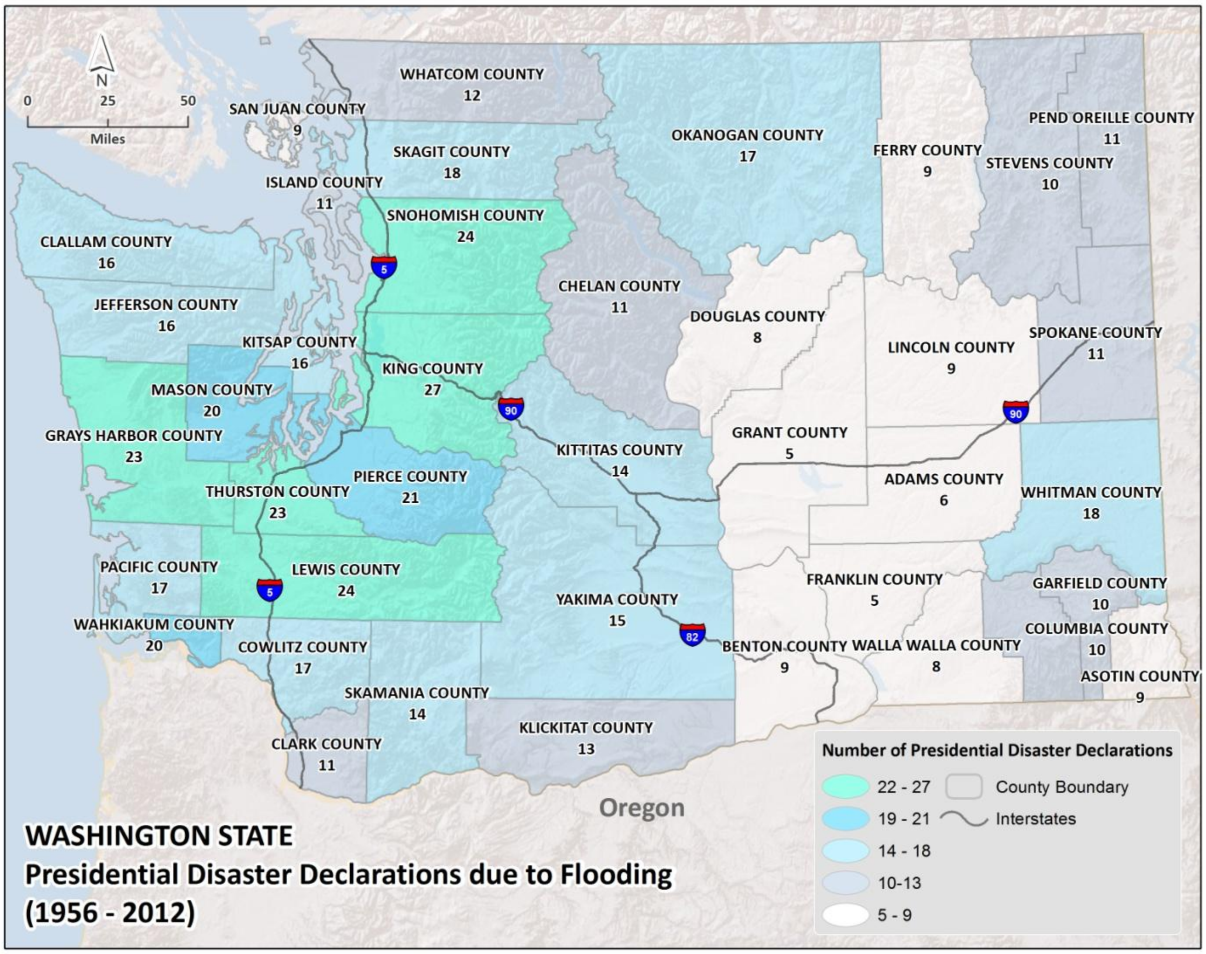
Table 4. Twenty Counties with Highest Number of Presidential Disaster Declarations Due to Flooding and Approximate Interval Between Major Flood Events, 1956 through 2012

County	#	Interval (years)	County	#	Interval (years)
King County	27	2	Cowlitz County	17	3
Lewis County	24	2	Okanogan County	17	3
Snohomish County	24	2	Pacific County	17	3

Table 4. Twenty Counties with Highest Number of Presidential Disaster Declarations Due to Flooding and Approximate Interval Between Major Flood Events, 1956 through 2012

County	#	Interval (years)	County	#	Interval (years)
Grays Harbor County	23	2	Clallam County	16	4
Thurston County	23	2	Jefferson County	16	4
Pierce County	21	3	Kitsap County	16	4
Mason County	20	3	Yakima County	15	4
Wahkiakum County	20	3	Kittitas County	14	4
Skagit County	18	3	Skamania County	14	4
Whitman County	18	3	Klickitat County	13	4

Figure 9 Number of Presidential Disasters due to Flooding per County



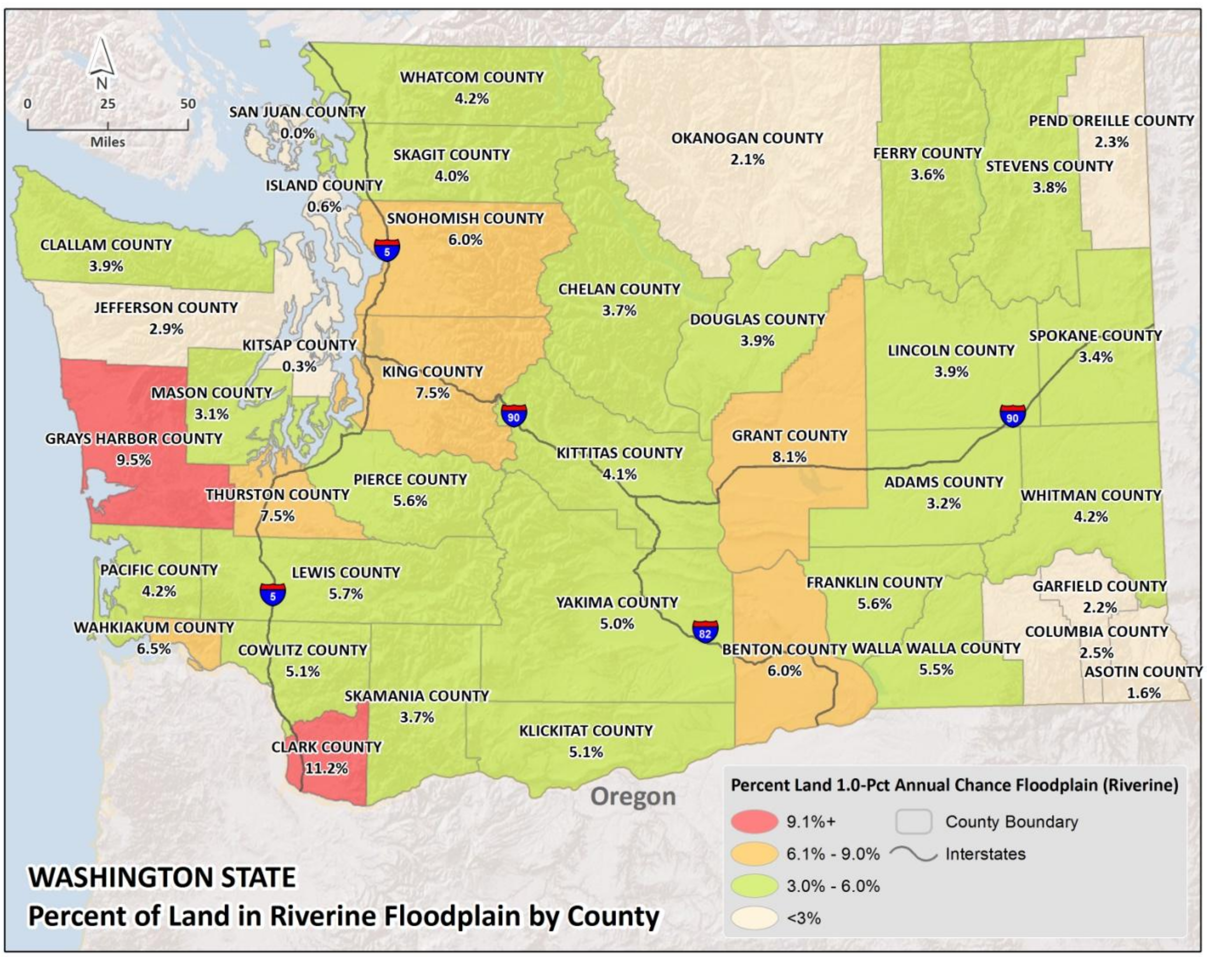
Percentage of County in Riverine Floodplain

The top twenty counties have 1.0-percent annual chance floodplain varying from 11.2 percent to 4.0 percent of their total county area. This information is shown in Table 5 below and also depicted in Figure 10.

Table 5. Twenty Counties with Highest Percentage of County Covered by 1.0-percent Annual Chance Floodplain (top twenty)

County	Total Sq. Mi.	1.0-% ACF (Sq. Mi.)	% in FP	County	Total Sq. Mi.	1.0-% ACF (Sq. Mi.)	% in FP
Clark	655.7	73.3	11.2	Pierce	1,689.9	94.9	5.6
Grays Harbor	1,929.2	182.4	9.5	Walla Walla	1,302.1	72.0	5.5
Grant	2,794.0	227.0	8.1	Cowlitz	1,165.4	59.8	5.1
King	2,188.1	165.2	7.5	Klickitat	1,904.0	96.4	5.1
Thurston	735.5	55.5	7.5	Yakima	4,311.4	217.1	5.0
Wahkiakum	265.4	17.3	6.5	Whatcom	2,162.0	91.4	4.2
Benton	1,761.8	106.2	6.0	Pacific	938.0	39.4	4.2
Snohomish	2,106.9	127.0	6.0	Whitman	2,185.2	91.3	4.2
Lewis	2,434.5	137.8	5.7	Kittitas	2,333.0	96.2	4.1
Franklin	1,267.4	71.4	5.6	Skagit	1,754.8	70.2	4.0

Figure 10 Percentage of County Covered by 1.0-percent Annual Chance Flood.



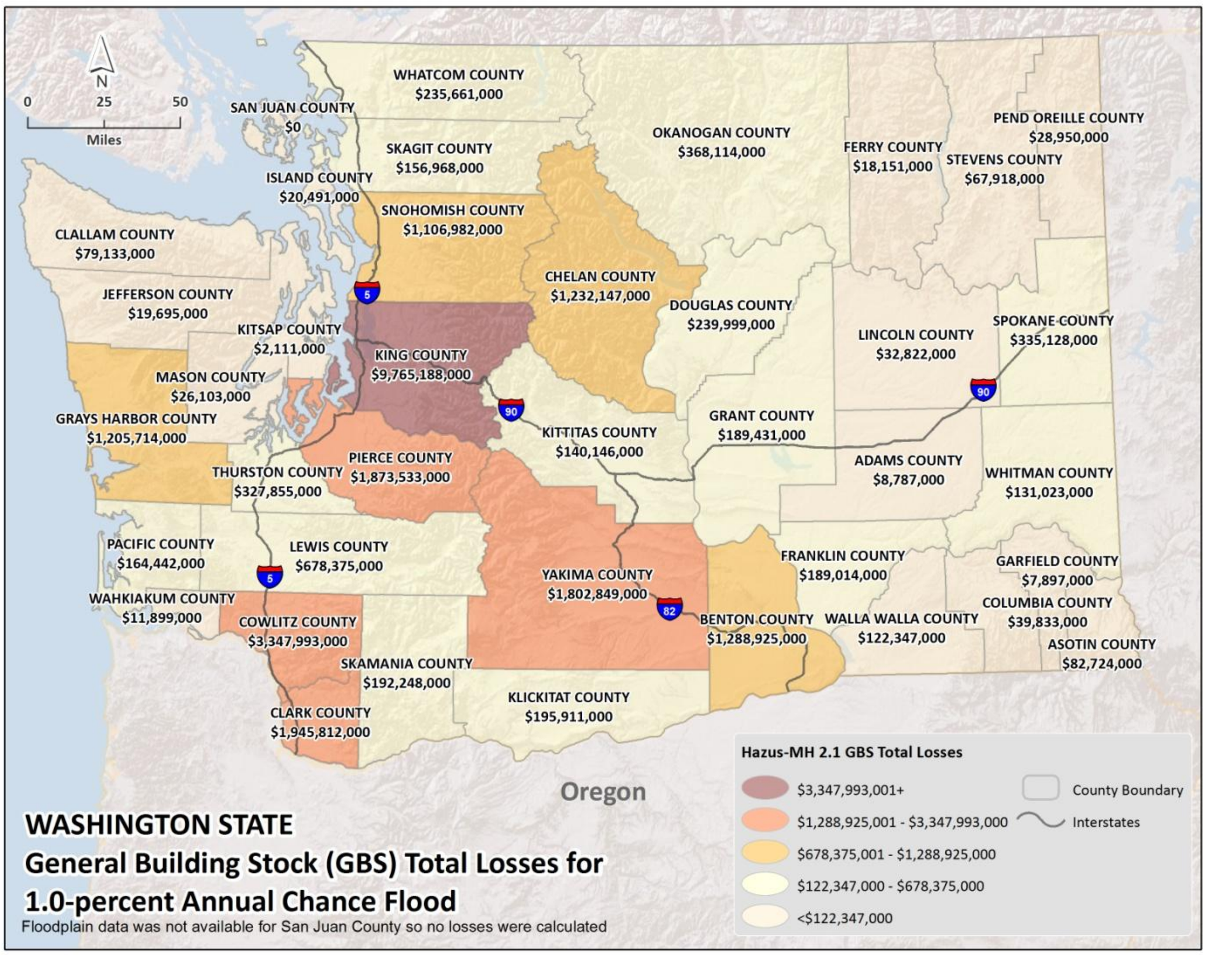
Hazus-MH Losses

The counties with the top twenty highest total general building stock losses from the 1.0-percent annual chance riverine flood are shown in Table 6 and Figure 11 below:

Table 6. Twenty Counties with Highest Hazus-MH 2.1 GBS Loss Estimates

County	GBS Total Losses	County	GBS Total Losses
King	$9,765,188,000	Okanogan	$368,114,000
Cowlitz	$3,347,993,000	Spokane	$335,128,000
Clark	$1,945,812,000	Thurston	$327,855,000
Pierce	$1,873,533,000	Douglas	$239,999,000
Yakima	$1,802,849,000	Whatcom	$235,661,000
Benton	$1,288,925,000	Klickitat	$195,911,000
Chelan	$1,232,147,000	Skamania	$192,248,000
Grays Harbor	$1,205,714,000	Grant	$189,431,000
Snohomish	$1,106,982,000	Franklin	$189,014,000
Lewis	$678,375,000	Pacific	$164,442,000

Figure 11 Hazus-MH 2.1 GBS Losses by County



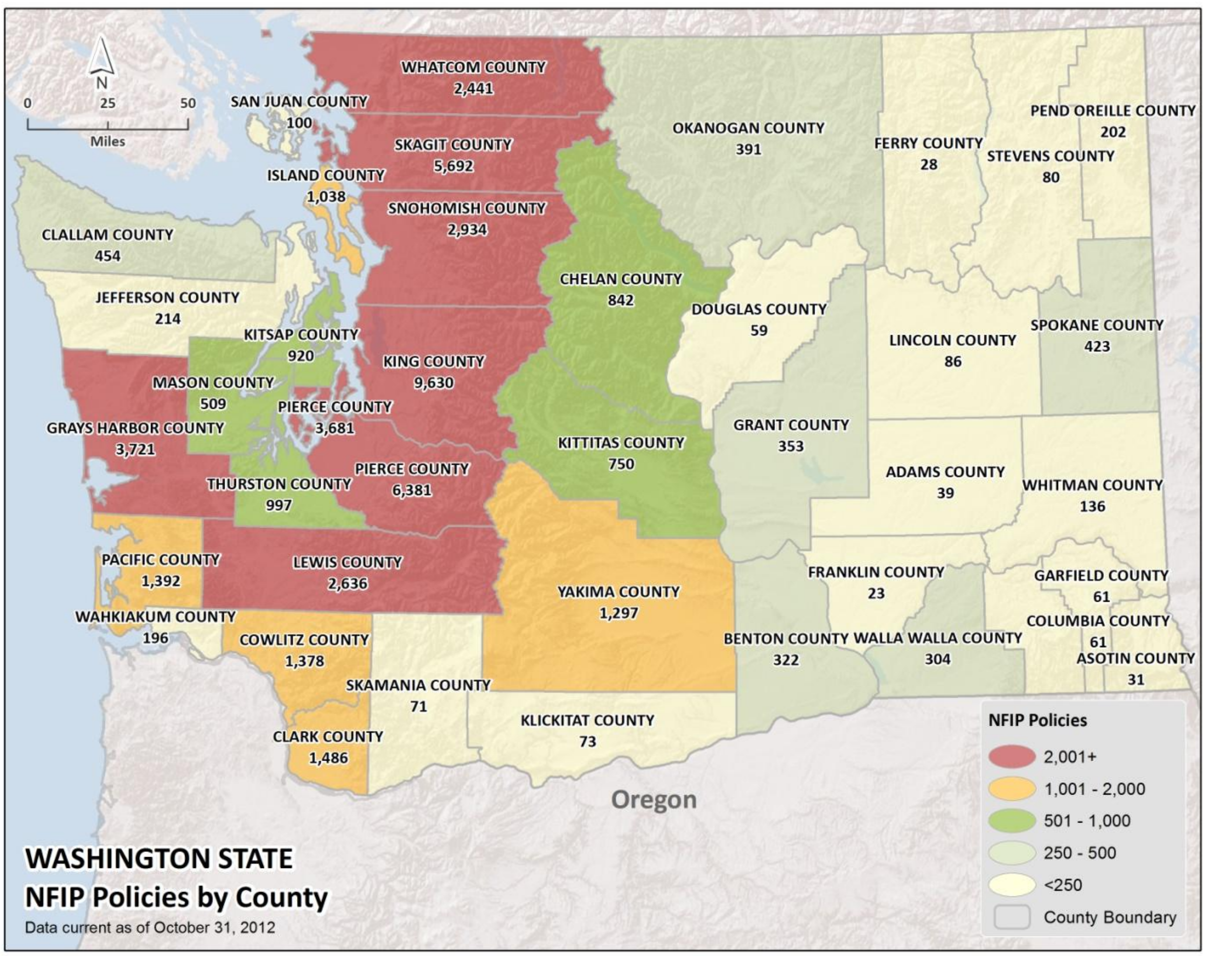
National Flood Insurance Program (NFIP) Policies in Place[46]

Table 7 below shows the twenty counties with the largest number of flood insurance policies currently in force as of October 31, 2012. This number includes their cities, towns, and unincorporated areas. Figure 12 follows which shows policies throughout the state.

Table 7. Twenty Counties with Highest Number of NFIP Policies in Force

County	# Policies	County	# Policies
King	9,630	Yakima	1,297
Skagit	5,692	Island	1,038
Grays Harbor	3,721	Thurston	997
Pierce	3,681	Kitsap	920
Snohomish	2,934	Chelan	842
Lewis	2,636	Kittitas	750
Whatcom	2,441	Mason	509
Clark	1,486	Clallam	454
Pacific	1,392	Spokane	423
Cowlitz	1,378	Okanogan	391

Figure 12 Number of NFIP Policies by County



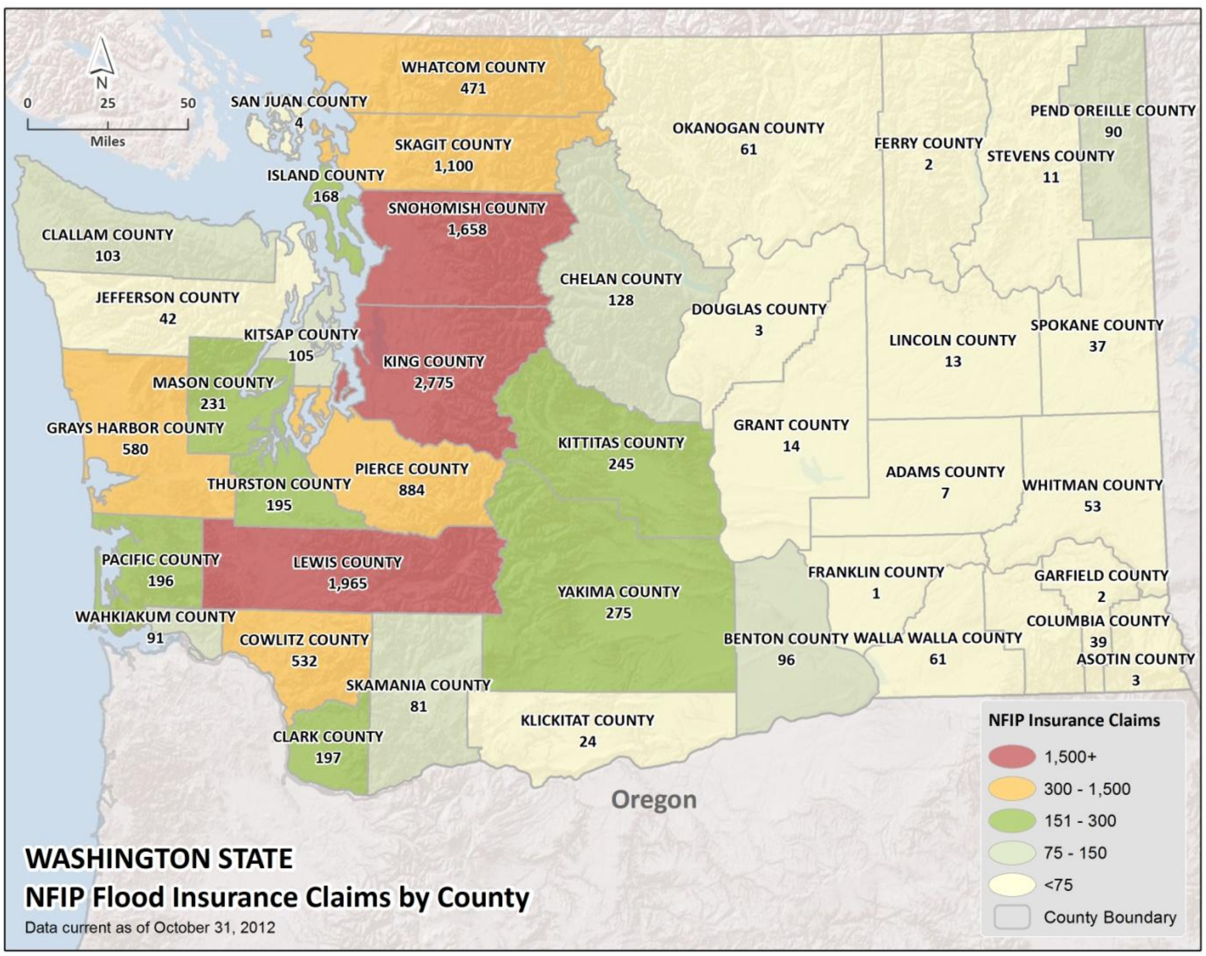
Flood Insurance Claims[47]

Table 8 below shows the twenty counties with most flood insurance claims. This number includes their cities, towns, and unincorporated areas. Figure 13, following the table, shows the claims throughout the state. A complete list of all claim information filed is available at the end of this section as Appendix A.

Table 8. Twenty Counties with Highest Number of NFIP Claims

County	# Claims	County	# Claims
King	2,775	Kittitas	245
Lewis	1,965	Mason	231
Snohomish	1,658	Clark	197
Skagit	1,100	Pacific	196
Pierce	884	Island	168
Grays Harbor	580	Chelan	128
Cowlitz	532	Kitsap	105
Whatcom	471	Clallam	103
Thurston	295	Benton	96
Yakima	275	Wahkiakum	91

Figure 13 Number of NFIP Claims by County



Lastly, NFIP policies and claims are reported by county in Table 9 below.

Table 9. Flood Insurance Policies and Claims by County* Through October 31, 2012

County	No. of Policies	No. of Claims Filed
King	9,630	2,775
Skagit	5,692	1,100
Grays Harbor	3,721	580
Pierce	3,681	884
Snohomish	2,934	1658
Lewis	2,636	1,965
Whatcom	2,441	471
Clark	1,486	197
Pacific	1,392	196
Cowlitz	1,378	532
Yakima	1,297	275
Island	1,038	168
Thurston	997	195
Kitsap	920	105
Chelan	842	128
Kittitas	750	245
Mason	509	231
Clallam	454	103
Spokane	423	37
Okanogan	391	61
Grant	353	14
Benton	322	96
Walla Walla	304	61
Jefferson	214	42
Pend Oreille	202	90
Wahkiakum	196	91
Whitman	136	53
San Juan	100	4
Lincoln	86	13
Stevens	80	11
Klickitat	73	24
Skamania	71	81
Columbia	61	39
Garfield	61	2
Douglas	59	3
Adams	39	7
Asotin	31	3
Ferry	28	2
Franklin	23	1
TOTALS	45,093	12,647

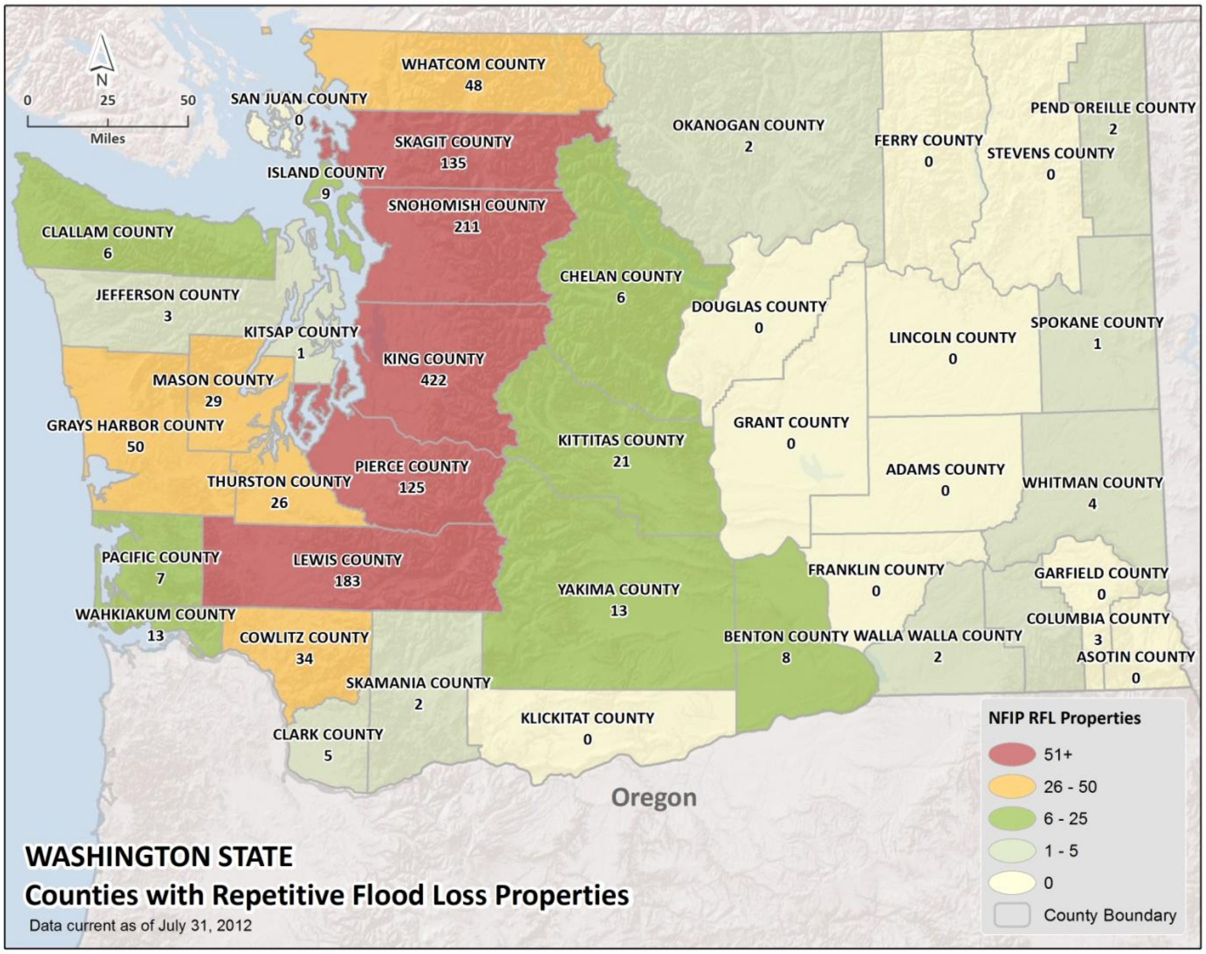
* County total – includes incorporated cities and towns

Repetitive Flood Loss (RFL) Properties[48]
Repetitive Flood Loss Properties can also be an indication of flood risk and vulnerabiilty in the are. Counties with RFL properties are listed in Table 10 and shown in the Figure 14 below.

Table 10. Counties with RFL Properties

County	# RFL Properties*	County	# RFL Properties*
King	422	Benton	8
Snohomish	211	Pacific	7
Lewis	183	Chelan	6
Skagit	135	Clallam	6
Pierce	125	Clark	5
Grays Harbor	50	Whitman	4
Whatcom	48	Jefferson	3
Cowlitz	34	Columbia	3
Mason	29	Okanogan	2
Thurston	26	Pend Oreille	2
Kittitas	21	Skamania	2
Wahkiakum	13	Walla Walla	2
Yakima	13	Kitsap	1
Island	9	Spokane	1
			* Current as of July 2012
Note: County totals include properties in the unincorporated areas of the County as well as the properties inside of the limits of the incorporated cities and towns within those Counties.			

Figure 14 Number of NFIP Repetitive Flood Loss Properties by County



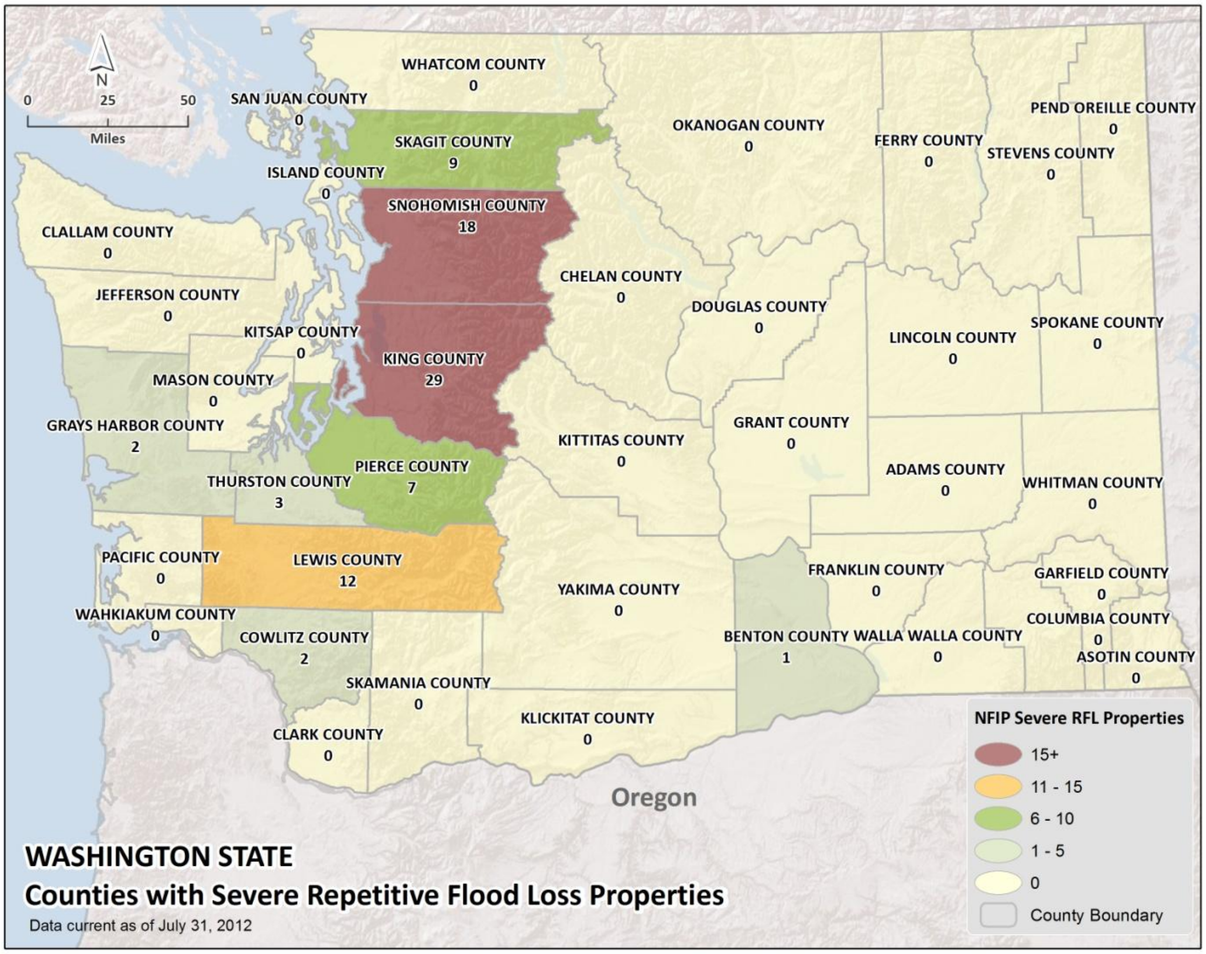
Severe Repetitive Flood Loss Properties[49]

Severe Repetitive Flood Loss Properties can also be an indication of flood risk and vulnerabiilty in the are. Counties with Severe RFL properties are listed in Table 11 and shown in Figure 15 below.

Table 11. Counties with SRL Properties

County	# Severe RFL Properties*
King	29
Snohomish	18
Lewis	12
Skagit	9
Pierce	7
Thurston	3
Cowlitz	2
Grays Harbor	2
Benton	1
Whatcom	1
Total	**91**
	* Current as of July 2012

Figure 15 Number of NFIP Severe Repetitive Flood Loss Properties by County



Jurisdictions Most Vulnerable to Flooding

Jurisdictions most vulnerable to flooding were determined by scoring each county based on the above factors of frequency of flooding that causes major damage, the percentage of the county in floodplain, the number of flood insurance policies currently in effect, the number of flood insurance claims paid, the number of repetitive flood loss properties, and the number of severe repetitive loss properties. The scoring metric is shown in Table 12 below. The jurisdictional results are in Table 13 and Figure 16 below. A maximum value of 28 points was possible (King County received this score). The ten counties with the highest score are considered most vulnerable to flooding and are highlighted in Table 13 and in the Figure 16. Note that county totals include properties in the unincorporated areas of the County as well as the properties inside of the limits of the incorporated cities and towns within those Counties.

Table 12. Scoring Metric for Determining Most Vulnerable Jurisdictions

Approx. Frequency of Occurrence	% Area in 1-pct Riverine ACF	Hazus-MH 2.1 GBS Losses	# Flood Insurance Policies	# Flood Insurance Claims	# Repetitive Flood Loss Properties	# Severe Repetitive Loss	Score
3 Yrs.	6.5% or More	>$2bil	> 2,000	> 750	> 100	10 or more	4 pts each
4 Yrs.	4.0 – 6.4%	$1-2bil	1,000 – 1,999	300 – 749	50 - 99	7 to 9	3 pts each
5 Yrs.	3.0 – 3.9%	$100mil - 1bill	500 – 999	100 – 299	20 - 49	4 to 6	2 pts each
6+Yrs.	0 – 2.9%	<100mil	250 – 499	1 – 99	1 - 19	1 to 3	1 pt each

Table 13. Jurisdictional Results

COUNTY	Approx. Frequency of Occurrence	% Area in 1-pct Riverine ACF	Hazus-MH 2.1 GBS Losses	# Flood Insurance Policies	# Flood Insurance Claims	# Repetitive Flood Loss Properties	# SRL Properties	Score
Adams County	9	3.2	$8,787,000	39	7	-	0	5
Asotin County	6	1.6	$82,724,000	31	3	-	0	4
Benton County	6	6.0	$1,288,925,000	322	96	8	1	9
Chelan County	5	3.7	$1,232,147,000	842	128	6	0	12
Clallam County	4	3.9	$79,133,000	454	103	6	0	10
Clark County	5	11.2	$1,945,812,000	1,486	197	5	0	16
Columbia County	6	2.5	$39,833,000	61	39	3	0	5
Cowlitz County	3	5.1	$3,347,993,000	1,378	532	34	2	20
Douglas County	7	3.9	$239,999,000	59	3	-	0	6
Ferry County	6	3.6	$18,151,000	28	2	-	0	4
Franklin County	11	5.6	$189,014,000	23	1	-	0	7
Garfield County	6	2.2	$7,897,000	61	2	-	0	4
Grant County	11	8.1	$189,431,000	353	14	-	0	9

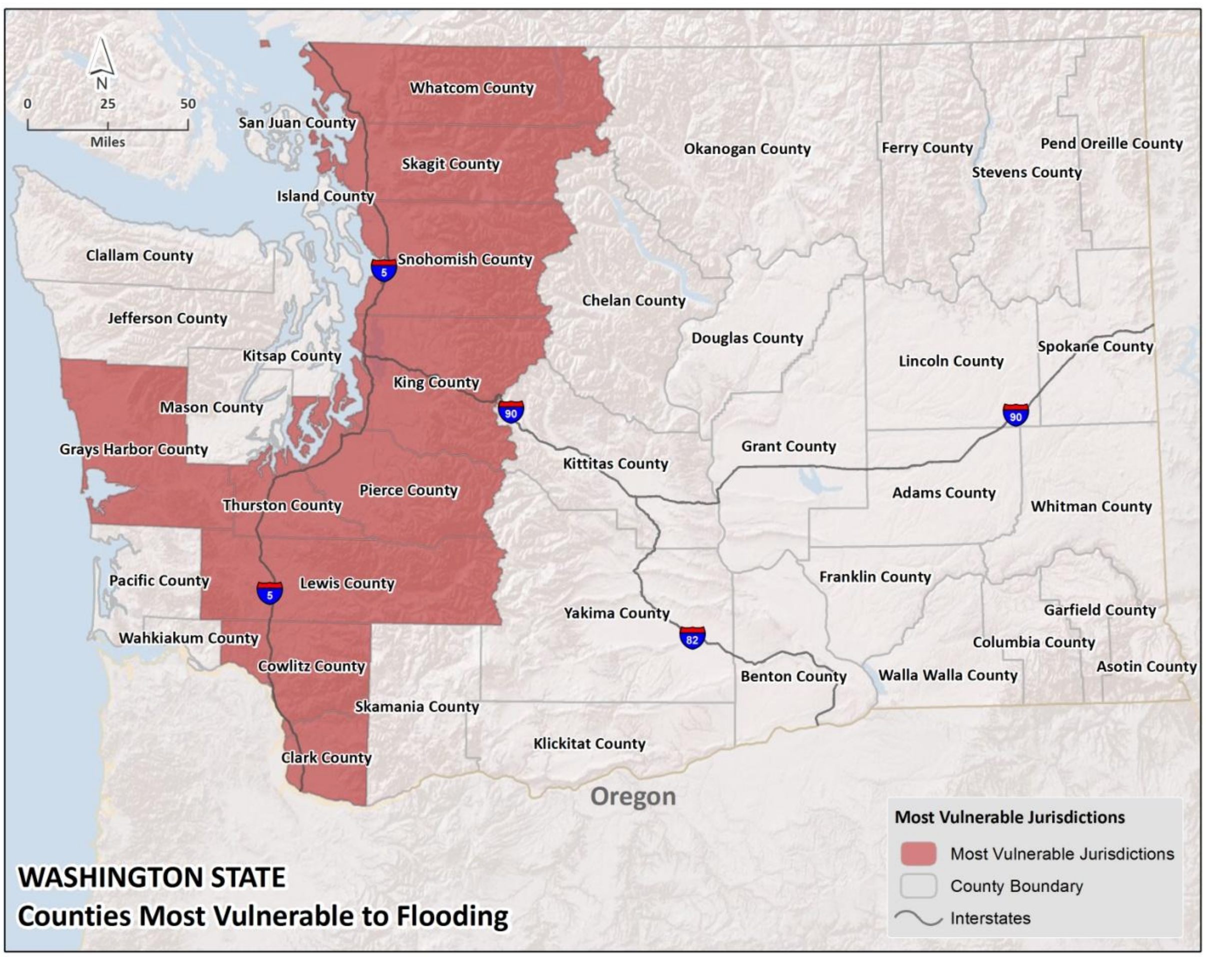
Table 13. Jurisdictional Results

COUNTY	Approx. Frequency of Occurrence	% Area in 1-pct Riverine ACF	Hazus-MH 2.1 GBS Losses	# Flood Insurance Policies	# Flood Insurance Claims	# Repetitive Flood Loss Properties	# SRL Properties	Score
Grays Harbor County	2	9.5	$1,205,714,000	3,721	580	50	2	22
Island County	5	0.6	$20,491,000	1,038	168	9	0	10
Jefferson County	4	2.9	$19,695,000	214	42	3	0	7
King County	2	7.5	$9,765,188,000	9,630	2,775	422	29	28
Kitsap County	4	0.3	$2,111,000	920	105	1	0	10
Kittitas County	4	4.1	$140,146,000	750	245	21	0	14
Klickitat County	4	5.1	$195,911,000	73	24	-	0	9
Lewis County	2	5.7	$678,375,000	2,636	1,965	183	12	25
Lincoln County	6	3.9	$32,822,000	86	13	-	0	5
Mason County	3	3.1	$26,103,000	509	231	29	0	13
Okanogan County	3	2.1	$368,114,000	391	61	2	0	10
Pacific County	3	4.2	$164,442,000	1,392	196	7	0	15
Pend Oreille County	5	2.3	$28,950,000	202	90	2	0	6
Pierce County	3	5.6	$1,873,533,000	3,681	884	125	7	25
San Juan County	6	0.0	N/A	100	4	-	0	4
Skagit County	3	4.0	$156,968,000	5,692	1,100	135	9	24
Skamania County	4	3.7	$192,248,000	71	81	2	0	9
Snohomish County	2	6.0	$1,106,982,000	2,934	1,658	211	18	26
Spokane County	5	3.4	$335,128,000	423	37	1	0	9
Stevens County	6	3.8	$67,918,000	80	11	-	0	5

Table 13. Jurisdictional Results

COUNTY	Approx. Frequency of Occurrence	% Area in 1-pct Riverine ACF	Hazus-MH 2.1 GBS Losses	# Flood Insurance Policies	# Flood Insurance Claims	# Repetitive Flood Loss Properties	# SRL Properties	Score
Thurston County	2	7.5	$327,855,000	997	195	26	3	17
Wahkiakum County	3	6.5	$11,899,000	196	91	13	0	12
Walla Walla County	7	5.5	$122,347,000	304	61	2	0	11
Whatcom County	5	4.2	$235,661,000	2,441	471	48	1	17
Whitman County	3	4.2	$131,023,000	136	53	4	0	11
Yakima County	4	5.0	$1,802,849,000	1,297	275	13	0	15

Figure 16 Counties Most Vulnerable to Flooding



Potential Climate Change Impacts[50,51,52,53,54,55]

Vulnerability to flood hazards is a function of location, type of human activity, use, and frequency of flooding events. The effects of flooding on people and structures can be lessened by total avoidance of flood hazard areas or by restricting, prohibiting, or imposing conditions on hazard-zone activity. Local governments can reduce flooding effects through land-use policies and regulations. Individuals can reduce their exposure to hazards by educating themselves on the past history of a site and by making inquiries to planning and engineering departments of local governments. In addition, it is highly advised to consult the professional services of an engineering geologist, geotechnical engineer, or a civil engineer, who can properly evaluate a site, built or un-built.

Climate change is a slow onset hazard, occurring over a long period of time. To some degree, it is a natural occurrence though evidence suggests that human activity hastens the onset and magnitude of this hazard. It may include conditions such as extreme winter weather or unusual timing of seasonal events that impacts several interrelated systems such as when plants bloom or when streams are fullest. Other factors include increased severity of known hazards. Climate change can exacerbate flooding severity including the depth of water, extent of areas inundated, and the velocity, or force, of the water's flow. In turn, this puts more people and property at risk to flooding and its associated hazards. Sea level rise is also associated with this phenomenon which impacts Washington's coastline.

Sea level rise is defined as the mean rise in sea level. It is thought to be caused by two factors: 1) rising ocean temperature - as the ocean warms, sea water expands in volume; 2) continental ice shelf melt - this increasing the amount of water in the oceans. This leads to a greater area of land being inundated by sea water. NOAA records indicate that sea level has been steadily rising at a rate of 0.04 to 0.1 inches per year since 1900, and further evidence shows this rate is increasing perhaps up to a rate of 0.12 inches per year.[56] The United Nation's Intergovernmental Panel on Climate Change (IPCC) reports that from 1993 to 2003, global sea level rose about 3 millimeters (approximately 0.12 inches) each year, and approximately half of that increase is attributed to the ocean expanding as it warms. While a sea rise of a few millimeters may seem insignificant, Carol Auer, an Oceanographer with the National Oceanic and Atmospheric Administration (NOAA) says, "A half-inch of vertical sea level rise translates to about three feet of land lost on a sandy open coast, due to long term erosion. Moreover, even a slightly higher sea level can cause more dramatic deltas and estuary tides. Rising sea levels also make coastal areas more vulnerable to storm surges, and in turn, to flooding". According to a 2009 NOAA report, historic sea level rise is 0.8 inches per decade in Washington based on data from 1854 to 2006.[57] Climate Central, an independent agency, reported a projected sea level rise of 11 inches by 2050.[58] A 2005 Department of Ecology and University of Washington presentation suggested that areas near Seattle and Tacoma will rise of 1 meter by 2100. Areas near Friday Harbor and Neah Bay were projected to experience a lesser rise of 0.5 meters.[59] Other predictions suggest some areas of the Washington's coastline may experience sea level fall due land being pushed upward along the Cascadia Subduction Zone.[60] As suggested by these studies, sea level rise is a relatively new hazard to be studied lending it to some discrepancy in future projections. The State of Washington has begun to put measures in place to mitigate and decelerate the impacts occurring in the state.

According to a 2005 Governor's report prepared by the Climate Impacts Group titled *Uncertain Future: Climate Change and its Effects on Puget Sound*, from "paleoclimatological evidence, we know that over the history of the earth high levels of greenhouse gas concentrations have correlated with, and to a large extent caused, significant warming to occur, with impacts generated on a global scale." While the report also indicates that the "ultimate impact of climate change on any individual species or ecosystem cannot be predicted with precision," there is no doubt that Washington's climate has demonstrated change.

In July 2007, the Climate Impacts Group launched an unprecedented assessment of climate change impacts on Washington State. *The Washington Climate Change Impacts Assessment* (WACCIA) involved developing updated climate change scenarios for Washington State and using these scenarios to assess the impacts of climate change on the following sectors: agriculture, coasts, energy, forests, human health, hydrology and water resources, salmon, and urban stormwater infrastructure. The assessment was funded by the Washington State Legislature through House Bill 1303.

Also signed 2007 was Executive Order 07-02 Washington Climate Change Challenge. It established goals for reducing greenhouse emissions, creating jobs and reducing fuels spending. According to the Department of Ecology, it also directed the state to assess steps required to prepare for the impacts of climate change on water supply, public health, agriculture, forestry and coastal areas.

In 2009, the Washington State Legislature approved the *State Agency Climate Leadership Act* Senate Bill 5560. The Act committed state agencies to lead by example in reducing their greenhouse gas (GHG) emissions to: 15 percent below 2005 levels by 2020; 36 percent below 2005 by 2035; and 57.5 percent below 2005 levels (or 70 percent below the expected state government emissions that year, whichever amount is greater.). The Act, codified in RCW 70.235.050-070, directed agencies to annually measure their greenhouse gas emissions, estimate future emissions, track actions taken to reduce emissions, and develop a strategy to meet the reduction targets. Starting in 2012 and every two years thereafter, each state agency is required to report to Washington State Department of Ecology the actions taken to meet the emission reduction targets under the strategy for the preceding biennium.

Executive Order 09-05 was also passed in 2009, which was called Washington's Leadership on Climate Change. It had several requirements including a strategy to reduce the state's statutory greenhouse gas reduction limits, industry emission benchmarks, and joining West Coast states and the private sector to develop and implement a "West Coast Green Highway."

Recognizing Washington's vulnerability to climate impacts, the Legislature and Governor Chris Gregoire directed state agencies to develop an integrated climate change response strategy to help state, tribal and local governments, public and private organizations, businesses and individuals prepare. The state Departments of Agriculture, Commerce, Ecology, Fish and Wildlife, Health, Natural Resources and Transportation worked with a broad range of interested parties to develop recommendations that form the basis for a report by the Department of Ecology: *Preparing for a Changing Climate: Washington State's Integrated Climate Change Response Strategy*.

Over the next 50 - 100 years, the potential exists for significant climate change impacts on Washington's coastal communities, forests, fisheries, agriculture, human health, and natural disasters. These impacts could potentially include increased annual temperatures, rising sea level, increased sea surface temperatures, more intense storms, and changes in precipitation patterns. Therefore, climate change has the potential to impact the occurrence and intensity of natural disasters, potentially leading to additional loss of life and significant economic losses. Recognizing the global, regional, and local implications of climate change, Washington State has shown great leadership in addressing mitigation through the reduction of greenhouse gases.

Some suggest that there is a better way to deal with floods: the "soft path" to flood risk management. The "soft path" strategy to flood management takes into account the fact that floods will happen and to learn to deal with them the best way possible. This strategy is also based on an understanding that flooding is essential for the health of riverine ecosystems. A "soft path" approach means taking measures to reduce the speed, size and duration of floods by restoring meanders and wetlands…." This approach "also means doing all we can to get out of floods' destructive path with improved warning and evacuation measures. Such practices are already in use in some parts of the United States and around the world. Improving our ability to cope with floods requires adopting a more sophisticated set of techniques. The "soft path" of flood management should be a core part of efforts to adapt to a changing climate. Such a strategy may reduce deaths due to flooding and could result in much healthier rivers and streams.

At Risk State Facilities

A Hazus-MH 2.1 analysis was employed to model potential building losses due to flooding for state-owned and state-leased facilities utilizing the Washington State Office of Financial Managements 2012 dataset of state operated facilities.

The analysis for the state owned facilities utilized the 1.0-percent annual chance riverine floodplain data used to determine 1.0-percent annual chance losses (as described above in the Hazus-MH 2.1 Flood Methodology and Results section). State operated facilities were run as Hazus User Defined Facilities. Hazus User Defined Facilities are represented as a point at a specific latitude/longitude location and not as the entire footprint of the building on the ground. Data specific to each building such as elevation, value, area, number of floors, and construction type were utilized in the analysis for each building within Hazus-MH 2.1.

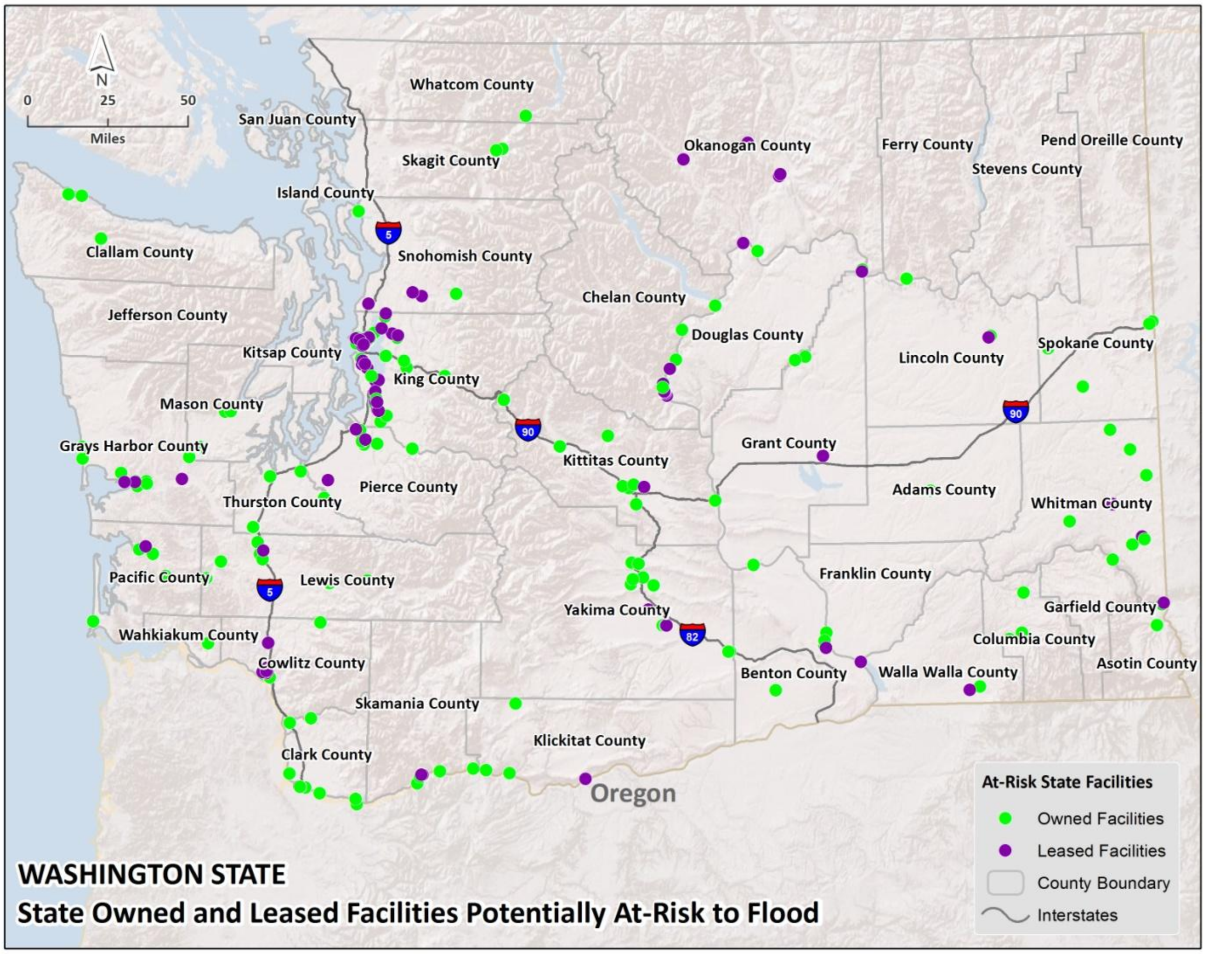
Assumptions were made to the OFM data in order to be used by Hazus as User Defined Facilities. Most critically, building type and building replacement value needed attention. For building type, it was assumed that all structures were one story and constructed of wood. It should be noted that this is not the true building construction of all buildings modeled but was a necessary assumption to analyze the large number of buildings with limited available data. Regarding building replacement value, there were both missing and erroneous data in the OFM data. Therefore, 2012 R.S. Means Facilities Construction Cost data was used to determine building replacement cost using a combination of the building occupancy (Hazus classification of Government buildings (GOV1)), existing building square footage, year built and the assumed building type. Content values were determined based on guidance in the Hazus Technical Manual, which states that GOV1 occupancies have a content value that is equal to the building replacement value. Lastly, it was assumed that each building had an elevation of one foot above the ground (indicating flood level would have to exceed one foot damages).

A total of 9,975 state facilities were analyzed in the state based on Washington State Office of Financial Management (OFM) 2012 dataset of state leased and owned facilities. Their combined estimated replacement value and area was determined to be $13,363,228,000 and 105,060,000 square feet, respectively. Of these buildings, 8,893 were reported as owned and 1,082 were reported as leased. State owned buildings have a combined exposure (building replacement value) of $11,858,700,000 and leased buildings have a combined replacement value of $1,504,528,000. State owned buildings have a combined area of 93,425,000 square feet, and leased buildings have a combined area of 11,635,000 square feet.

Hazus-MH 2.1 was run for the 1.0-percent annual chance riverine floodplain. This analysis found over 1,000 state owned and leased facilities that are potentially at-risk to flooding throughout the state. A majority, 851, are state-owned properties. The state owned facilities have an estimated building loss of approximately $400,208,000 and approximated contents loss of $953,000,000. This results in a loss ratio for building and contents of 10 percent. Leased facilities may experience an estimated building loss of $24,844,000 and content losses of $79,956,000, representing a loss ratio of about 1 percent of the total state operated facilities.

As could be expected, many of these facilities reside in the most vulnerable jurisdictions located in the western portion of the state along the Puget Sound. Additional concentrations are located in southeastern portion of the state, especially Whitman County, and in the middle of the state within Douglas, Kittitas, and Yakima counties. A complete list of the at-risk facilities, including potential damage to the building and contents, is in WA EMD's possession. A map of those facilities found to be potentially at-risk to the 1.0-percent annual chance flood is depicted in the map below.

Figure 17 State Owned and Leased Facilities At-Risk to the 1.0-percent Annual Chance Riverine Flood



What's Next?

Flood Control Assistance Account Program (FCAAP)

For the 2009-2011 biennium, the Governor's recommended budget included an additional $4 million for flood damage prevention grants. However, due to State revenue shortfalls, this addition was lost along with 50% of the existing FCAAP allocation. Since the need for such funding has been well documented, as FCAAP grant funds requested generally exceed available funds by 400-600%, Ecology hopes to secure additional funding in future biennia. During the next three year planning cycle update (2010 – 2013), Washington State Department of Ecology plans to continue to seek legislative authorization to secure additional funding for the Flood Control Assistance Account Program (FCAAP) to provide more and larger grants for flood hazard mitigation projects.

Although final budgets have yet to be approved by the legislature and the Governor's office (during, the 2013 State Hazard Mitigation Plan Update), indications are that the FCAAP will be reduced 50% again this biennium. That means there will be only $2M in the account, and a competitive grants program will not be offered for the 2013-2015 biennium. There is a possibility that a new capital-budget based fund source for a competitive flood hazard reduction grant program will be approved this session, but that remains to be determined.

FCAAP grants will continue to be coordinated with the State Emergency Management Division's (EMD) operation of their hazard mitigation grants to the fullest extent possible. Staff from each agency will continue to participate in the grant application evaluation process for both FCAAP and the unified HMA grants (including the new National Flood Mitigation program), and other potential funding sources for flood grant projects.

Severe Repetitive Loss (SRL) Program

Ecology and EMD are in the process of developing a strategy to maximize the use of the Severe Repetitive Loss (SRL) Program grant funding. This effort will target the 91 SRLs in the state and will include the use of Increased Cost of Compliance (ICC) funds from the property owners' flood insurance policies. It will include training for local governments, outreach, and coordination with FEMA Region X staff.

Floodplain Management

Ecology is working closely with FEMA Region-X on the implementation of higher standards for the 122 communities in Puget Sound that are under the jurisdiction of the Puget Sound Biological Opinion for Salmon and Orca (BiOp). The BiOp requires implementation of the Reasonable and Prudent measures to ensure that activities under the NFIP do not cause negative impacts to ESA listed species or their critical habitat.

Ecology has joined with EPA, FEMA, NOAA, Puget Sound Partnership, The Nature Conservancy, USACE, and USGS in Floodplains by Design. One of the first projects is to overlay insurance claims, SRL, and RL properties against fish restoration habitat in a GIS environment to identify properties for functional evaluation as future buyout properties that will provide both flood mitigation and fish habitat.[61]

Additionally, the Puget Sound Partnership Action Agenda includes the Protect and Restore Floodplain Function as the Upland and Terrestrial Strategy number A5 in its latest plan. The Action Agenda sets two recovery targets for floodplains in the Puget Sound that it aims to achieve by 2020: 15 percent of degraded floodplain areas are restored or floodplain projects to achieve that outcome are underway across Puget Sound; and No additional loss of floodplain function in any Puget Sound watershed relative to a 2011 baseline.[62]

Other Floodplain Management Initiatives

There is also considerable funding and activity occurring in various parts of the state in regard to flood hazard reduction, including but not limited to; 1) the creation of a new flood wall in the Mt. Vernon area, 2) upgrades, setbacks, and replacement structures in the Green River valley in King County, and 3) a major flood hazard reduction study and related projects in the Chehalis River basin. All of these actions include some level of state funding, running into the tens of millions of dollars.

Risk MAP (Risk Mapping Assessment and Planning)

The purpose behind FEMA's Risk MAP Strategy is to constantly reduce losses to life and property. Flood mapping is used for risk assessments which are incorporated into mitigation plans where risk reduction measures are identified for future action. The top twenty watersheds were analyzed and ranked by risk as part of Risk MAP. The study can be found below in Appendix B. The Lower Skagit, Puget Sound and Strait of Georgia watersheds ranked highest.

Current Risk MAP activities (as of April 1, 2013) are outlined below:

Table 14. Current Risk MAP activities (as of April 1, 2013)

Project Name	STATUS	Date
Cowlitz - Castle Rock	On-hold	10/31/2011
King County CTP FY09	Active	2/1/2013
Kitsap County Coastal PMR - FY11 (C)	Active	2/27/2014
Snohomish County Coastal PMR - FY11 (C)	Active	2/28/2014
Cowlitz County PAL PMR-FY09 (L)	On-hold	10/31/2012
Cowlitz River-Kelso PAL Cowlitz County PMR-FY09 (L)	On-hold	10/31/2012
Longview PAL Cowlitz County PMR-FY09 (L)	On-hold	10/31/2012
Thornton Creek PMR-FY10 (O)	Active	12/31/2012
Deschutes FY12 (WO) HUC17110016	Active	9/30/2014
Grays Harbor Coastal PMR-FY09-(C)	Active	10/24/2012
Island County Coastal-FY12 (C)	Active	2/26/2015
Kittitas County CW-FY09 (EO)	Active	5/20/2013
Lower Chehalis FY12 (WO) HUC17100104	Active	11/5/2013
Mason County Coastal-CW-FY12 (C)	Active	5/5/2014
Naches-Yakima County-FY10 (W)-HUC17030002	Active	10/31/2014
Pacific County CW Coastal-FY09 (C)	Active	5/10/2013
Pierce County Coastal PMR- FY-11 (C)	Active	12/30/2013
Salish Sea Coastal FY 12 (C)	Active	
Washougal PAL-Clark County PMR-FY09 (L)	On-hold	9/28/2012
Skagit Co. Coastal PMR-FY12 (C)	Active	2/21/2015

Thurston County Coastal PMR-FY11 (C)	Active	1/15/2014
White River-Pierce County PMR-FY09 (OE)	On-hold	6/30/2013
Whatcom County Coastal PMR-FY12 (C)	Active	2/14/2015
Whitman County CW-FY09 (EO)	On-hold	12/27/2012
Woodland PAL Cowlitz County PMR-FY09 (L)	On-hold	10/31/2012

Appendix A[63]

NFIP Loss Statistics by Washington State Jurisdictions
1978 through January 31, 2013

LOSS STATISTICS
WASHINGTON
AS OF 01/31/2013

COUNTY NAME	COMMUNITY NAME	TOTAL LOSSES	CLOSED LOSSES	OPEN LOSSES	CWOP LOSSES	TOTAL PAYMENTS
ADAMS COUNTY	LIND, TOWN OF	1	1	0	0	18,431.39
	RITZVILLE, CITY OF	3	2	0	1	6,545.26
	WASHTUCNA, TOWN OF	1	1	0	0	2,241.04
ASOTIN COUNTY	ASOTIN COUNTY*	3	3	0	0	15,664.29
BENTON COUNTY	BENTON CITY, TOWN OF	20	15	0	5	211,461.44
	BENTON COUNTY *	45	35	0	10	613,792.45
	KENNEWICK, CITY OF	4	2	0	2	7,288.30
	PROSSER, CITY OF	1	1	0	0	8,154.30
	RICHLAND, CITY OF	17	11	0	6	175,651.79
	WEST RICHLAND, TOWN OF	10	9	0	1	207,335.97
CHELAN COUNTY	CASHMERE, CITY OF	7	1	0	6	7,976.50
	CHELAN COUNTY *	99	74	0	25	975,185.13
	LEAVENWORTH, CITY OF	4	3	0	1	87,000.27
	WENATCHEE, CITY OF	18	6	0	12	5,093.37
CLALLAM COUNTY	CLALLAM COUNTY *	85	47	0	38	950,517.16
	FORKS, CITY OF	1	1	0	0	2,556.64
	PORT ANGELES, CITY OF	10	6	0	4	78,283.49
	SEQUIM, CITY OF	7	2	0	5	55,797.74
CLARK COUNTY	BATTLE GROUND, CITY OF	3	2	0	1	3,265.40
	CAMAS, CITY OF	4	3	0	1	13,710.27
	CLARK COUNTY *	102	77	0	25	1,666,659.68
	VANCOUVER, CITY OF	9	4	0	5	101,610.40
	WASHOUGAL, CITY OF	10	8	0	2	71,369.59
	WOODLAND, CITY OF	69	51	0	18	988,025.89
COLUMBIA COUNTY	COLUMBIA COUNTY*	2	1	0	1	7,903.48
	DAYTON, CITY OF	36	25	0	11	141,396.90
	STARBUCK, CITY OF	1	0	0	1	.00
COWLITZ COUNTY	CASTLE ROCK, CITY OF	29	22	0	7	616,450.54
	COWLITZ COUNTY *	411	346	0	65	8,988,647.84
	KALAMA, CITY OF	3	3	0	0	93,973.60
	KELSO, CITY OF	49	38	0	11	820,639.15
	LONGVIEW, CITY OF	40	24	0	16	366,434.48
DOUGLAS COUNTY	DOUGLAS COUNTY *	3	3	0	0	20,029.18
FERRY COUNTY	FERRY COUNTY *	2	1	0	1	11,770.96
FRANKLIN COUNTY	FRANKLIN COUNTY *	1	0	0	1	.00
GARFIELD COUNTY	POMEROY, CITY OF	2	1	0	1	94.98
GRANT COUNTY	EPHRATA, CITY OF	12	2	0	10	9,100.42
	GRANT COUNTY*	1	1	0	0	2,423.42
	MOSES LAKE, CITY OF	1	1	0	0	1,776.84
GRAYS HARBOR COUNTY	ABERDEEN, CITY OF	221	144	1	76	686,941.00
	COSMOPOLIS, CITY OF	3	3	0	0	2,021.76
	ELMA, CITY OF	18	18	0	0	487,641.12
	GRAYS HARBOR COUNTY*	210	188	1	21	4,413,813.63
	HOQUIAM, CITY OF	76	53	2	21	412,631.25
	MONTESANO, CITY OF	15	14	0	1	195,095.97
	OAKVILLE, CITY OF	8	8	0	0	231,456.51
	OCEAN SHORES, CITY OF	22	12	0	10	194,080.31
	WESTPORT, CITY OF	12	7	0	5	96,860.90
ISLAND COUNTY	ISLAND COUNTY *	182	115	15	52	1,193,738.33
	LANGLEY, CITY OF	2	0	0	2	.00
JEFFERSON COUNTY	JEFFERSON COUNTY *	34	22	1	11	316,932.41
	PORT TOWNSEND, CITY OF	9	4	0	5	26,687.08

KING COUNTY	AUBURN, CITY OF	10	6	0	4	43,341.02
	BELLEVUE, CITY OF	45	31	1	13	535,787.38
	BOTHELL, CITY OF	10	7	0	3	33,665.27
	BURIEN, CITY OF	17	10	0	7	84,053.59
	CARNATION, CITY OF	26	21	0	5	786,646.68
	DES MOINES, CITY OF	4	4	0	0	211,934.98
	DUVALL, CITY OF	4	4	0	0	146,511.59
	ENUMCLAW, CITY OF	3	3	0	0	69,500.65
	FEDERAL WAY, CITY OF	1	0	1	0	.00
	ISSAQUAH, CITY OF	148	123	0	25	3,974,505.06
	KENMORE, CITY OF	1	1	0	0	14,697.30
	KENT, CITY OF	31	12	0	19	129,404.88
	KING COUNTY*	1,175	954	11	210	21,277,014.81
	KIRKLAND, CITY OF	7	4	0	3	44,518.84
	LAKE FOREST PARK, CITY OF	4	1	0	3	1,886.44
	MERCER ISLAND, CITY OF	5	1	0	4	6,952.20
	MILTON, CITY OF	4	4	0	0	70,379.73
	NORMANDY PARK, CITY OF	7	3	0	4	13,978.43
	NORTH BEND, CITY OF	78	61	0	17	985,053.86
	PACIFIC, CITY OF	25	24	0	1	436,228.15
	REDMOND, CITY OF	10	4	0	6	21,542.88
	RENTON, CITY OF	17	10	0	7	84,974.92
	SAMMAMISH, CITY OF	2	2	0	0	41,996.22
	SEATAC, CITY OF	1	1	0	0	1,319.24
	SEATTLE, CITY OF	197	107	13	77	1,443,105.21
	SHORELINE, CITY OF	1	1	0	0	4,021.74
	SKYKOMISH, TOWN OF	18	18	0	0	304,215.24
	SNOQUALMIE, CITY OF	950	866	0	84	17,963,766.70
	TUKWILA, CITY OF	3	1	0	2	1,309.89
KITSAP COUNTY	BAINBRIDGE ISLAND, CITY OF	8	4	2	2	96,975.25
	BREMERTON, CITY OF	7	5	0	2	8,905.60
	KITSAP COUNTY *	98	51	4	43	1,503,205.62
KITTITAS COUNTY	CLE ELUM, CITY OF	13	10	0	3	205,420.05
	ELLENSBURG, CITY OF	26	18	0	8	195,494.80
	KITTITAS COUNTY *	194	159	1	34	2,208,149.14
	KITTITAS, TOWN OF	11	5	0	6	8,610.64
	SOUTH CLE ELUM, CITY OF	1	1	0	0	8,374.12
KLICKITAT COUNTY	GOLDENDALE, CITY OF	1	1	0	0	4,595.36
	KLICKITAT COUNTY *	23	21	0	2	305,085.56
LEWIS COUNTY	CENTRALIA, CITY OF	717	668	1	48	25,448,455.26
	CHEHALIS, CITY OF	511	445	4	62	28,085,458.58
	LEWIS COUNTY *	729	638	4	87	22,605,362.81
	MORTON, CITY OF	1	0	0	1	.00
	PE ELL, TOWN OF	1	1	0	0	37,770.81
	TOLEDO, CITY OF	4	3	0	1	75,538.10
	WINLOCK, TOWN OF	2	1	0	1	859.31
LINCOLN COUNTY	ALMIRA, TOWN OF	2	1	0	1	3,338.05
	SPRAGUE, CITY OF	8	6	0	2	95,694.71
	WILBUR, TOWN OF	2	1	0	1	2,477.83
MASON	SKOKOMISH INDIAN TRIBE	1	1	0	0	728.40
MASON COUNTY	MASON COUNTY*	222	185	3	34	3,652,659.75
	SHELTON, CITY OF	12	8	0	4	132,510.12
OKANOGAN COUNTY	BREWSTER, TOWN OF	1	1	0	0	4,700.29
	OKANOGAN COUNTY *	30	19	0	11	268,266.87
	OKANOGAN, CITY OF	13	9	0	4	31,871.31
	OMAK, CITY OF	5	5	0	0	65,180.53
	OROVILLE, TOWN OF	9	6	0	3	12,179.27
	PATEROS, TOWN OF	1	0	0	1	.00
	TONASKET, TOWN OF	1	0	0	1	.00
	WINTHROP, TOWN OF	1	0	0	1	.00
PACIFIC COUNTY	ILWACO, TOWN OF	4	2	0	2	4,595.09
	LONG BEACH, TOWN OF	1	1	0	0	5,025.50
	PACIFIC COUNTY *	136	96	0	40	2,379,071.20
	RAYMOND, CITY OF	39	35	0	4	262,004.67
	SOUTH BEND, CITY OF	16	11	0	5	54,878.72
PEND OREILLE COUNTY	CUSICK, TOWN OF	3	3	0	0	70,646.02
	METALINE, TOWN OF	1	1	0	0	1,907.32
	NEWPORT, CITY OF	2	2	0	0	28,451.57
	PEND OREILLE COUNTY *	84	75	0	9	1,214,555.92
PIERCE COUNTY	BONNEY LAKE, CITY OF	2	2	0	0	8,753.69
	BUCKLEY, CITY OF	5	4	0	1	127,368.45
	FIFE, CITY OF	4	3	0	1	19,232.23
	FIRCREST, CITY OF	12	8	0	4	79,427.69
	GIG HARBOR, TOWN OF	2	1	0	1	2,375.03
	ORTING, TOWN OF	32	22	0	10	345,247.27
	PIERCE COUNTY*	515	418	9	88	11,233,945.06
	PUYALLUP, CITY OF	90	69	0	21	2,729,905.04
	SOUTH PRAIRIE, TOWN OF	18	15	0	3	198,616.37
	STEILACOOM, TOWN OF	2	2	0	0	12,279.65
	SUMNER,CITY OF	132	112	2	18	3,879,810.24
	TACOMA, CITY OF	80	60	0	20	1,350,952.61
	WILKESON, TOWN OF	3	3	0	0	36,351.45
SAN JUAN COUNTY	SAN JUAN COUNTY*	4	2	0	2	26,407.09

SKAGIT COUNTY	BURLINGTON, CITY OF	30	16	0	14	45,650.94
	CONCRETE, TOWN OF	15	12	0	3	93,078.44
	HAMILTON, TOWN OF	224	198	0	26	3,911,359.77
	LA CONNER, TOWN OF	5	2	0	3	2,664.54
	MOUNT VERNON, CITY OF	98	62	0	36	590,616.19
	SEDRO- WOOLLEY, CITY OF	35	29	0	6	336,318.68
	SKAGIT COUNTY *	693	563	2	128	7,272,877.18
SKAMANIA COUNTY	SKAMANIA COUNTY *	79	72	0	7	1,350,490.20
	STEVENSON, TOWN OF	2	2	0	0	19,363.38
SNOHOMISH COUNTY	ARLINGTON, CITY OF	8	8	0	0	202,257.57
	BRIER, CITY OF	3	1	0	2	9,680.81
	DARRINGTON, TOWN OF	3	1	0	2	132,901.34
	EDMONDS, CITY OF	18	13	0	5	334,295.64
	EVERETT, CITY OF	13	8	1	4	219,839.71
	GOLD BAR, CITY OF	1	1	0	0	1,002.24
	GRANITE FALLS, CITY OF	1	0	0	1	.00
	INDEX, TOWN OF	36	30	0	6	715,457.38
	LAKE STEVENS, CITY OF	4	3	0	1	17,059.83
	LYNNWOOD, CITY OF	25	22	2	1	948,012.99
	MARYSVILLE, CITY OF	9	6	0	3	50,552.17
	MONROE, CITY OF	66	60	0	6	784,316.21
	MOUNTLAKE TERRACE, CITY OF	5	4	0	1	51,411.08
	MUKILTEO, CITY OF	4	1	1	2	4,015.00
	SNOHOMISH COUNTY *	1,203	985	9	209	18,905,849.63
	SNOHOMISH, CITY OF	54	47	0	7	1,040,420.33
	STANWOOD, CITY OF	35	23	0	12	412,078.64
	SULTAN, CITY OF	183	162	0	21	2,617,572.12
SPOKANE COUNTY	CHENEY, CITY OF	1	0	0	1	.00
	MEDICAL LAKE, CITY OF	1	0	0	1	.00
	SPANGLE, CITY OF	4	4	0	0	193,449.23
	SPOKANE COUNTY*	19	11	0	8	191,360.20
	SPOKANE, CITY OF	12	9	0	3	112,978.89
STEVENS COUNTY	CHEWELAH, CITY OF	6	2	0	4	5,079.58
	STEVENS COUNTY *	5	4	0	1	45,526.41
THURSTON COUNTY	BUCODA, TOWN OF	43	38	0	5	257,010.48
	LACEY, CITY OF	3	1	0	2	8,088.08
	OLYMPIA, CITY OF	20	16	0	4	369,197.88
	TENINO, CITY OF	7	7	0	0	105,231.94
	THURSTON COUNTY *	220	173	3	44	3,466,400.57
	TUMWATER, CITY OF	2	2	0	0	12,514.40
	YELM, CITY OF	2	1	0	1	7,602.70
WAHKIAKUM COUNTY	CATHLAMET, TOWN OF	1	1	0	0	4,906.03
	WAHKIAKUM COUNTY *	92	75	3	14	1,682,803.69
WALLA WALLA COUNTY	COLLEGE PLACE, CITY OF	1	1	0	0	4,259.05
	WAITSBURG, CITY OF	31	25	0	6	394,036.41
	WALLA WALLA COUNTY *	29	21	0	8	315,907.64
WHATCOM COUNTY	BELLINGHAM, CITY OF	26	19	0	7	659,075.54
	BLAINE, CITY OF	2	2	0	0	22,115.36
	EVERSON, CITY OF	46	38	0	8	426,052.24
	FERNDALE, CITY OF	37	29	0	8	1,048,432.06
	LUMMI INDIAN RESERVATION	9	6	2	1	141,846.11
	LYNDEN, CITY OF	4	4	0	0	16,134.99
	NOOKSACK, CITY OF	2	1	0	1	1,843.30
	SUMAS, CITY OF	66	53	0	13	757,631.16
	WHATCOM COUNTY *	288	220	4	64	3,630,254.53
WHITMAN COUNTY	ALBION, TOWN OF	4	4	0	0	38,033.66
	ENDICOTT, TOWN OF	1	1	0	0	1,432.85
	GARFIELD, TOWN OF	2	2	0	0	24,665.92
	PALOUSE, CITY OF	8	4	0	4	262,593.41
	PULLMAN, CITY OF	29	22	0	7	136,666.04
	ROSALIA, TOWN OF	3	1	0	2	9,183.40
	WHITMAN COUNTY *	6	3	0	3	1,956.71
YAKIMA COUNTY	NACHES, CITY OF	4	2	0	2	27,324.86
	SELAH, CITY OF	48	44	0	4	699,673.04
	SUNNYSIDE, CITY OF	1	0	0	1	.00
	TOPPENISH, CITY OF	8	7	0	1	43,550.02
	UNION GAP, CITY OF	1	1	0	0	3,290.80
	WAPATO, CITY OF	8	7	0	1	30,433.06
	YAKIMA COUNTY *	195	139	0	56	1,011,645.03
	YAKIMA, CITY OF	10	5	0	5	14,963.69
TOTAL FOR WASHINGTON		12,743	10,261	103	2,379	239,738,441.71

Source: FEMA Claim Information by State, 1978 to 2013. Available at: http://bsa.nfipstat.fema.gov/reports/1040.htm#53

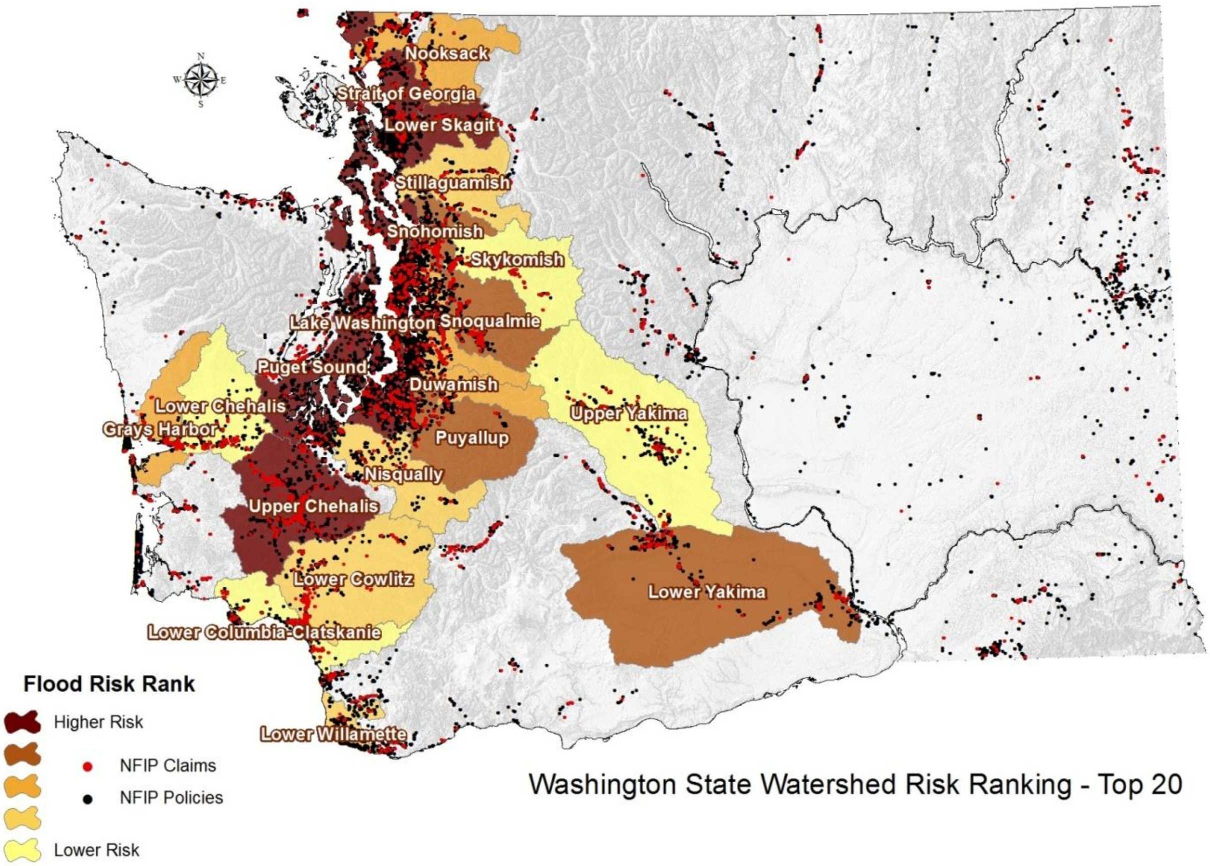
Appendix B

Department of Ecology Washington State Watershed Risk Assessment (2012)

Washington State Watershed Risk Assessment

Introduction

This Risk Assessment is a product of Washington State's Business planning process that heavily engages in digital and spatial platforms to assess flood hazards that provide instant quantitative information spatially across the state with dynamic capabilities to assess evolving risks. The purpose of this Risk Assessment is to provide a valuable planning and sequencing tool to the FEMA-WA State partnership. This Assessment was developed and delivered in GIS database with searchable tables, links to dynamic tables for editing and updating attribute data, and database-driven mapping. This study was completed by the State of Washington Department of Ecology and analyzes flood risk based on watershed available in the western portion of the state.



Washington State Watershed Risk Ranking - Top 20

Risk Assessment Factors
Three risk assessment factors were developed and assigned to FEMA's standard Hydrologic Unit Code (HUC), specifically, the HUC8 level watersheds:

- Population Density 60%
- NFIP Policies & Claims 30%
- Floodplain Area 10%

FEMA provided total population values by watershed from Federal Census data. The State recalculated total population values into population density values by watershed area and generated an attribute in the HUC8 GIS spatial data table representing population density.
FEMA also provided NFIP policies and claims data in a spatial point file feature with attribute tables. The State spatially joined NFIP policies point features to the HUC8 watershed data table as an attribute of total policies and claims per watershed.
The State generated the floodplain area attribute by intersecting FEMA's Q3 data with the HUC8 watershed spatial data and calculated the percent floodplain to watershed area in the attribute table.

Watershed Ranking
Total numbers and areas were avoided and a weighted scheme was developed to emphasize risk factors with greater influence on risk concentrations. Population density was assigned a sixty percent weight as the predominate risk factor. NFIP policies and claims were allocated thirty percent weighted value and floodplain area given ten percent of the scheme.
The weighted method was removed and equal quantities were ranked to evaluate the sensitivity if the weighted approach. All top twenty watersheds remained in the top twenty with emphasis given to large unpopulated floodplain deltas and understated the value of population density as a predominate risk factor.
All three weighted factors were sorted in ascending order and assigned a value from one to seventy one with the highest risk watersheds assigned the lowest values. The three rankings were summed equally and again assigned a rank value with the highest risk watersheds assigned the lowest values. The resulting assessment assigned a value to all seventy-one watersheds.

The top twenty at-risk watersheds are detailed and mapped below:

HUC8 Name	Pop 2010	Trifecta Rank	FP Area Rank	Pop Density Rank	Policies Claims Rank	Topo	Discovery	Final weighted rank	Map Page
Lower Skagit	70102	30	2	11	1	Yes	Coastal	1	5
Puget Sound	1512450	4	17	3	3	Yes	Coastal	2	7
Strait of Georgia	96930	22	7	9	9			3	9
Upper Chehalis	90534	9	3	22	2	Yes	Riverine	4	11
Snohomish	233826	23	18	4	15	Yes		5	13

Puyallup	255521	2	23	8	6	Yes		6	15
Lower Yakima	287260	7	4	14	17	Yes		7	17
Snoqualmie	67487	18	21	15	4	Yes	Coastal	8	19
Grays Harbor	34964	29	13	23	7	Yes	Coastal	9	21
Duwamish	379604	12	42	5	5		Coastal	10	23
Lake Washington	1329140	6	45	1	8	Yes		11	25
Nooksack	64635	16	11	18	19	Yes	Riverine	12	27
Stillaguamish	51139	21	20	21	11	Yes	Coastal	13	29
Nisqually	87525	13	22	12	25	Yes	Riverine	14	31
Lower Willamette	181920	99	28	7	27	Yes		15	33
Lower Chehalis	32212	17	6	29	21	Yes		16	35
Lower Cowlitz	58735	28	19	28	13	Yes	Levee	17	37
Lower Columbia-Clatskanie	38200	10	29	26	16	Yes		18	39
Upper Yakima	59460	11	15	36	18	Yes	Riverine	19	41
Skykomish	28652	19	33	33	10	Yes		20	43

Lower Skagit Watershed

Risk MAP Rank: 1 of 67

HUC8 Name	Sq miles	Trifecta Rank	Floodplain SQ Miles	Floodplain area Rank	Pop density Rank	Policies & Claims Rank	Risk MAP Rank
Lower Skagit	454	30	89	2	11	1	1

Communities:

Burlington, Concrete, Hamilton, La Conner, Lyman, Mount Vernon, Sedro-Woolley, Stanwood

Principal Flood Problems: Skagit River

Flooding from the Skagit River affects the cities of Burlington, Mount Vernon and Sedro Woolley, the Towns of Hamilton, Lyman, La Conner and the unincorporated areas of Skagit County.

Flooding problems occur from high-tide levels in Skagit Bay or from major floods on the Skagit River and its tributaries. Tidal flooding can occur when a high astronomical tide is heightened by a large storm surge. Wave run-up is a significant factor in areas where the shorelines are not sheltered from local wind effects.

Major floods of the Skagit River and its tributaries are caused by winter rainstorms. The Skagit basin, lying directly in the storm path of cyclonic disturbances from the Pacific Ocean, is subject to numerous storms, which are frequently quite severe. Not uncommon are two or more storms in rapid succession, sometimes less than 24 hours apart. Rain-type floods usually occur in November or December, but may occur as early as October or as late as February. These floods are characterized by sharply rising river flows, high magnitude peaks, and flood durations of several days. Often, heavy rainfall is accompanied by snowmelt which increases the runoff. On the mountain slopes, storm precipitation is heavy and almost continuous as a result of combined frontal and orographic effects.

Earlier levee construction was to provide protection from spring floods which permit ted farmers to plant earlier. These levees were subsequently improved to also provide more winter protection.

The Skagit River represents the major flooding source of the delta area. Flooding occurs from multiple levee failures and bank and levee overtopping during a 100-year flood. Downstream of Sedro Woolley, the Skagit River flows through a large delta area that fronts Samish, Padilla, and Skagit Bays. Within this area, the floodplain forms a large alluvial fan with an east-west width of approximately 11 miles and a north-south width of 19 miles. The most severe floods and the corresponding peak discharges since 1908, when stream gauging in the Skagit River Basin began.

Puget Sound Watershed

WA Risk MAP Rank: 2 of 67

HUC8_Name	Sq miles	Trifecta Rank	Floodplain SQ Miles	Foodplain Area Rank	Pop density Rank	Policies & Claims Rank	Risk Rank
Puget Sound	1492	4	40.5	17	3	3	2

Communities:

Anacortes, Bainbridge Island, Bremerton, Burien, Coupeville, Des Moines, DuPont, Edgewood, Edmonds, Everett, Federal Way, Fife, Fircrest, Gig Harbor, Kent, Lacey, Lakewood, Langley, Lynnwood, Marysville, Milton, Milton, Mukilteo, Normandy Park, Oak Harbor, Olympia, Olympia, Olympia, Port Orchard, Port Townsend, Poulsbo, Puyallup, Ruston, SeaTac, Seattle, Shelton, Shoreline, Steilacoom, Tacoma, Tumwater, University Place, Woodway

Principal Flood Problems

Population is the biggest risk factor in the Puget Sound Basin. Coastal flooding rarely causes damages without riverine influences. Flooding problems occur from high-tide levels in Puget Sound combined with high flows from riverine systems and concentrated low pressure storms. Low lying populated areas of Puget Sound, sloughs, and areas exposed to westward wind fetch experience the highest flood risk. Typical examples are the cities of Olympia and La Connor, the Skokomish and Skagit deltas, and coastal areas of Island and San Juan Counties.

Groundwater Flooding

The unique geomorphic history of Puget Sound, Washington, leads to the unusual phenomenon of ground-water flooding when wet conditions persist for much more than a year. In the central Pierce County area of Southern Puget Sound, some relic drainage channels — legacies of melting glaciers at the conclusion of the last Ice Age — now convey only ground water. When wet conditions prevail, ground-water flooding can be observed moving progressively "downstream" in these channels.

Cost of Flooding in Western Washington

More than 28,000 structures have been built in floodplains since the National Flood Insurance Program's inception. Since 1990, the costs of flooding in Western Washington have been have been disastrous and costly for all of us:

- Puget Sound has experienced 16 federally declared flood disasters.
- 58 lives have been lost due to floods.
- More than $1.4 billion in flood damages have been paid by taxpayers.
- Levees failed or overtopped in ten of the past 16 flood disasters, costing $125 million in repairs to more than 200 sites.
- 833 homes in the Puget Sound Area have flooded repeatedly (three times or more), and cost taxpayers $71 million in insurance claims.
- Interstate 5 has been closed four times costing more than $181 million in losses.
- In a single 1990 flood, more than 600 cattle died in Snohomish and King Counties. In a 2003 flood, more than 300 farm animals perished.

Strait of Georgia Watershed

WA Risk MAP Rank: 3 of 67

HUC8 name	Sq. miles	FEMA Trifecta Rank	Floodplain SQ Miles	Floodplain Area Rank	Pop Density Rank	Policies & Claims Rank	Risk Rank
Strait of Georgia	440.84	22	58.8	7	9	9	3

Communities:

Blaine, Ferndale, Bellingham, Sedro-Woolley, Anacortes, Burlington

Primary Flooding Sources:

Whatcom Creek, Friday Creek, Samish River, Samish River, Strait of Georgia

Principal Flood Problems:

Flood damage in the coastal areas of Whatcom County is caused by a combination of high tide levels and wave action. The observed tide level is a result of astronomical tide (caused by gravitational effects of sun and moon) and storm surge (rise in water levels as a result of wind stress and low atmospheric pressure). Waves, breaking onto the shoreline, produce an additional water level rise at the beach (wave setup), and waves running up the beach (wave run-up) can cause impact damage far above the stillwater level. Flood elevations were determined by combining the effects of tide and wave setup. When both calculated wave heights at the shoreline and wave run-up exceeded 3 feet, a wave hazard area was denoted in the region between the 1-percent-annual-chance flood elevation and the estimated limits of wave run-up.

Coastal Flooding in the Cities of Bellingham and Blaine Flood damage in the coastal areas of Bellingham and Blaine is caused by a combination of high tide levels and wave action. The observed tide level is a result of astronomical tide (caused by gravitational effects of the sun and moon) and storm surge (rise in water levels due to wind stress and low atmospheric pressure). Waves breaking onto the shoreline produce an additional water-level rise at the beach (wave setup), and waves running up the beach (wave run-up) can cause impact damage far above the stillwater level. Flood elevations were determined by combining the effects of tide and wave setup.

Upper Chehalis Watershed

WA Risk MAP Rank: 4 of 67

HUC8 Name	Sq Miles	FEMA Trifecta Rank	Floodplain SQ Miles	Floodplain Density Rank	Population Density Rank	Policies & Claims Rank	Risk Rank

Upper Chehalis	1299	9	85.1	3	22	2	4

Communities:

Bucoda, Centralia, Chehalis, Napavine, Oakville, Pe Ell, Tenino, Tumwater

Primary Flooding Sources:

Black River, Chehalis River, Middle Fork, Newaukum River, North Fork Newaukum River, Skookumchuck River, South Fork Chehalis River, South Fork Newaukum River

Principal Flood Problems:

The Chehalis River Basin of western Washington is the second largest in the state, second only to the Columbia Basin. In the last two decades, four 100-year floods have occurred there: in January and November 1990, February 1996, and December 2007. Extreme flood events along the Centralia Reach have severely impacted transportation. In 1990, I-5 was closed for one day; in 1996, four days; and in 2007, four days. In 2004 the Army Corps estimated that transportation-delay costs for the freeway were 3.4 million dollars per day of closure, and that a 100-year flood could be expected to bring 4.5 days of closure costing 15.3 million dollars.

Federal Involvement

There is a long history of government flood projects, studies, and proposals in the basin, with particular focus on the flood-prone Centralia Reach of the upper river, near the Twin Cities of Lewis County, Centralia and Chehalis. In 1931, 1935, and 1944 Army Corps reports on the basin determined that flood control was not feasible. In 1965 a federal study began that determined large-scale projects were not justified, though levees, channel modifications, and headwater dams may be. In 1972 interim reports were published, and beginning in 1974 a levee alternative was evaluated for the Centralia area. In 1982 a U.S> Army Corps feasibility study recommended increasing storage of the Skookumchuck Reservoir on the Skookumchuck River, a tributary which joins the Chehalis River near Centralia. Preconstruction engineering and design began in 1988; work was suspended in 1991, when the project was determined unfeasible; and a final report was released in 1992.

Snohomish Watershed

WA Risk MAP Rank: 5 of 67

HUC8 Name	HUC8 sq. mi.	FEMA Trifecta Rank	Floodplain sq. mi.	Floodplain Area Rank	Population Density Rank	Policies & Claims Rank	Risk Rank
Snohomish	291.5	23	40.3	18	4	15	5

Communities:

Arlington, Everett, Granite Falls, Lake Stevens, Marysville, Mill Creek, Monroe, Snohomish

Primary Flooding Sources:

Snohomish River, Pilchuck River, Snoqualmie River

Principal Flood Problems:

Flooding in the Snohomish watershed may occur from high tide levels in Puget Sound or from floods on the various rivers and streams in the county. Tidal flooding can occur when a high astronomical tide (gravitational effects of the sun and moon) is heightened by a large storm surge (rise in water levels due to wind stress and low atmospheric pressure). Wave run-up is a significant factor when occurring during high-tide conditions in areas where the shorelines are not sheltered from local wind effects. Major floods on rivers and streams in Snohomish County are caused by rainstorms between October and March. Though floodwaters are primarily from rainfall, they are often augmented by snowmelt. Snowmelt floods in spring and summer months are usually not as severe. Rain-runoff floods in the study basins are characterized by sharply rising riverflows, with high-magnitude peaks and flood durations ranging from a few hours on small streams to several days on larger rivers. The greatest threat from flooding occurs between late November and early February, when moisture-laden storms pass through the Puget Sound region. Characteristically, these storms are 24 hours in duration, with moderate and fairly constant precipitation seldom exceeding 1 inch per hour. Not uncommon are two or more storms in rapid succession, sometimes less than 24 hours apart. The Snohomish River floodplain is subject to frequent inundation. Except for the French Creek Drainage District, existing levees provide protection only from normal spring floods that would damage crops. Overtopping maybe expected every 2 to 5 years on average, depending on height and condition of levees. Streamflow records are available from two gaging stations operated by the USGS on the Snohomish River. The gaging station on the Snohomish River near the City of Monroe is located approximately 0.1 mile downstream of the Skykomish and Snoqualmie River confluence and has operated since 1963. Records for the gage at the City of Snohomish included both stage and discharge between 1942 and 1965, but since 1965 only stages are available through the USGS.

Puyallup Watershed

WA Risk MAP Rank: 6 of 67

HUC8 Name	HUC8 sq. mi.	FEMA Trifecta Rank	Floodplain sq. mi.	Floodplain Area Rank	Population Density Rank	Policies & Claims Rank	Risk Rank
Puyallup	984.7	2	33.0	23	8	6	6

Communities

Algona, Auburn, Bonney Lake, Buckley, Carbonado, Edgewood, Enumclaw, Fife, Orting, Pacific, Puyallup, South Prairie, Sumner, Tacoma, Wilkeson

Primary Flooding Sources

Carbon River, Carbon River, Clearwater River, Greenwater River, Mowich River, Puyallup River, South Mowich River, West Fork White River, White River

Principal Flood Problems

Major floods on the Puyallup River were recorded 18 times at the City of Puyallup between 1914 and 1943, before Mud Mountain Dam was completed. The largest flood, 57,000 CFS, occurred on

December 10, 1933. The river has not exceeded zero flood damage flow (45,000 CFS at Puyallup) since the Mud Mountain Dam was completed in 1943. It is estimated that the natural peak flow of the January 1965 flood would have been 53,000 CFS, but the Mud Mountain Project reduced it to 41,500 CFS. Major flood damage still occurs in the vicinity of the Town of Orting, where the channel capacity of the Puyallup River has been exceeded frequently. The largest flood recorded at the gaging station near Orting at River Mile 26.4 was 15,300 CFS in November 1962. In December 1977, major damage occurred in the communities of Alderton and McMillin because of high flows on the Puyallup River. The only extensive flood plains on the White River are located in the Sumner area at the mouth. Mud Mountain Dam, at River Mile29.6, has regulated flood flows on the lower White River so as not to exceed 20,000 CFS and has thus limited major damage. Most of the flood damage from the Carbon River occurs in the lower4-mile reach in the vicinity of Orting. The steep gradient of the river upstream of Orting causes high velocities that erode the stream banks and result in channel changes during high flows. The channel capacity in the Orting area is estimated at 6,000 CFS. The largest flood recorded at the USGS gaging station at Fairfax (gage no. 12093900) at River Mile 17.7 was 10,000cfs in December 1977.

Lower Yakima Watershed

WA Risk MAP Rank: 7 of 67

HUC8 Name	HUC8 sq. mi.	FEMA Trifecta Rank	Floodplain sq. mi.	Floodplain Area Rank	Population Density Rank	Policies & Claims Rank	Risk Rank

Lower Yakima	2905.4	7	75.1	4	14	17	7

Communities

Benton City, Grandview, Granger, Harrah, Kennewick, Mabton, Moxee, Prosser, Richland, Sunnyside, Toppenish, Union Gap, Wapato, West Richland, Yakima, Zillah

Primary Flooding Sources

Yakima River, Ahtanum Creek, Cowiche Creek, Wide Hollow Creek

Principal Flood Problems

When the combined flow of the Naches and Yakima Rivers exceeds approximately 12,000 cubic feet per second (CFS), overflow occurs and inundates property in the floodplains. In 65 years of gage records on the Yakima River, 43 occasions of overbank flows have been observed (References 5, 6, and 7). The highest recorded flows are associated with heavy winter rainfall, sometimes augmented by rising temperatures which cause local snowmelt. Such conditions occurred in 1896, 1906, 1917, and 1933. Peak flows observed were as follows:

- November 16, 1896 45,600 CFS Union Gap
- November 15, 1906 63,900 CFS Union Gap
- December 30, 1917 52,900 CFS Parker
- December 23, 1933 65,000 CFS Parker

After 1933, the highest winter flood flow occurred in 1974, when 28,000 CFS was recorded at Parker on January 17. Spring floods, caused by snowmelt at higher elevations in the watershed, also occur. Spring floods with flows in the range of from 12,000 to 20,000 CFS have occurred approximately 20 times during 65 years of continuous records. The three most severe spring floods recorded had peak flows as follows, measured at the Parker Gage:

- June 3, 1913 22,600 CFS
- June 19, 1916 24,800 CFS
- May 29, 1948 37,700 CFS

The highest reported damage toll was that of the January 1974 floods, estimated at $13 million (Reference 12). The total included agricultural damage of $3 million and $4 million damage to roads, highways, and other public facilities. Seventy-seven homes were destroyed, and 383 others received major damage; 1,115 families were affected, and 2 fatalities were reported.

Snoqualmie Watershed

WA Risk MAP Rank: 8 of 67

HUC8 Name	HUC8 sq. mi.	FEMA Trifecta Rank	Floodplain sq. mi.	Floodplain Area Rank	Population Density Rank	Policies & Claims Rank	Risk Rank
Snoqualmie	694.0	18	33.6	21	15	4	8

Communities

Carnation, Duvall, North Bend, Redmond, Sammamish, Snoqualmie

Primary Flooding Sources

North Fork Snoqualmie River, North Fork Tolt River, Raging River, Snoqualmie River, South Fork Snoqualmie River, South Fork Tolt River, Tolt River

Principal Flood Problems

Climatic and topographic conditions of the upper Snoqualmie Valley create two distinct high-flow periods each year. In the spring or early, summer, the seasonal rise in temperature melts snow in the headwaters and causes increased flow. The other high-flow period, the winter flood, is the most damaging. Winter storms bring in moisture-laden air from the Pacific Ocean and mild temperatures causing snowmelt, combined to cause floods of high magnitude and short duration. Most of the major floods have occurred during November, December, January, and February. Without the protection by flood control reservoirs, the communities along the free flowing Snoqualmie River and its forks are vulnerable to severe flooding such as occurred in November 1959 and December 1975. The largest known flood in the Snoqualmie-North Bend area occurred on November 23, 1959. As the rivers in the basin swelled on that November day, there occurred a classic example of how wildly a river can change its course. About 9 miles east of the City of North Bend, the South Fork cut a new channel on the opposite side of its valley through what was a section of the main cross state arterial, the Snoqualmie Pass Highway. The largest known flood in the Carnation area occurred in December 1975. Agriculture and transportation damages constituted the principal losses. However, the lower valley is inundated to some extent almost every winter. Other major floods occurred in February 1932, December 1967, and January 1969. Storms which cause flooding in the Tolt River Watershed are usually associated with long, steady rains (i.e., winter maritime occluded frontal systems) which are typified by longer duration, more uniform intensity, and more evenly distributed precipitation than the unstable shower (convective) storms. With this type of rainstorm, the flooding in one basin, such as the Tolt, will be associated with flooding on adjacent basins; thus, the rare occurrence of a 100-year frequency flood on the Tolt would most likely be associated with high water backwater of the Snoqualmie River.

The elevation of future floods depends upon the level of the Snoqualmie River at the peak discharge of the Tolt River, the amount of landfill or diking, the physical arrangement or layout, and the hydraulic conditions of the channel.

Grays Harbor Watershed

WA Risk MAP Rank: 9 of 67

HUC8 Name	HUC8 sq. mi.	FEMA Trifecta Rank	Floodplain sq. mi.	Floodplain Area Rank	Population Density Rank	Policies & Claims Rank	Risk Rank
Grays Harbor	587.1	29	47.2	13	23	7	9

Communities

Aberdeen, Cosmopolis, Hoquiam, Ocean Shores, Westport

Primary Flooding Sources

East Fork Humptulips River, Elk River, Humptulips River, Johns River, Little Hoquiam River, Middle Fork Hoquiam River, North Fork Johns River, South Fork Johns River, West Branch Elk River, West Fork Hoquiam River

Principal Flood Problems

Flooding in Grays Harbor County occurs principally in the winter. High spring tides and strong winds from winter storms produce storm surges that cause coastal flooding. Heavy rains with some snowmelt produce the highest runoff flows in the winter. The storms that produce the storm surges also bring heavy rains, therefore, the high riverflows are held back by tides, producing the greatest flooding at river mouths.

Duwamish Watershed

WA Risk MAP Rank: 10 of 67

HUC8 Name	HUC8 sq. mi.	FEMA Trifecta Rank	Floodplain sq. mi.	Floodplain Area Rank	Population Density Rank	Policies & Claims Rank	Risk Rank
Duwamish	495.6	12	12.7	42	5	5	10

Communities

Algona, Auburn, Black Diamond, Burien, Covington, Des Moines, Enumclaw, Federal Way, Kent, Maple Valley, Renton, SeaTac, Seattle, Tukwila

Primary Flooding Sources

Black River, Duwamish River, Green River

Principal Flood Problems

Flooding damage to crops and property in the lower Green River Valley has been a problem since the earliest settlement of the area. Flooding occurred almost annually but the impact to the farmland was minimal. After urbanization, the impact of flooding became more severe. Rapid increase in construction of roads, housing, and parking lots increased the volume and rate at which runoff reached the valley floor. Commercial and industrial landfills have been typically located in the lower valley, resulting in alteration of natural drainage patterns and reduction in overbank storage. During periods of excessive precipitation, surface and subsurface runoff from the steep valley walls cause groundwater elevations in the valley floor to rise significantly. This creates open ponding in topographically depressed areas. This condition is further aggravated by flood flows and corresponding high water elevations on the Green River, resulting in a perched channel condition, which prevents natural drainage of subsurface water. In some areas, the overlying soils are generally less pervious than the deeper sands and runoff collects in pond perched above the water table. Under regulated conditions, significant flooding still does occur in areas unprotected by levee systems and from interior local drainage runoff that outlet to the Green River. High water levels in the Green River and concerns with existing levee system freeboard and structural integrity limit the discharge of runoff waters carried by Mill Creek (Auburn), the Black River, and various other tributaries. The high water levels of the Green River require that the tributary flows be stored and released by gravity or pump discharge to the river channel in a manner consistent with the requirements of the Green River Management Agreement. Under existing conditions, extensive backwater flooding occurs at the uncontrolled outlets of Mill Creek (Auburn) and Mullen Slough, south and west of State Routes 516 and 167, respectively.

Lake Washington Watershed

WA Risk MAP Rank: 11 of 67

HUC8 Name	HUC8 sq. mi.	FEMA Trifecta Rank	Floodplain sq. mi.	Floodplain Area Rank	Population Density Rank	Policies & Claims Rank	Risk Rank
Lake Washington	597.1	6	12.1	45	1	8	11

Communities

Beaux Arts, Bellevue, Bothell, Brier, Clyde Hill, Edmonds, Everett, Hunts Point, Issaquah, Kenmore, Kent, Kirkland, Lake Forest Park, Lynnwood, Maple Valley, Medina, Mercer Island, Mill Creek, Mountlake Terrace, Mukilteo, Newcastle, Redmond, Renton, Sammamish, Seattle, Shoreline, Tukwila, Woodinville, Yarrow Point

Primary Flooding Sources

Cedar River, Lake Washington, Sammamish River

Principal Flood Problems

Stream flow on the Cedar River has been recorded almost continuously since 1895 at the gage near Landsburg. The greatest flood which has occurred over the past 50 years took place on December 4, 1975, with a peak discharge at Landsburg of 8,800 CFS. Based on an updated frequency curve for the Renton USGS stream gage for the 40 years of record through 1985, the recurrence interval for that event exceeded 100 years. Preliminary peak flow estimates by the USGS (Reference 22) for the recent November 1986 event indicate a peak flow of approximately 5,300 CFS, with a recurrence interval of approximately 100 years. Preliminary peak flow estimates by the USGS (Reference 22) for the recent November 1986 event indicate a peak flow of approximately 5,300 CFS, with a recurrence interval of approximately 10 years. Damages in the Cedar River basin from the December 1975 flood event were estimated at $1,760,000. In the reach under study, the west bank of an improved channel at the mouth of the Cedar River was overtopped above the South Boeing Bridge and the Renton Municipal Airport experienced significant flooding and had to close down until the floodwaters receded. Extent of flooding for the November 1986 event in the lower 2-mile reach under study was mainly limited to the improved channel with the exception of some overbank flooding adjacent to the Renton Airfield. Upstream of the improved channel, portions of the Maplewood Additions and other scattered residential developments have been inundated by past flooding events. Log and debris jams have been experienced on the lower river channel, especially during the 1933 and 1975 floods. The lower reach of the river channel, through the City of Renton, has been aggrading in recent years based on comparison of current and previous cross section data. This may result in increases in flood levels and potential overflows.

Nooksack Watershed

WA Risk MAP Rank: 12 of 67

HUC8 Name	HUC8 sq. mi.	FEMA Trifecta Rank	Floodplain sq. mi.	Floodplain Area Rank	Population Density Rank	Policies & Claims Rank	Risk Rank
Nooksack	790.1	16	49.5	11	18	19	12

Communities

Bellingham, Everson, Ferndale, Lynden

Primary Flooding Sources

Lummi River, Middle Fork Nooksack River, Nooksack River, North Fork Nooksack River, Red River, Samish River, South Fork Nooksack River

Principal Flood Problems

Large, scattered areas of the Nooksack River Valley are annually subject to local flooding. The remainder of the floodplain is subject to flooding approximately once in 2 to 5 years, affecting areas utilized almost entirely for agriculture and containing both farm and residential buildings. Maximum known flow was 49,300 cubic feet per second (CFS) at Deming in 1932 as computed from high-water marks. At this discharge, most of the floodplain is inundated. Along the South Fork and downstream near Everson, the flooded area is an irregular strip approximately 0.5 mile wide. Between the constrictions at Everson and Ferndale, the floodwater surface varies from 1 to 2 miles in width, and downstream of Ferndale, the delta is covered for a width of 3 to 4 miles. In the agricultural setting of the Nooksack Valley, the greater part of flood damage occurs to land and crops. This results from drowning of grasses and other plants; loss of livestock; erosion of banks and fallow ground; leaching of fertilizer; infestations by weed seed; carrying away of fences; deposition of sand, gravel, and driftwood; and temporary loss of pasture use because of ground saturation. A special situation occurs in the delta when tidal dikes are breached by impounding river waters. The resulting saltwater intrusion may reduce productivity for several years.

Next in order of importance are damages to buildings, particularly in the low-lying areas of populated areas and to a lesser extent on farms. Damage to levees by erosion and overtopping is a significant problem, recurring during most large floods. Floods in 1951, 1975, 1989, 1990, 1999, and 2002 caused levees to fail along both banks of the Nooksack River. Roadways suffer erosion of embankments and shoulders, undermining of pavement, and a temporary weakening because of subgrade saturation. Restriction of travel may cause financial losses.

In the upper portions of the valley above Everson, flood damages consist chiefly of bank erosion and the deposition of sand and gravel on farmlands.

Stillaguamish Watershed

WA Risk MAP Rank: 13 of 67

HUC8 Name	HUC8 sq. mi.	FEMA Trifecta Rank	Floodplain sq. mi.	Floodplain Area Rank	Population Density Rank	Policies & Claims Rank	Risk Rank
Stillaguamish	702.6	21	34.5	20	21	11	13

Communities

Arlington, Granite Falls, Marysville, Stanwood

Primary Flooding Sources

Boulder River, North Fork Stillaguamish River, South Fork Stillaguamish River, Stillaguamish River

Principal Flood Problems

Streamflow records for the Stillaguamish River have been reported at USGS stream-gaging stations on the South Fork Stillaguamish River near the City of Granite Falls and North Fork Stillaguamish River near the City of Arlington since 1928. Streamflow records are not available for the main stem, but river stages are reported from a National Weather Service (NWS) non-recording gage on the Stillaguamish River at the City of Arlington. All major floods of record on the Stillaguamish River have occurred between November and February and were caused by high rates of precipitation with accompanying snowmelt. Discharges usually rise and fall rapidly, and two or more crests may occur in rapid succession as a series of storms move across the basin. The Stillaguamish River basin suffers damaging floods approximately every 3 to 5 years. From the confluence of the North and South Fork Stillaguamish Rivers at the City of

Arlington, the Stillaguamish River meanders westerly 23 miles through a fertile floodplain. In the vicinity of the community of Silvana, the stream flows through two channels, Cook Slough and the Stillaguamish River. The channels recombine near River Mile (RM) 11 and then divide again near RM 8. From this point, the main stream flows approximately 2 miles through Hat Slough and discharges into Port Susan. Below the head of Hat Slough, the old Stillaguamish River channel, via the City of Stanwood, has become aggraded to the extent that it carries little or no river flow during the dry season. Below the City of Stanwood, flows in the old channel discharge into Port Susan through South Pass and into Skagit Bay through West Pass. The Stillaguamish River system is tidal for approximately 11.5 miles upstream from its mouth. The total range between mean higher-high water and mean lower-low water is approximately 11 feet.

Nisqually Watershed

WA Risk MAP Rank: 14 of 67

HUC8 Name	HUC8 sq. mi.	FEMA Trifecta Rank	Floodplain sq. mi.	Floodplain Area Rank	Population Density Rank	Policies & Claims Rank	Risk Rank

Nisqually	769.8	13	33.1	22	12	25	14

Communities

DuPont, Eatonville, Lacey, McKenna, Roy, Yelm

Primary Flooding Sources

Little Mashel River, Little Nisqually River, Mashel River, Nisqually River, Paradise River

Principal Flood Problems

Flood damage along the Nisqually River is generally limited to an area near the community of McKenna at River Mile 21.8 and to the Nisqually Delta, which is a wide 3-mile-long flood plain at the mouth of the river. The land from McKenna to LaGrande Dam has a narrow flood plain with limited access. Approximately 18,000 CFS in the Nisqually River at McKenna is considered to represent the upper limit of zero flood damage. This flow has been exceeded six times during the period of record (1947-78) at the USGS gaging station on the Nisqually River below Powell Creek near McKenna (gage no. 12088400) at River Mile 31.6. At this station, the three most severe floods occurred in December 1975 (30,700 CFS), January 1965 (25,700 CFS), and January 1974 (23,200 CFS). An estimated flood of 42,000 CFS at the same site occurred in December 1933, inundating most of the delta.

Lower Willamette Watershed

WA Risk MAP Rank: 15 of 67

HUC8 Name	HUC8 sq. mi.	FEMA Trifecta Rank	Floodplain sq. mi.	Floodplain Area Rank	Population Density Rank	Policies & Claims Rank	Risk Rank
Lower Willamette	644.1	99	26.7	28	7	27	15

Communities

Battle Ground, Camas, Ridgefield, Vancouver

Primary Flooding Sources

Columbia River

Principal Flood Problems

Although many large Columbia River floods have occurred in Clark County, existing flood control storage will reduce the severity of future floods. The June 1948 and June 1956 floods were typical spring-summer floods caused by snowmelt runoff. Although less significant than the aforementioned floods, the December 1964 flood is noteworthy because it was an unusually large winter flood resulting primarily from rainfall. Peak discharges at the U.S. Geological Survey (USGS) gage at The Dalles, Oregon, for the June 1948 and June 1956 floods were 1,010,000 and 823,000 cubic feet per second (CFS), respectively. Discharges are given for The Dalles (approximately 55 miles upstream of Vancouver) rather than at Clark County because The Dalles is the first gage upstream of the mouth of the Columbia River with a reliable stage- discharge relationship. The discharge of the December 1964 flood is not comparable to the floods of 1948 and 1956 because large inflows occurred downstream of The Dalles. The estimated return periods for the 1948 and 1956 floods were 48 years and 18 years, respectively.

The Columbia River floods of 1948 and 1956 caused light damage to residential areas of Clark County.

Most of the damage in the unincorporated areas occurred in low lying farm and industrial areas. Emergency flood fighting measures along the Columbia River and temporary evacuation reduced damage.

Lower Chehalis Watershed

WA Risk MAP Rank: 16 of 67

HUC8 Name	HUC8 sq. mi.	FEMA Trifecta Rank	Floodplain sq. mi.	Floodplain Area Rank	Population Density Rank	Policies & Claims Rank	Risk Rank
Lower Chehalis	817.9	17	65.6	6	29	21	16

Communities

Aberdeen, Cosmopolis, Elma, McCleary, Montesano

Primary Flooding Sources

Canyon River, Chehalis River, East Fork Satsop River, East Fork Wishkah River, Little River, Middle Fork Satsop River, Satsop River, West Fork Satsop River ,West Fork Wishkah River, Wishkah River, Wynoochee River

Principal Flood Problems

Flooding in Grays Harbor County occurs principally in the winter. High spring tides and strong winds from winter storms produce storm surges that cause coastal flooding. Heavy rains with some snowmelt produce the highest runoff flows in the winter. The storms that produce the storm surges also bring heavy rains, therefore, the high riverflows are held back by tides, producing the greatest flooding at river mouths. Flows have been recorded, on the Chehalis River at Porter since January 1952. The two largest floods on record at this station had discharges of 55,660 cubic feet per second (CFS) (January 1972) and 49,600 CFS (January 1971). The COE estimates the recurrence intervals for these floods are once in 75 years and once in 60 years, respectively (Reference 1). The COE completed construction of a dam on the Wynoochee River at RM 51.8 in August 1972. Until January 1982, the highest flow recorded

at the gage located just above Black Creek was 18,100 CFS in December 1972. Based on the exceedance-frequency curve developed by the USGS for this gaging site, this discharge has a recurrence interval

of approximately once in 2 years. There is a gage on the Satsop River at RM 2.3. This gage has been

in operation since March 1929. The highest discharge recorded at the gage has been 46,600 CFS in January 1935. Based on the exceedance-frequency curve developed by the USGS for this gaging site, this discharge has a recurrence interval of approximately once in 50 years.

Lower Cowlitz Watershed

WA Risk MAP Rank: 17 of 67

HUC8 Name	HUC8 sq. mi.	FEMA Trifecta Rank	Floodplain sq. mi.	Floodplain Area Rank	Population Density Rank	Policies & Claims Rank	Risk Rank
Lower Cowlitz	1451.1	28	40.2	19	28	13	17

Communities

Castle Rock, Kelso, Longview, Morton, Mossyrock, Toledo, Vader, Winlock

Primary Flooding Sources

Coweman River, Cowlitz River, East Fork Tilton River, Green River, North Fork Tilton River, North Fork Toutle River, South Fork Toutle River, Tilton River, Toutle River, West Fork Tilton River

Principal Flood Problems

Major floods usually result from a combination of intense rainfall and snowmelt after the watershed has been saturated from prior rainfall. Columbia River floods generally are an annual event which occurs in the spring when the snow melts in the mountains. However, there has been winter flooding through the study reach of magnitudes comparable with the larger spring freshets. Flooding from rivers and smaller creeks within the Cowlitz, Kalama, and Lewis River basins generally occurs during the winter months of November through January. The historical record of flooding in Cowlitz County is available only for the period since substantial population centers became established. In December 1933, the county experienced one of the worst and most extensive floods in memory when Cowlitz, Coweman, Kalama, and Lewis Rivers Peaked well in excess of their current estimated 100-year discharge. Damage to the area was estimated at more than $3 million, occurring mainly within the populated urban centers of Kelso, Castle Rock, and Woodland when protective dikes were washed out and nearly 3000 people were forced to evacuate their homes because of the high water. Several major ridges were destroyed and considerable damage to rural highways and farmland was incurred. In June 1948, Columbia River swelled to a Peak discharge of more than 1 million cubic feet per second and caused an estimated $7.2 million damage, $6 million of which was to farm property, in the region from Woodland to Willow Grove. Flooding was intensified by high tides which affected Columbia River elevations within Cowlitz County.

Lower Columbia-Clatskanie Watershed

WA Risk MAP Rank: 18 of 67

HUC8 Name	HUC8 sq. mi.	FEMA Trifecta Rank	Floodplain sq. mi.	Floodplain Area Rank	Population Density Rank	Policies & Claims Rank	Risk Rank
Lower Columbia-Clatskanie	907.0	10	25.2	29	26	16	18

Communities

Cathlamet, Kalama, Kelso, Longview, Woodland

Primary Flooding Sources

Columbia River

Principal Flood Problems

Although many large Columbia River floods have occurred in Clark County, existing flood control storage will reduce the severity of future floods. The June 1948 and June 1956 floods were typical spring-summer floods caused by snowmelt runoff. Although less significant than the aforementioned floods, the December 1964 flood is noteworthy because it was an unusually large winter flood resulting primarily from rainfall. Peak discharges at the U.S. Geological Survey (USGS) gage at The Dalles, Oregon, for the June 1948 and June 1956 floods were 1,010,000 and 823,000 cubic feet per second (CFS), respectively. Discharges are given for The Dalles (approximately 55 miles upstream of Vancouver) rather than at Clark County because The Dalles is the first gage upstream of the mouth of the Columbia River with a reliable stage- discharge relationship. The discharge of the December 1964 flood is not comparable to the floods of 1948 and 1956 because large inflows occurred downstream of The Dalles. The estimated return periods for the 1948 and 1956 floods were 48 years and 18 years, respectively.

The Columbia River floods of 1948 and 1956 caused light damage to residential areas of Clark County.

Most of the damage in the unincorporated areas occurred in low lying farm and industrial areas. Emergency flood fighting measures along the Columbia River and temporary evacuation reduced damage.

Upper Yakima Watershed

WA Risk MAP Rank: 19 of 67

HUC8 Name	HUC8 sq. mi.	FEMA Trifecta Rank	Floodplain sq. mi.	Floodplain Area Rank	Population Density Rank	Policies & Claims Rank	Risk Rank
Upper Yakima	2138.8	11	44.0	15	36	18	19

Communities

Cle Elum, Ellensburg, Kittitas, Roslyn, Selah, South Cle Elum

Primary Flooding Sources

Cle Elum River, Cooper River, Kachess River, Middle Fork Teanaway River, North Fork Teanaway River, Teanaway River, West Fork Teanaway River, Yakima River

Principal Flood Problems

Floods on the Yakima, Teanaway, and Cle Elum Rivers occur as the result of snowmelt in spring and early summer, and occur after heavy rains in November and December. The snowmelt floods are characterized by slow rise and long duration of flow; river stages may be increased by ice and debris jams. The winter flood crests are reduced because of Kachess, Keechelus, and Cle Elum Lakes' reservoir storage as flooding occurs after the irrigation season when storage is available. However, these reservoirs control only a small part of the runoff, and storage may not be available if a second winter flood occurs. Since 1862, 18 floods have occurred on the Yakima River and its tributaries. Five of the most severe floods occurred in November 1906 (41,000 cubic feet per second (CFS)), December 1933 (32,200 CFS), May 1948 (27,700 CFS), December 1975 (16,600 CFS), and December 1977 (21,500 CFS). These peak discharges were recorded at the U.S. Geological Survey gaging station on the Yakima River at Umtanum, Washington, Station No. 12484500. This site is 10 miles south of Ellensburg. Ellensburg and Kittitas are surrounded by a complex irrigation system consisting of the North Branch, Town, and Cascade Canals; Whipple Wasteway; and Reecer, Currier, Whiskey, Mercer, Wilson, Cooke, and Caribou Creeks. This system has a decreasing capacity downstream, and, if used to route floodwaters, may be overtaxed. In the 1948 flood, floodwaters diverted from one basin caused problems in another. Ice and debris have an impact on flood stages when culverts and bridges are obstructed. Historic high-water elevations and streamflow information were obtained from U.S. Geological Survey publications. Other high-water marks were obtained from records of the floods of December 1975 and December 1977 by the study contractor.

Skykomish Watershed

WA Risk MAP Rank: 20 of 67

HUC8 Name	HUC8 sq. mi.	FEMA Trifecta Rank	Floodplain sq. mi.	Floodplain Area Rank	Population Density Rank	Policies & Claims Rank	Risk Rank
Skykomish	834.8	19	22.1	33	33	10	20

Communities

Everett, Gold Bar, Index, Monroe, Skykomish, Sultan

Primary Flooding Sources

Beckler River, North Fork Skykomish River, Rapid River, Skykomish River, South Fork Skykomish River, Sultan River, Wallace River

Principal Flood Problems

Flooding of the City of Everett may occur from high tide levels in Puget Sound or from floods on the various rivers and streams in the county. High tides alone do not usually cause flooding but, when combined with high winds, can cause flooding along the coastline. Tidal flooding within the City of Everett along the coastal industrial area has occurred three times in the last 25 years, as reported by local residents. Coincidence of the annual highest tide level with a river peak can enlarge the extent of river flooding, but over the 30 years during which records have been kept, the magnitude of such coincident tides has not exceeded that having a 3-year recurrence interval. The major problem associated with floods within the City of Everett has been inundation of the low-lying agricultural lands, resulting in loss of crops and, in some cases, failure of dikes and blocked roads. Within the City of Monroe, the estimated 100-year flood from the Skykomish River will inundate approximately 80 acres of undeveloped land in the south and southeastern parts of the city. The estimated 100-year flood from the Snohomish River will inundate approximately 100 acres of developed agricultural land in the extreme northwestern part of the city. The Woods Creek floodplain in the City of Monroe is dominated by floodwaters backing up from the Skykomish River. Flooding in the City of Mukilteo may occur from high-tide levels and storm surge accompanied by winds in Possession Sound. Very little flood-damage potential exists in the City of Mukilteo area. Flooding in the City of Snohomish by the Snohomish and Pilchuck Rivers is confined primarily to the southeastern part of the City where there are scattered residences and undeveloped land. Photographs of the 1951 flood and the 1979 flood on the Snohomish River at the City of Snohomish are shown in Figures 3, 14, and 15. Flooding in the City of Sultan is caused by major floods on the Sultan and Skykomish Rivers. The Wallace River is not a major flooding factor because areas subject to flooding from the Wallace River are more significantly affected by backwater from the Skykomish River. Flooding occurs in the City of Sultan when high flows on the Sultan and Skykomish Rivers go over the banks on the western and southern sides of the city. Floodwaters also enter the City of Sultan when high flows on the Skykomish River back up into the Sultan River and go over banks on both sides of the lower Sultan River.

Glossary of Flood Terms

1.0-precent annual chance flood: The flood having a 1% or greater probability of occurring in any year; also called the 100-year flood

0.2-precent annual chance flood: The flood having a 0.2% or greater probability of occurring in any year; also called the 500-year flood.

Base Flood: A flood having a 1-percent probability of being equaled or exceeded in any given year; also referred to as the 100-year flood.

Base Flood Elevation (BFE): Defined by FEMA as the elevation of the crest of the base or 100-year flood relative to mean sea level. BFE is not depth of flooding. To determine depth of flooding, you would need to subtract the lowest elevation of a particular property from the BFE.

Flood Insurance Rate Map (FIRM): An official map of a community, on which the Federal Insurance and Mitigation Administration has delineated both the Special Flood Hazard Areas and the risk premium zones applicable to the community. Most FIRM's include detailed floodplain mapping for some or all of a community's floodplains.

Floodplain: Any land area susceptible to being inundated by floodwaters from any source.

Freeboard: A margin of safety added to the base flood elevation to account for waves, debris, miscalculations, or lack of data.

Panel: Panel number is numerical designation used to identify the FIRM Map associated with a given area. The first six digits of the Panel number is the community number.

Panel Date: This is the date recorded in the FEMA FMSIS database, which is associated with the given Panel Number.

Repetitive Loss Property: A property for which two or more National Flood Insurance Program losses of at least $1,000 each have been paid within any 10 year period since 1978.

Special Flood Hazard Area (SFHA): An area designated as within a "Special Flood Hazard Area" (or SFHA) on a FIRM. This is an area inundated by 1% annual chance flooding for which BFEs or velocity may have been determined. No distinctions are made between the different flood hazard zones that may be included within the SFHA. These may include Zones A, AE, AO, AH, A99, AR, V, or VE.

References

[1] Hydrologic Information Center – NWS Flood Fatality Data. National Weather Center. Accessed 26 March 13. Available at: http://www.nws.noaa.gov/hic/flood_stats/recent_individual_deaths.shtml

[2] "Federal Disaster Assistance, Improved Criteria Needed to Assess a Jurisdiction's Capability to Respond and Recover on Its Own." GOA-12-838. September 2012. U.S. Government Accountability Office (GAO). Available at: http://www.gao.gov/assets/650/648162.pdf

[3] The totals come from the following sources: Stafford Act disaster assistance costs for disaster from 1980 through January 2009 come from a spreadsheet maintained by State Hazard Mitigation Officer for assistance programs managed by Washington Military Department, Emergency Management Division, (March 2009). Small Business Administration loan figures come from a spreadsheet covering disaster assistance loans provided by the U.S. Small Business Administration from 1992 through 2002, (April 28, 2003). Figures for Federal Highway Administration Emergency Relief Program assistance provided from 1980 to 2003 come from data supplied by the Washington State Department of Transportation, (March 2003). The totals do not include other disaster assistance, such as that provided by the U.S. Army Corps of Engineers to repair damages levees.

[4] David Kresch and Karen Dinicola, U.S. Department of the Interior, U.S. Geological Survey, Fact Sheet 228-96, *What Causes Floods in Washington State?*, date unknown.

[5] FEMA, *Significant Flood Events* as of January 31, 2013. Available at: http://www.fema.gov/policy-claim-statistics-flood-insurance/policy-claim-statistics-flood-insurance/policy-claim-13-9

[6] Myers, Mary Fran. University of Colorado, Natural Hazards Research and Applications Information Center. (citing a Yen and Yen study from the National Weather Service). Available at: http://sciencepolicy.colorado.edu/socasp/weather1/myers.html

[7] Photo credit: WSDOT

[8] Philip King, Aaron McGregor and Justin Whittet (2011), *The Economic Costs of Sea-Level Rise to California Beach Communities*. California Department of Boating and Waterways and San Francisco State University.

[9]FloodSmart.gov: The Official Site of the NFIP. Available at: http://www.floodsmart.gov/floodsmart/pages/flood_facts.jsp

[10] FEMA, (2002) *National Flood Insurance Program: Program Description*. Accessed: 1 April 2010. Available at: http://www.fema.gov/library/viewRecord.do?id=1480

[11] FEMA, "*Impact of Changes to the NFIP, Flood Insurance Reform Act of 2012*." Accessed 28 March 2013. Available at: http://www.fema.gov/library/viewRecord.do?id=7187

[12] FEMA Community Rating System. Accessed: 2 April 2010. Available at: http://www.fema.gov/business/nfip/crs.shtm

[13] FEMA's Risk MAP (Mapping, Assessment, and Planning) Strategy. Accessed: 2 April 2010. Available at: http://www.fema.gov/plan/ffmm.shtm

[14] MGS Engineering Consultants. *Map of 24-hour precipitation totals that would qualify as a 100-year event*. January 12, 2009. Accessed March 23, 2009. Available at: http://www.mgsengr.com/precipfrqfiles/wa_100y_24h_0120.png

---

15 Chris Hill et al., *Top Ten 20th Century Weather Events In Washington State*, National Weather Service, Seattle Forecast Office, December 1999, <http://www.seawfo.noaa.gov/WATOP10.htm>, (February 20, 2003).

16 Richard W. Paulson et al., *National Water Summary 1988-89, Hydrologic Events and Floods and Droughts*, Washington Floods and Droughts State Summary, United States Geological Survey Water-Supply Paper 2375, 1991.

17 Sweeney, Michael (4 Dec. 1977). "Officials Tally Flood Bill." *Seattle Times* A-1, A-4.

18 Information from *Flood Mitigation Implementation Measures Report for Whatcom County, FEMA-676-DR*, Washington State Department of Emergency Services et al., November 1983.

19 Information from *Flood Mitigation Strategies for Disasters 757 and 762, 1986*, Washington State Department of Community Development, Emergency Management Division, December 1, 1986.

20 Ibid.

21 Information from *Interagency Flood Hazard Mitigation Report, FEMA-784-DR-WA*, Region X Interagency Mitigation Team, January 1987.

22 Information from *Hazard Mitigation Survey Report, FEMA-822-DR-WA*, Washington State Department of Community Development, Division of Emergency Management, 1989.

23 Information from *Hazard Mitigation Opportunities in the State of Washington, Report of the Interagency Hazard Mitigation Team, FEMA-852-DR-WA*, Region X Interagency Hazard Mitigation Team, February 15, 1990.

24 Chris Hill et al., *Top Ten 20th Century Weather Events In Washington State*, National Weather Service, Seattle Forecast Office, December 1999, <http://www.seawfo.noaa.gov/WATOP10.htm>, (February 20, 2003)

25 *Hazard Mitigation Opportunities in the State of Washington, Report of the Intergency Hazard Mitigation Team, FEMA-883-DR-WA*, Federal Emergency Management Agency Region X, January 1991.

26 Information from *Interagency Hazard Mitigation Team Report, with Early Implementation Strategies for DR-1079-WA and DR-1100-WA*, Federal Emergency Management Agency Region X, July 1996.

27 Information from *Maximum stages and discharges during floods of November 28-30, 1995*, United States Geological Survey, Tacoma Office, January 1996.

28 Information from Interagency Hazard Mitigation Team Report, with Early Implementation Strategies for DR-1079-WA and DR-1100-WA, Federal Emergency Management Agency Region X, July 1996.

29 Chris Hill et al., *Top Ten 20th Century Weather Events In Washington State*, National Weather Service, Seattle Forecast Office, December 1999, <http://www.seawfo.noaa.gov/WATOP10.htm>, (February 20, 2003).

30 Information from *Post Event Report: Winter Storm of 1996-97, Federal Disaster DR 1159, Western Washington Summary*, US Army Corps of Engineers, Seattle District, Mary 16, 1997.

31 Information from Hazard Mitigation Survey Team Report for the 1996-1997 Washington Winter Storms, DR-1152-WA, DR-1159-WA, DR-1172-WA, Washington State Emergency Management Division and Federal Emergency Management Agency Region 10.

32 Information from *Post Event Report: Winter Storm of 1996-97, Federal Disaster DR 1159, Western Washington Summary*, US Army Corps of Engineers, Seattle District, Mary 16, 1997.

[33] Rick van der Zweep, *Washington State October 2003 Flood Report*, National Oceanic and Atmospheric Administration, Northwest River Forecast Center, <http://www.mwrfc.boaa.gov/floods/oct_2003/wa_oct2003_flood.html>, (March 26, 2004).

[34] Office of Washington State Climatologist (2007). *Washington 2006 Top 10 Weather & Climate Events*. Accessed: March 23, 2009. Available at: http://www.climate.washington.edu/events

[35] Office of Washington State Climatologist. *2006 Record November Rainfall*. December 5, 2006. Accessed March 23, 2009. Available at: http://www.climate.washington.edu/events/2006NovRain.html

[36] Office of Washington State Climatologist. *December 2007 Record Flooding*. December 12, 2007. Accessed: March 23, 2009. Available at: http://www.climate.washington.edu/events/dec2007floods

[37] FEMA. *Washington Disaster Aid Tops $72.5 Million* (2008). Accessed March 23, 2009. Available at: http://www.fema.gov/news/newsrelease.fema?id=42969

[38] FEMA, Almost $11 Million in Disaster Assistance to Washington Residents with March 31st Deadline Fast Approaching. March 20, 2009. Accessed March 23, 2009. Available at: http://www.fema.gov/news/newsrelease.fema?id=47770

[39] NOAA, "Pacific Northwest Flood Event of Jan 15-19, 2011." Accessed 1 April 2013. Available at: http://www.nwrfc.noaa.gov/floods/jan_2011/january2011floodReport.pdf

[40] Office of the Washington State Climatologist, "January 2012 Snowfall. 26 January 2012. Accessed 1 April 2013. Available at: http://www.climate.washington.edu/events/2012snow/

[41] Earth Observatory. 23 January 2012. Accessed 1 April 2013. Available at: http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=77016

[42] "Cantwell, Murray Call for Swift Assistance for Northeast WA in Wake of Severe Storm Damage." Press Release. Maria Cantwell U.S. Senator Site. Accessed March 30, 2013. Available at: http://www.cantwell.senate.gov/public/index.cfm/press-releases?ID=267c2e16-b0bd-413e-9176-e81702a08d57

[43] "Wooldridge, Emily. "Windstorm Knocks Down 200 Trees at Daroga State Park." World Publication. 20 July 2012. Accessed 1 April 2013. Available at: http://www.wenatcheeworld.com/news/2012/jul/20/wind-storm-knocks-down-200-trees-at-daroga-state/

[44] Seattle Tacoma Bremerton MSA Consumer Price Index, All Items. U.S. Department of Labor, Bureau of Labor Statistics. Available at: http://www.bls.gov/ro9/9250.pdf

[45] Federal Disaster Declarations. 1956 – 2012. Available at: http://www.fema.gov/disasters/grid/state-tribal-government?field_disaster_type_term_tid_1=6837&=GO

[46] *National Flood Insurance Report. Generated by:* Chuck Steele, Washington State Department of Ecology. 25 March 25, 2010.

[47] Ibid.

[48] Information from *National Flood Insurance Program NextGen SQANet,* Repetitive Flood Loss Report, Provided by WA EMD. <http://www.nfipnextgen.com/awareness.html>, (July 2012).

[49] Information from *National Flood Insurance Program NextGen SQANet,* Severe Repetitive Flood Loss Report, Provided by WA EMD. <http://www.nfipnextgen.com/awareness.html>, (July 2012).

[50] Snover, A.K., P.W. Mote, L. Whitely Binder, A.F. Hamlet, and N.J. Mantua (2005). Uncertain Future: Climate Change and its Effects on Puget Sound. A report for the Puget Sound Action Team by the Climate Impacts Group (Center for Science in the Earth System, Joint Institute for the Study of Atmosphere and Oceans, University of Washington, Seattle).

[51] Robert Roy Britt, "Surprising Side Effects of Global Warming," *LiveScience*, December 22, 2004, <http://www.livescience.com/environment/041222_permafrost.html> (January 25, 2008).

[52] Hillary Mayell, "Climate Studies Point to More Floods in This Century," *National Geographic*, January 30, 2002 <http://news.nationalgeographic.com/news/2002/01/0130_020130_greatfloods.html> (July 22, 2008).

[53] Anna Vigran, "With Climate Change Comes Floods," *National Public Radio*, Online January 14, 2008, <http://www.npr.org/templates/story/story.php?storyId=18022014> (July 22, 2008).

[54] Patrick McCully, "New Thinking Needed on Floods," *The Baltimore Sun*, July 17, 2007, p. 11A (June 26, 2008).

[55] "Resources: Frequently Asked Questions," *National Flood Insurance Program – Flood Smart*, n.d., <http://www.floodsmart.gov/floodsmart/pages/faqs_flood.jsp> (July 25, 2008).

[56] "Sea Level is Rising at an Increasing Rate." Ocean Facts National Ocean Service, NOAA. Accessed 1 April 2013. Available at: http://oceanservice.noaa.gov/facts/sealevel.html

[57] Zervas, C. 2009. Sea Level Variations of the United States, 1854 - 2006, NOAA Technical Report NOS COOPS 053.

[58] Surging Seas Report, 2012. Climate Central. Accessed 4 April 2013. Available at: http://slr.s3.amazonaws.com/factsheets/Washington.pdf

[59] Canning, Douglas (Washington Department of Ecology and Climate Impacts Group, University of Washington). "Sea level Rise and Coastal Hazards in Washington State." 2005. Available at: http://your.kingcounty.gov/dnrp/library/archive-documents/dnrp/climate-change/conference-2005-results/coastal-areas/pdf/presentation-canning.pdf

[60] "Sea Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future (2012). Available: http://dels.nas.edu/Report/Level-Rise-Coasts/13389

[61] FEMA, Mark Carey; Puget Sound Partnership, Dave St. John; and The Nature Conservancy, Bob Carey. Personal Correspondence about Floodplains by Design and Puget Sound Partnership Action Plan. 7 May 2013.

[62] Puget Sound Partnership, *The 2012/2013 Action Agenda for Puget Sound. The Puget Sound Action Agenda is the plan for cleaning up, restoring, and protecting Puget Sound by 2010.* August 28, 2012. Accessed 7 May 2013.

[63] FEMA, NFIP Claim Information by State (1978 through 01/31/2013). *Loss Statistics*. Accessed: 26 March 2013 Available at: http://bsa.nfipstat.fema.gov/reports/1040.htm#53