

HAZUS-MH: Earthquake Event Report

Region Name:: Cascadia_North_M83

Earthquake Scenario: Cascadia North Section M8.3

Print Date: June 06, 2011

Totals only reflect data for those census tracts/blocks included in the user's study region.

Disclaimer:

The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific earthquake. These results can be improved by using enhanced inventory, geotechnical, and observed ground motion data.

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General Description of the Region

HAZUS is a regional earthquake loss estimation model that was developed by the Federal Emergency Management Agency and the National Institute of Building Sciences. The primary purpose of HAZUS is to provide a methodology and software application to develop earthquake losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from earthquakes and to prepare for emergency response and recovery.

The earthquake loss estimates provided in this report was based on a region that includes 23 county(ies) from the following state(s):

Washington

Note:

Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 36,495.82 square miles and contains 1,084 census tracts. There are over 2,043 thousand households in the region and has a total population of 5,283,432 people (2000 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 1,877 thousand buildings in the region with a total building replacement value (excluding contents) of 402,081 (millions of dollars). Approximately 92.00 % of the buildings (and 0.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 151,145 and 21,726 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

HAZUS estimates that there are 1,877 thousand buildings in the region which have an aggregate total replacement value of 402,081 (millions of dollars) . Appendix B provides a general distribution of the building value by State and County.

In terms of building construction types found in the region, wood frame construction makes up 81% of the building inventory. The remaining percentage is distributed between the other general building types.

Critical Facility Inventory

HAZUS breaks critical facilities into two (2) groups: essential facilities and high potential loss (HPL) facilities. Essential facilities include hospitals, medical clinics, schools, fire stations, police stations and emergency operations facilities. High potential loss facilities include dams, levees, military installations, nuclear power plants and hazardous material sites.

For essential facilities, there are 75 hospitals in the region with a total bed capacity of 14,258 beds. There are 2,254 schools, 938 fire stations, 226 police stations and 55 emergency operation facilities. With respect to HPL facilities, there are 450 dams identified within the region. Of these, 146 of the dams are classified as 'high hazard'. The inventory also includes 839 hazardous material sites, 0 military installations and 0 nuclear power plants.

Transportation and Utility Lifeline Inventory

Within HAZUS, the lifeline inventory is divided between transportation and utility lifeline systems. There are seven (7) transportation systems that include highways, railways, light rail, bus, ports, ferry and airports. There are six (6) utility systems that include potable water, wastewater, natural gas, crude & refined oil, electric power and communications. The lifeline inventory data are provided in Tables 1 and 2.

The total value of the lifeline inventory is over 172,871.00 (millions of dollars). This inventory includes over 9,562 kilometers of highways, 4,996 bridges, 286,170 kilometers of pipes.

Table 1: Transportation System Lifeline Inventory

System	Component	# Locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	4,996	90,051.60
	Segments	3,454	53,323.90
	Tunnels	29	67.00
	Subtotal		143,442.50
Railways	Bridges	77	20.00
	Facilities	68	181.10
	Segments	1,407	2,642.40
	Tunnels	0	0.00
	Subtotal		2,843.50
Light Rail	Bridges	0	0.00
	Facilities	38	101.20
	Segments	48	203.90
	Tunnels	0	0.00
	Subtotal		305.00
Bus	Facilities	45	54.00
	Subtotal		54.00
Ferry	Facilities	45	59.90
	Subtotal		59.90
Port	Facilities	486	970.50
	Subtotal		970.50
Airport	Facilities	62	660.40
	Runways	74	2,809.30
	Subtotal		3,469.70
	Total		151,145.10

Table 2: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	2,861.70
	Facilities	41	1,501.80
	Pipelines	0	0.00
	Subtotal		4,363.50
Waste Water	Distribution Lines	NA	1,717.00
	Facilities	146	10,696.00
	Pipelines	0	0.00
	Subtotal		12,413.00
Natural Gas	Distribution Lines	NA	1,144.70
	Facilities	56	67.10
	Pipelines	0	0.00
	Subtotal		1,211.80
Oil Systems	Facilities	15	1.70
	Pipelines	0	0.00
	Subtotal		1.70
Electrical Power	Facilities	78	9,438.00
	Subtotal		9,438.00
Communication	Facilities	196	21.60
	Subtotal		21.60
	Total		27,449.60

Earthquake Scenario

HAZUS uses the following set of information to define the earthquake parameters used for the earthquake loss estimate provided in this report.

Scenario Name	Cascadia North Section M8.3
Type of Earthquake	User-defined
Fault Name	NA
Historical Epicenter ID #	NA
Probabilistic Return Period	NA
Longitude of Epicenter	NA
Latitude of Epicenter	NA
Earthquake Magnitude	8.30
Depth (Km)	NA
Rupture Length (Km)	NA
Rupture Orientation (degrees)	NA
Attenuation Function	NA

Building Damage

Building Damage

HAZUS estimates that about 55,055 buildings will be at least moderately damaged. This is over 3.00 % of the total number of buildings in the region. There are an estimated 1,939 buildings that will be damaged beyond repair. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the HAZUS technical manual. Table 3 below summaries the expected damage by general occupancy for the buildings in the region. Table 4 summaries the expected damage by general building type.

Table 3: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	7,352	0.43	483	0.49	363	0.89	137	1.12	20	1.01
Commercial	83,367	4.84	7,729	7.78	5,666	13.86	1,839	15.03	233	12.03
Education	3,095	0.18	229	0.23	175	0.43	54	0.44	5	0.28
Government	1,892	0.11	209	0.21	188	0.46	70	0.57	10	0.52
Industrial	25,061	1.45	2,653	2.67	2,152	5.26	687	5.62	75	3.87
Other Residential	308,399	17.89	37,930	38.20	27,400	67.02	8,322	68.02	1,424	73.42
Religion	5,902	0.34	457	0.46	364	0.89	125	1.02	15	0.77
Single Family	1,288,371	74.76	49,612	49.96	4,575	11.19	1,001	8.18	157	8.10
Total	1,723,439		99,303		40,883		12,233		1,940	

Table 4: Expected Building Damage by Building Type (All Design Levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	1,451,457	84.22	59,224	59.64	5,131	12.55	693	5.66	147	7.57
Steel	32,680	1.90	2,970	2.99	3,117	7.62	1,510	12.34	292	15.03
Concrete	32,565	1.89	3,244	3.27	2,796	6.84	855	6.99	110	5.65
Precast	24,032	1.39	1,932	1.95	2,057	5.03	960	7.85	114	5.89
RM	62,016	3.60	2,878	2.90	3,516	8.60	1,294	10.58	110	5.68
URM	11,635	0.68	2,399	2.42	1,042	2.55	246	2.01	56	2.87
MH	109,055	6.33	26,656	26.84	23,224	56.81	6,676	54.58	1,112	57.31
Total	1,723,439		99,303		40,883		12,233		1,940	

*Note:

RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had 14,258 hospital beds available for use. On the day of the earthquake, the model estimates that only 12,492 hospital beds (88.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 94.00% of the beds will be back in service. By 30 days, 98.00% will be operational.

Table 5: Expected Damage to Essential Facilities

Classification	Total	At Least Moderate Damage > 50%	# Facilities	
			Complete Damage > 50%	With Functionality > 50% on day 1
Hospitals	75	4	0	66
Schools	2,254	0	0	2,232
EOCs	55	0	0	54
PoliceStations	226	0	0	222
FireStations	938	0	0	910

Transportation and Utility Lifeline Damage

Table 6 provides damage estimates for the transportation system.

Table 6: Expected Damage to the Transportation Systems

System	Component	Number of Locations_				
		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality > 50 % After Day 1	After Day 7
Highway	Segments	3,454	0	0	3,454	3,454
	Bridges	4,996	11	0	4,985	4,995
	Tunnels	29	0	0	29	29
Railways	Segments	1,407	0	0	1,407	1,407
	Bridges	77	0	0	77	77
	Tunnels	0	0	0	0	0
	Facilities	68	0	0	68	68
Light Rail	Segments	48	0	0	48	48
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	38	0	0	38	38
Bus	Facilities	45	0	0	45	45
Ferry	Facilities	45	0	0	45	45
Port	Facilities	486	0	0	486	486
Airport	Facilities	62	0	0	62	62
	Runways	74	0	0	74	74

Note: Roadway segments, railroad tracks and light rail tracks are assumed to be damaged by ground failure only. If ground failure maps are not provided, damage estimates to these components will not be computed.

Tables 7-9 provide information on the damage to the utility lifeline systems. Table 7 provides damage to the utility system facilities. Table 8 provides estimates on the number of leaks and breaks by the pipelines of the utility systems. For electric power and potable water, HAZUS performs a simplified system performance analysis. Table 9 provides a summary of the system performance information.

Table 7 : Expected Utility System Facility Damage

System	Total #	With at Least Moderate Damage	# of Locations		with Functionality > 50 %	
			With Complete Damage		After Day 1	After Day 7
Potable Water	41	0	0		41	41
Waste Water	146	2	0		124	146
Natural Gas	56	0	0		56	56
Oil Systems	15	0	0		15	15
Electrical Power	78	0	0		78	78
Communication	196	5	0		196	196

Table 8 : Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	143,085	1783	816
Waste Water	85,851	1410	645
Natural Gas	57,234	1507	690
Oil	0	0	0

Table 9: Expected Potable Water and Electric Power System Performance

	Total # of Households	Number of Households without Service				
		At Day 1	At Day 3	At Day 7	At Day 30	At Day 90
Potable Water	2,043,617	2,858	1,875	532	0	0
Electric Power		0	0	0	0	0

Induced Earthquake Damage

Fire Following Earthquake

Fires often occur after an earthquake. Because of the number of fires and the lack of water to fight the fires, they can often burn out of control. HAZUS uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area. For this scenario, the model estimates that there will be 149 ignitions that will burn about 5.00 sq. mi (0.01 % of the region's total area.) The model also estimates that the fires will displace about 14,391 people and burn about 1,220 (millions of dollars) of building value.

Debris Generation

HAZUS estimates the amount of debris that will be generated by the earthquake. The model breaks the debris into two general categories: a) Brick/Wood and b) Reinforced Concrete/Steel. This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 1.400 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 30.00% of the total, with the remainder being Reinforced Concrete/Steel. If the debris tonnage is converted to an estimated number of truckloads, it will require 55,920 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.

Shelter Requirement

HAZUS estimates the number of households that are expected to be displaced from their homes due to the earthquake and the number of displaced people that will require accommodations in temporary public shelters. The model estimates 3,692 households to be displaced due to the earthquake. Of these, 2,452 people (out of a total population of 5,283,432) will seek temporary shelter in public shelters.

Casualties

HAZUS estimates the number of people that will be injured and killed by the earthquake. The casualties are broken down into four (4) severity levels that describe the extent of the injuries. The levels are described as follows;

- Severity Level 1: Injuries will require medical attention but hospitalization is not needed.
- Severity Level 2: Injuries will require hospitalization but are not considered life-threatening
- Severity Level 3: Injuries will require hospitalization and can become life threatening if not promptly treated.
- Severity Level 4: Victims are killed by the earthquake.

The casualty estimates are provided for three (3) times of day: 2:00 AM, 2:00 PM and 5:00 PM. These times represent the periods of the day that different sectors of the community are at their peak occupancy loads. The 2:00 AM estimate considers that the residential occupancy load is maximum, the 2:00 PM estimate considers that the educational, commercial and industrial sector loads are maximum and 5:00 PM represents peak commute time.

Table 10 provides a summary of the casualties estimated for this earthquake

Table 10: Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
2 AM	Commercial	11	2	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	20	5	1	1
	Industrial	19	3	0	1
	Other-Residential	471	66	3	6
	Single Family	126	10	1	1
	Total	647	87	5	9
2 PM	Commercial	737	126	14	27
	Commuting	1	1	1	0
	Educational	168	27	3	5
	Hotels	4	1	0	0
	Industrial	139	24	3	5
	Other-Residential	107	16	1	2
	Single Family	28	3	0	0
	Total	1,185	197	22	39
5 PM	Commercial	566	96	11	20
	Commuting	15	26	37	8
	Educational	16	2	0	0
	Hotels	6	1	0	0
	Industrial	87	15	2	3
	Other-Residential	170	24	1	2
	Single Family	47	4	0	0
	Total	907	170	51	34

Economic Loss

The total economic loss estimated for the earthquake is 5,121.88 (millions of dollars), which includes building and lifeline related losses based on the region's available inventory. The following three sections provide more detailed information about these losses.

Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the earthquake. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the earthquake.

The total building-related losses were 3,696.82 (millions of dollars); 27 % of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 44 % of the total loss. Table 11 below provides a summary of the losses associated with the building damage.

Table 11: Building-Related Economic Loss Estimates
(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Loses							
	Wage	0.00	22.51	213.57	11.14	14.54	261.76
	Capital-Related	0.00	9.60	191.96	6.91	3.09	211.56
	Rental	9.73	56.50	103.57	4.28	7.17	181.25
	Relocation	30.39	77.33	156.37	20.90	49.54	334.54
	Subtotal	40.12	165.94	665.47	43.23	74.34	989.10
Capital Stock Loses							
	Structural	75.43	114.48	195.20	56.49	50.32	491.91
	Non_Structural	511.51	396.60	439.94	118.08	103.25	1,569.38
	Content	231.27	82.64	195.51	69.69	46.03	625.14
	Inventory	0.00	0.00	5.43	14.99	0.86	21.29
	Subtotal	818.21	593.72	836.08	259.24	200.46	2,707.71
	Total	858.33	759.66	1,501.56	302.47	274.80	3,696.82

Transportation and Utility Lifeline Losses

For the transportation and utility lifeline systems, HAZUS computes the direct repair cost for each component only. There are no losses computed by HAZUS for business interruption due to lifeline outages. Tables 12 & 13 provide a detailed breakdown in the expected lifeline losses.

HAZUS estimates the long-term economic impacts to the region for 15 years after the earthquake. The model quantifies this information in terms of income and employment changes within the region. Table 14 presents the results of the region for the given earthquake.

Table 12: Transportation System Economic Losses
(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	53,323.90	\$147.13	0.28
	Bridges	90,051.61	\$619.91	0.69
	Tunnels	66.98	\$0.10	0.14
	Subtotal	143442.50	767.10	
Railways	Segments	2,642.42	\$1.50	0.06
	Bridges	19.99	\$0.09	0.44
	Tunnels	0.00	\$0.00	0.00
	Facilities	181.08	\$11.49	6.34
	Subtotal	2843.50	13.10	
Light Rail	Segments	203.85	\$0.00	0.00
	Bridges	0.00	\$0.00	0.00
	Tunnels	0.00	\$0.00	0.00
	Facilities	101.19	\$5.17	5.11
	Subtotal	305.00	5.20	
Bus	Facilities	53.96	\$3.07	5.69
	Subtotal	54.00	3.10	
Ferry	Facilities	59.90	\$2.74	4.58
	Subtotal	59.90	2.70	
Port	Facilities	970.54	\$57.80	5.96
	Subtotal	970.50	57.80	
Airport	Facilities	660.36	\$41.75	6.32
	Runways	2,809.34	\$9.62	0.34
	Subtotal	3469.70	51.40	
	Total	151145.10	900.40	

Table 13: Utility System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Potable Water	Pipelines	0.00	\$0.00	0.00
	Facilities	1,501.80	\$29.55	1.97
	Distribution Lines	2,861.70	\$11.73	0.41
	Subtotal	4,363.54	\$41.28	
Waste Water	Pipelines	0.00	\$0.00	0.00
	Facilities	10,696.00	\$277.47	2.59
	Distribution Lines	1,717.00	\$9.27	0.54
	Subtotal	12,412.98	\$286.74	
Natural Gas	Pipelines	0.00	\$0.00	0.00
	Facilities	67.10	\$1.58	2.35
	Distribution Lines	1,144.70	\$9.91	0.87
	Subtotal	1,211.83	\$11.49	
Oil Systems	Pipelines	0.00	\$0.00	0.00
	Facilities	1.70	\$0.01	0.90
	Subtotal	1.65	\$0.01	
Electrical Power	Facilities	9,438.00	\$184.65	1.96
	Subtotal	9,438.00	\$184.65	
Communication	Facilities	21.60	\$0.51	2.36
	Subtotal	21.56	\$0.51	
	Total	27,449.55	\$524.69	

Table 14. Indirect Economic Impact with outside aid
 (Employment as # of people and Income in millions of \$)

	LOSS	Total	%
First Year			
	Employment Impact	703,578	39.09
	Income Impact	2,092	2.34
Second Year			
	Employment Impact	248,049	13.78
	Income Impact	1,036	1.16
Third Year			
	Employment Impact	5,660	0.31
	Income Impact	207	0.23
Fourth Year			
	Employment Impact	320	0.02
	Income Impact	(80)	-0.09
Fifth Year			
	Employment Impact	16	0.00
	Income Impact	(96)	-0.11
Years 6 to 15			
	Employment Impact	0	0.00
	Income Impact	(97)	-0.11

Appendix A: County Listing for the Region

Chelan,WA

Clallam,WA

Clark,WA

Cowlitz,WA

Grays Harbor,WA

Island,WA

Jefferson,WA

King,WA

Kitsap,WA

Kittitas,WA

Klickitat,WA

Lewis,WA

Mason,WA

Pacific,WA

Pierce,WA

San Juan,WA

Skagit,WA

Skamania,WA

Snohomish,WA

Thurston,WA

Wahkiakum,WA

Whatcom,WA

Yakima,WA

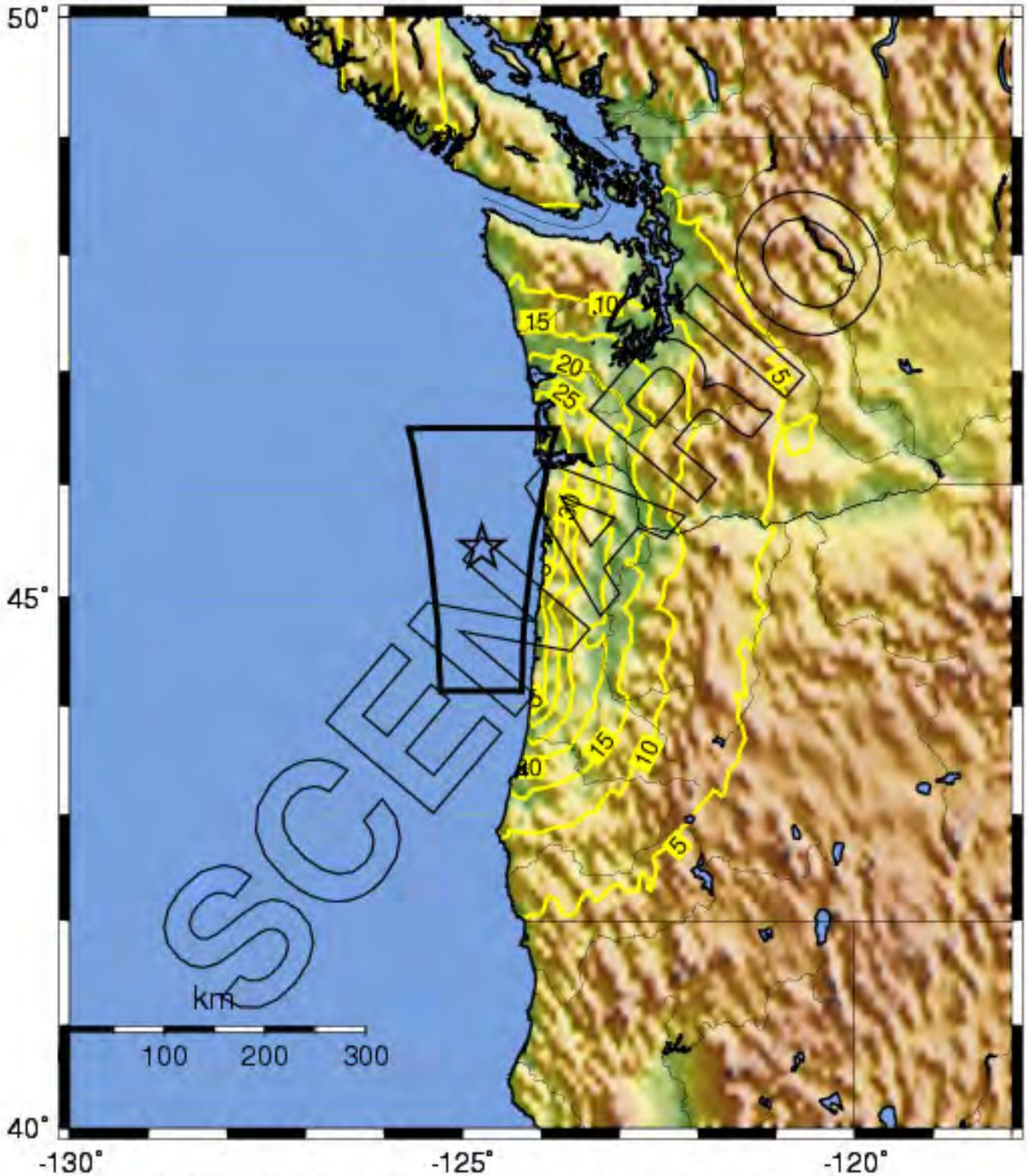
Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Washington	Chelan	68,646	3,915	1,524	5,439
	Clallam	68,232	3,789	1,128	4,917
	Clark	395,707	21,358	5,081	26,439
	Cowlitz	96,113	5,167	1,575	6,742
	Grays Harbor	69,881	3,866	1,228	5,095
	Island	78,149	5,289	842	6,132
	Jefferson	28,169	1,741	517	2,258
	King	1,828,516	123,492	35,829	159,322
	Kitsap	245,278	14,460	2,974	17,435
	Kittitas	37,701	2,087	539	2,627
	Klickitat	20,162	908	287	1,195
	Lewis	70,750	3,424	1,286	4,711
	Mason	53,236	3,094	593	3,687
	Pacific	20,855	1,443	384	1,828
	Pierce	757,734	42,208	10,185	52,394
	San Juan	15,413	1,454	350	1,805
	Skagit	111,356	6,119	1,896	8,015
	Skamania	10,300	551	118	670
	Snohomish	661,444	38,562	8,570	47,132
	Thurston	226,721	12,793	3,286	16,080
Wahkiakum	3,900	204	62	267	
Whatcom	185,545	10,528	3,715	14,244	
Yakima	229,624	9,899	3,738	13,637	
Total State		5,283,432	316,351	85,707	402,071
Total Region		5,283,432	316,351	85,707	402,071

-- Earthquake Planning Scenario --

Peak Accel. Map (in %g) for Casc_North8.3 Scenario

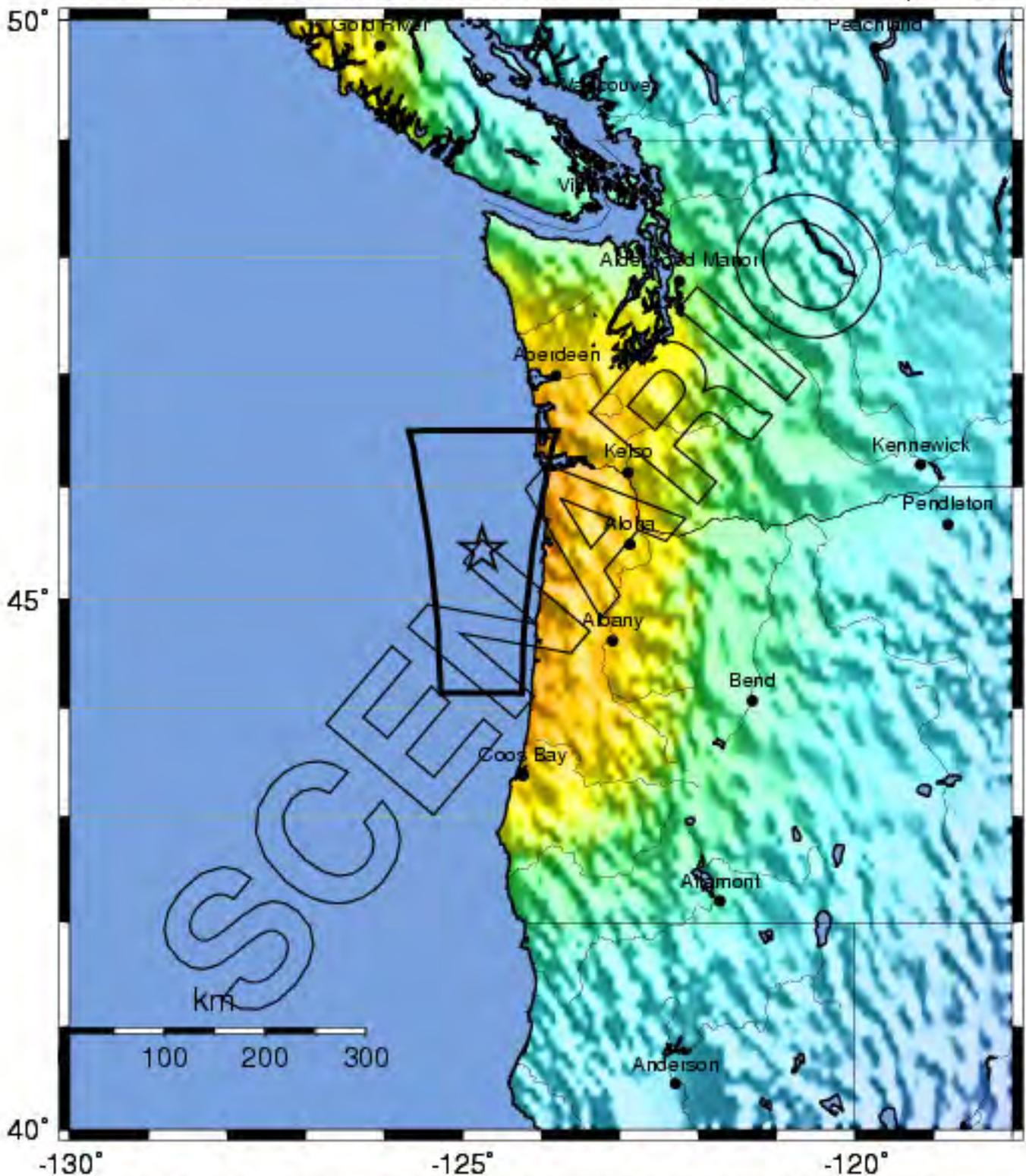
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-- Earthquake Planning Scenario --
 ShakeMap for Casc_North8.3 Scenario

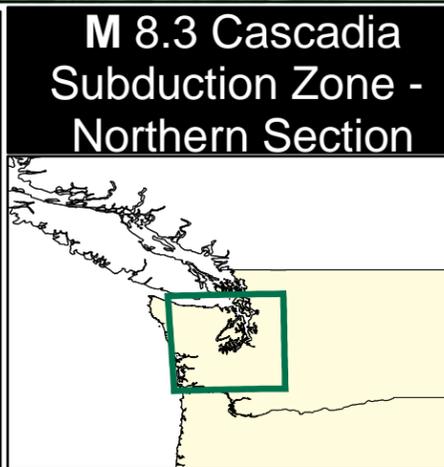
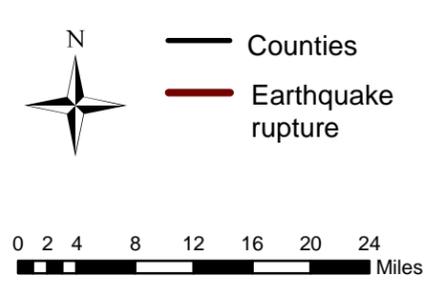
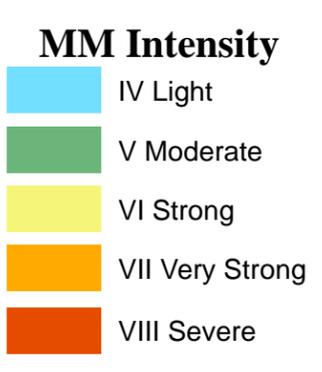
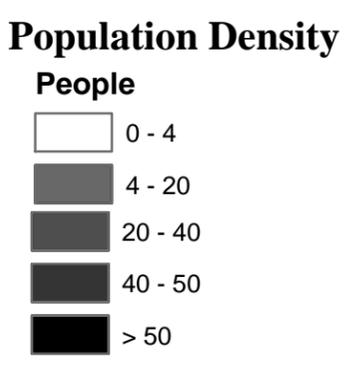
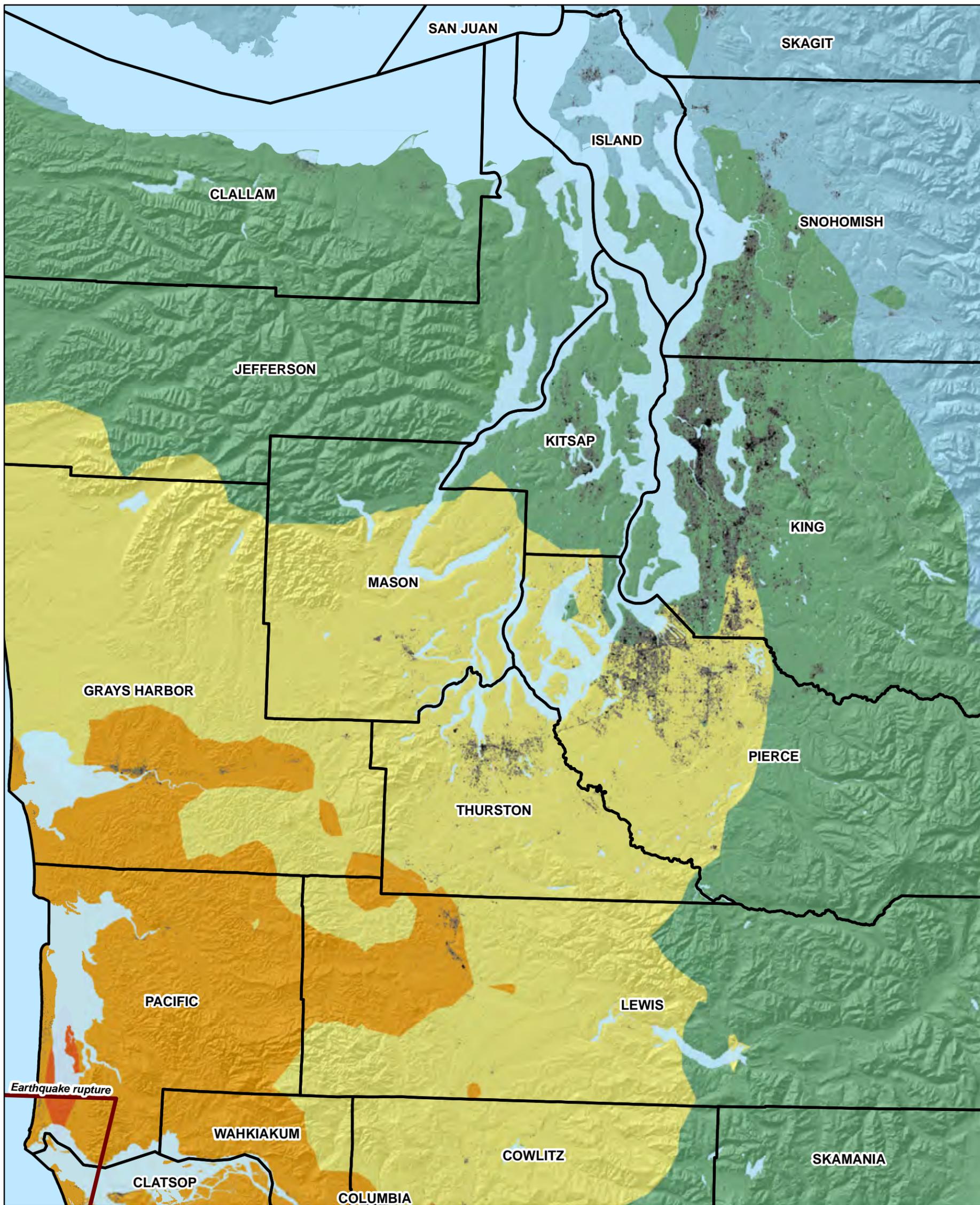
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PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Population Density and Ground Shaking Intensities - Earthquake Scenario: Washington

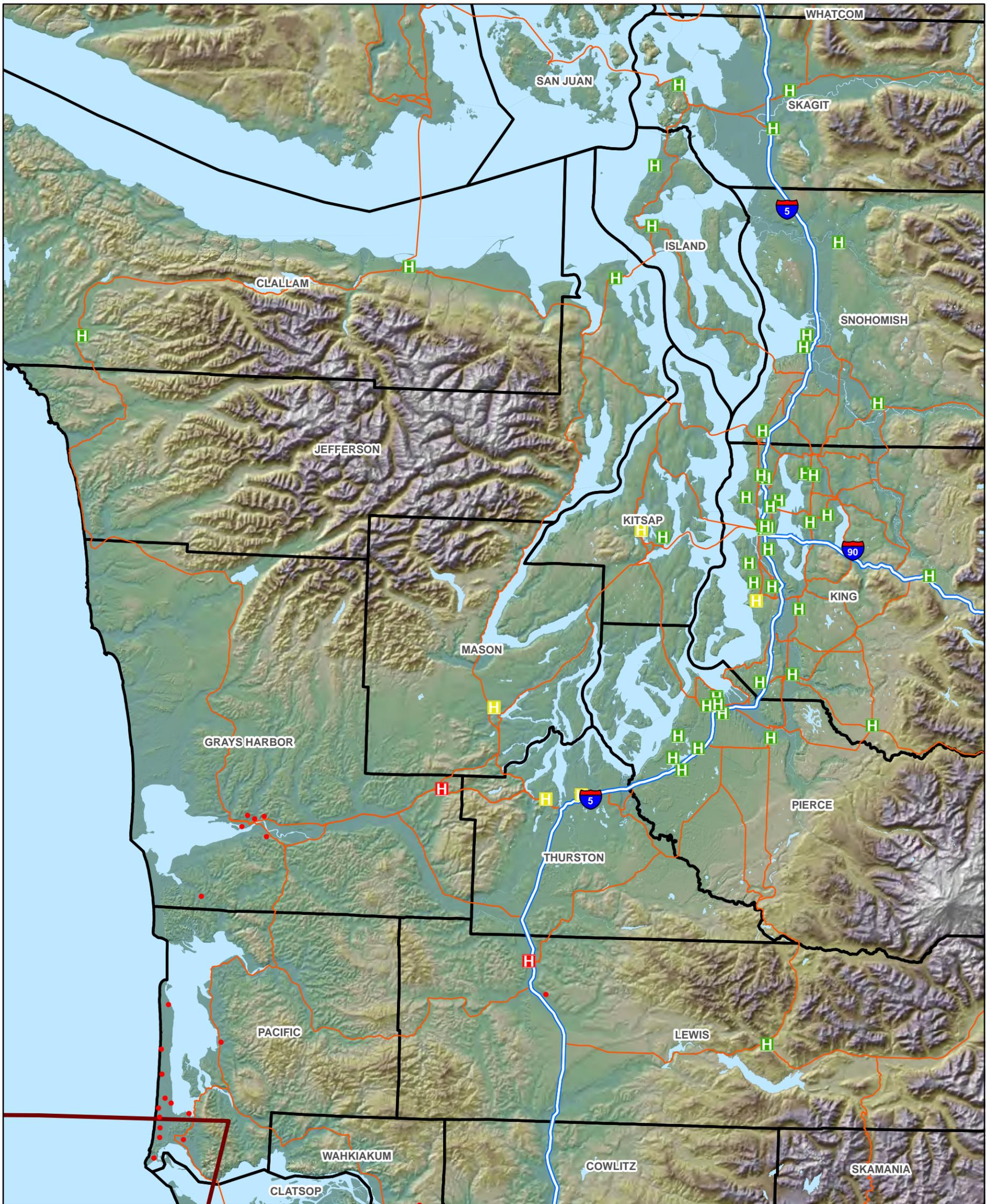


01-19-2011 Fabia Terra, URS Corporation

Sources: 2011 HAZUS runs by URS Corporation, MMI Map USGS 2009
 Projection: NAD83 Harn State Plane Washington 4602 (feet)

Figure 1

Fatalities (2 pm) and Impaired Hospitals (Day 1) - Earthquake Scenario: Washington



Impaired Hospitals at Day 1

Damage is expressed as the probability that a given hospital will be functional at Day 1.

- < 50%
- 50 - 90%
- > 90%

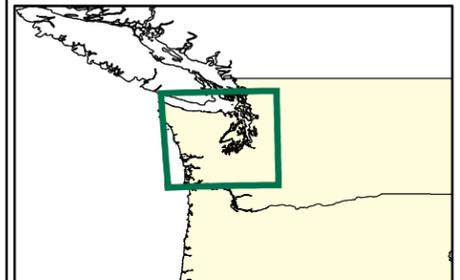
1 Dot = 1 Fatality (Severity Level 4 delineated by census tract)



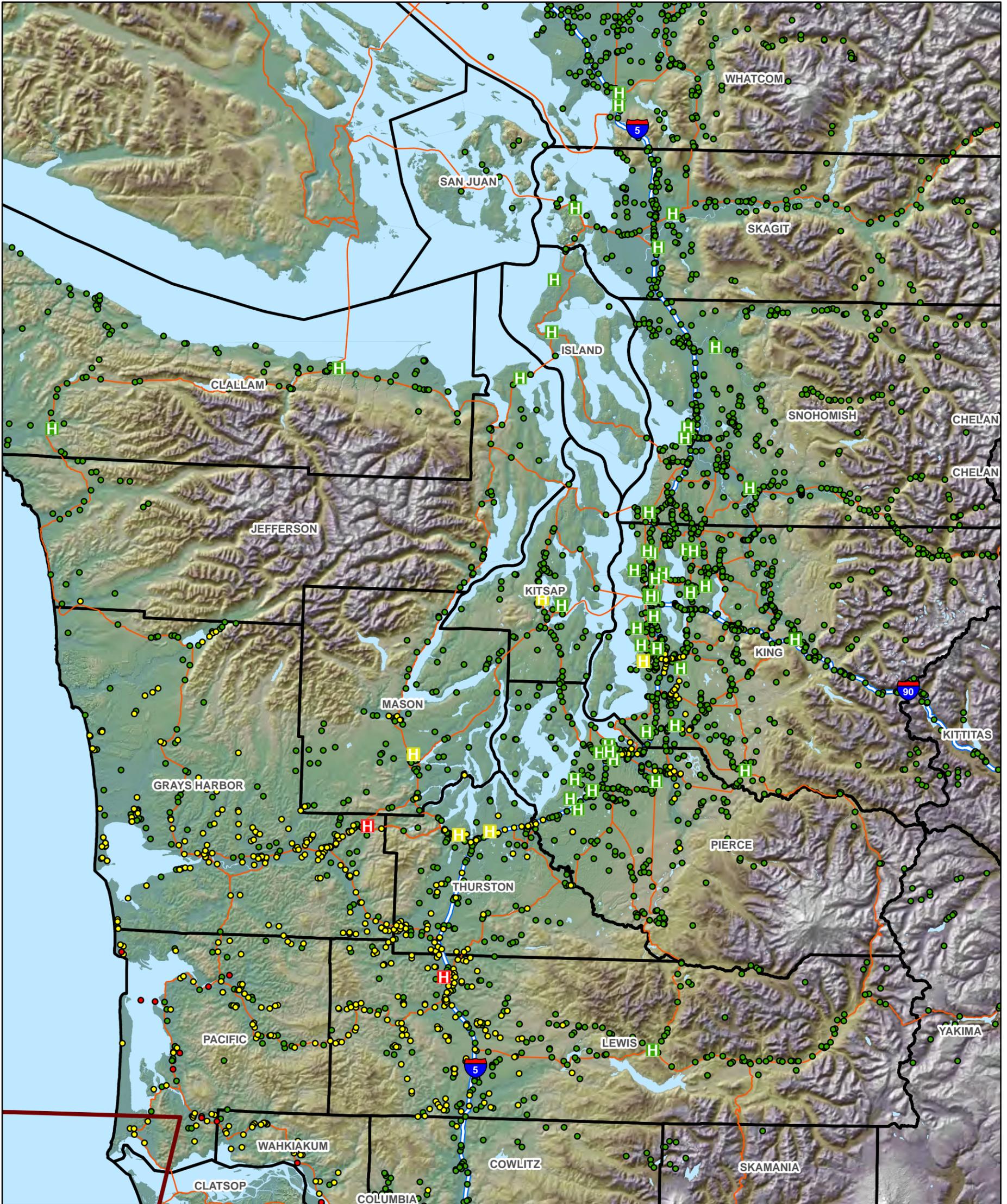
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County	Injuries Requiring Hospital Treatment (2 PM)	Fatalities (2 PM)
Clallam	1	0
Clark	389	6
Cowlitz	224	8
Grays Harbor	188	7
Jefferson	0	0
King	77	0
Lewis	112	3
Mason	10	0
Pacific	210	13
Pierce	65	0
Skamania	0	0
Thurston	94	1
Wahkaikam	16	1
Total	1,386	39

M 8.3 Cascadia Subduction Zone - Northern Section



Impaired Hospitals (Day 1), Hospital Bed Availability, & Bridge Functionality - Earthquake Scenario: Washington



County	Total # Hospital Beds	Hospital Beds Available	Injuries Requiring Hospital Treatment 2pm
Clallam	178	177	1
Cowlitz	346	12	224
Clark	760	144	389
Cowlitz	346	12	224
Grays Harbor	164	31	188
Jefferson	43	43	0
King	5,727	5,631	77
Lewis	415	246	112
Mason	68	57	10
Pacific	53	0	210
Pierce	3,270	3,180	65
Skamania	0	0	0
Thruston	494	419	94
Wahkaikam	0	0	16
Total	11,864	9,952	1,610

Highway Bridge Functionality (Day 1)

- Bridge Seg.
- < 50%
 - 50% - 90%
 - > 90%
- Damage is expressed as the probability that a given bridge segment will be functional at Day 1.

Impaired Hospitals at Day 1

- Damage is expressed as the probability that a given hospital will be functional at Day 1.
- < 50%
 - 50% - 90%
 - > 90%

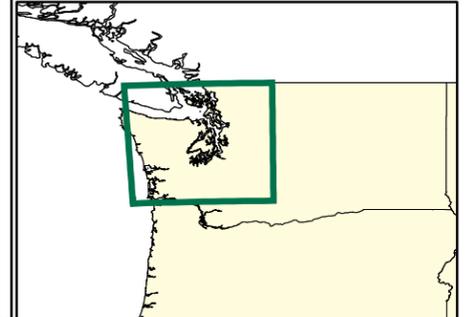
Roads

- Interstate
- Highway
- Counties
- Earthquake rupture



01-19-2011 Fabia Terra, URS Corporation

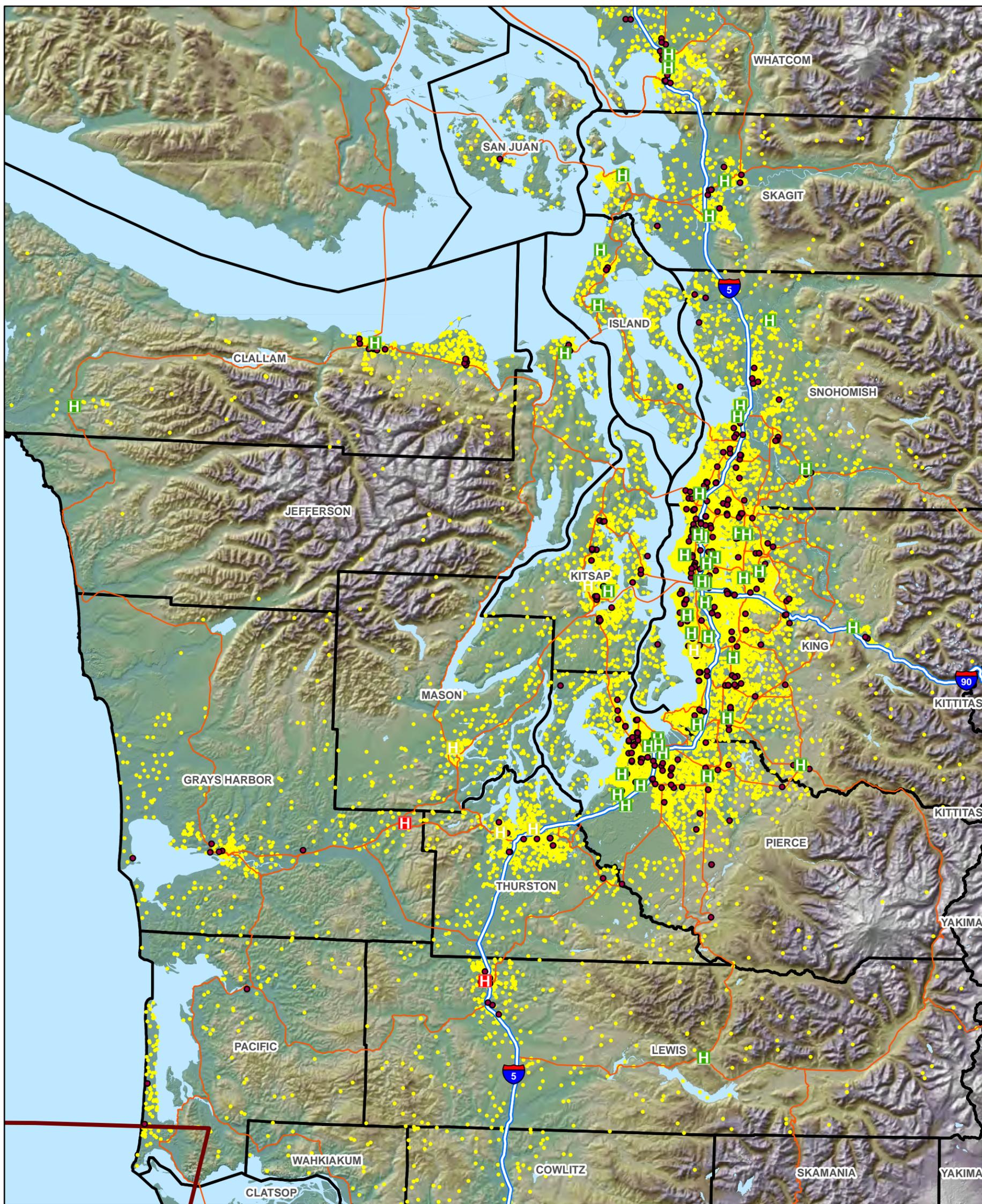
M 8.3 Cascadia Subduction Zone - Northern Section



Sources: 2011 HAZUS runs by URS Corporation, Highways HCIP Gold 2007
 Projection: NAD83 Harn State Plane Washington 4602 (feet)

Figure 3

Distribution of Elderly, Impaired Hospitals (Day 1), & Hospital Bed Availability - Earthquake Scenario: Washington



County	Total # Hospital Beds	Hospital Beds Available	Injuries Requiring Hospital Treatment 2pm
Clallam	178	177	1
Cowlitz	346	12	224
Clark	760	144	389
Cowlitz	346	12	224
Grays Harbor	164	31	188
Jefferson	43	43	0
King	5,727	5,631	77
Lewis	415	246	112
Mason	68	57	10
Pacific	53	0	210
Pierce	3,270	3,180	65
Skamania	0	0	0
Thruston	494	419	94
Wahkaikum	0	0	16
Total	11,864	9,952	1,610

1 Dot = 30 People over 65
 Nursing Home
 < 50%
 50 - 90%
 > 90%

Counties
 Earthquake rupture
 Interstate
 Highway

Impaired Hospitals at Day 1
 Damage is expressed as the probability that a given hospital will be functional at Day 1.

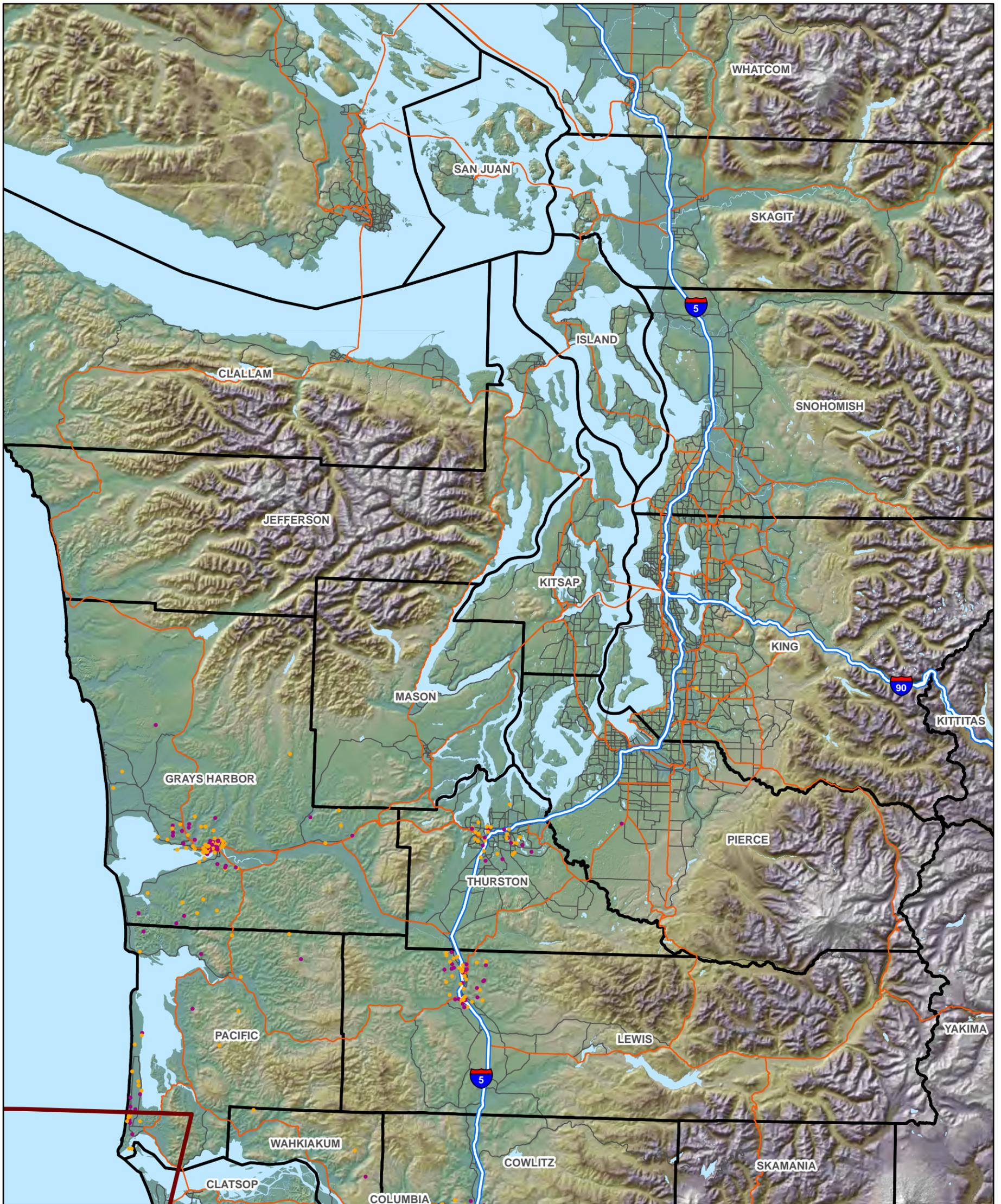
0 2.5 5 10 15 20 25 30
 Miles
 01-19-2011 Fabia Terra, URS Corporation

M 8.3 Cascadia Subduction Zone - Northern Section

Sources: 2011 HAZUS runs by URS Corporation, Highways and Nursing homes HCIP Gold 2007
 Projection: NAD83 Harn State Plane Washington 4602 (feet)

Figure 4

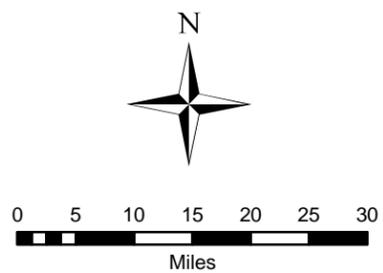
Estimated Displaced Households & Short Term Public Shelter Needs - Earthquake Scenario: Washington



	Total #
Public Shelter Needs (Individuals)	2,453
Displaced Households	3,692

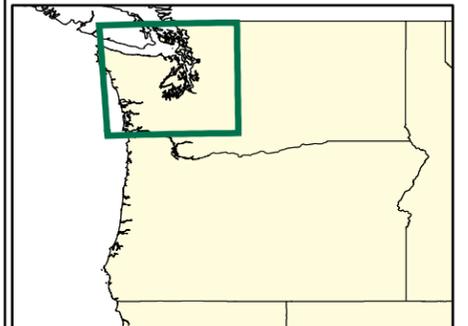
- 1 Dot = 10 Displaced Households*
 - 1 Dot = 10 Public Shelter Needs (Individuals)*
- * delineated by census tract

- Roads**
- Interstate
 - Highway
 - Major Road
- Counties**
- Counties
 - Earthquake rupture



01-19-2011 Fabia Terra, URS Corporation

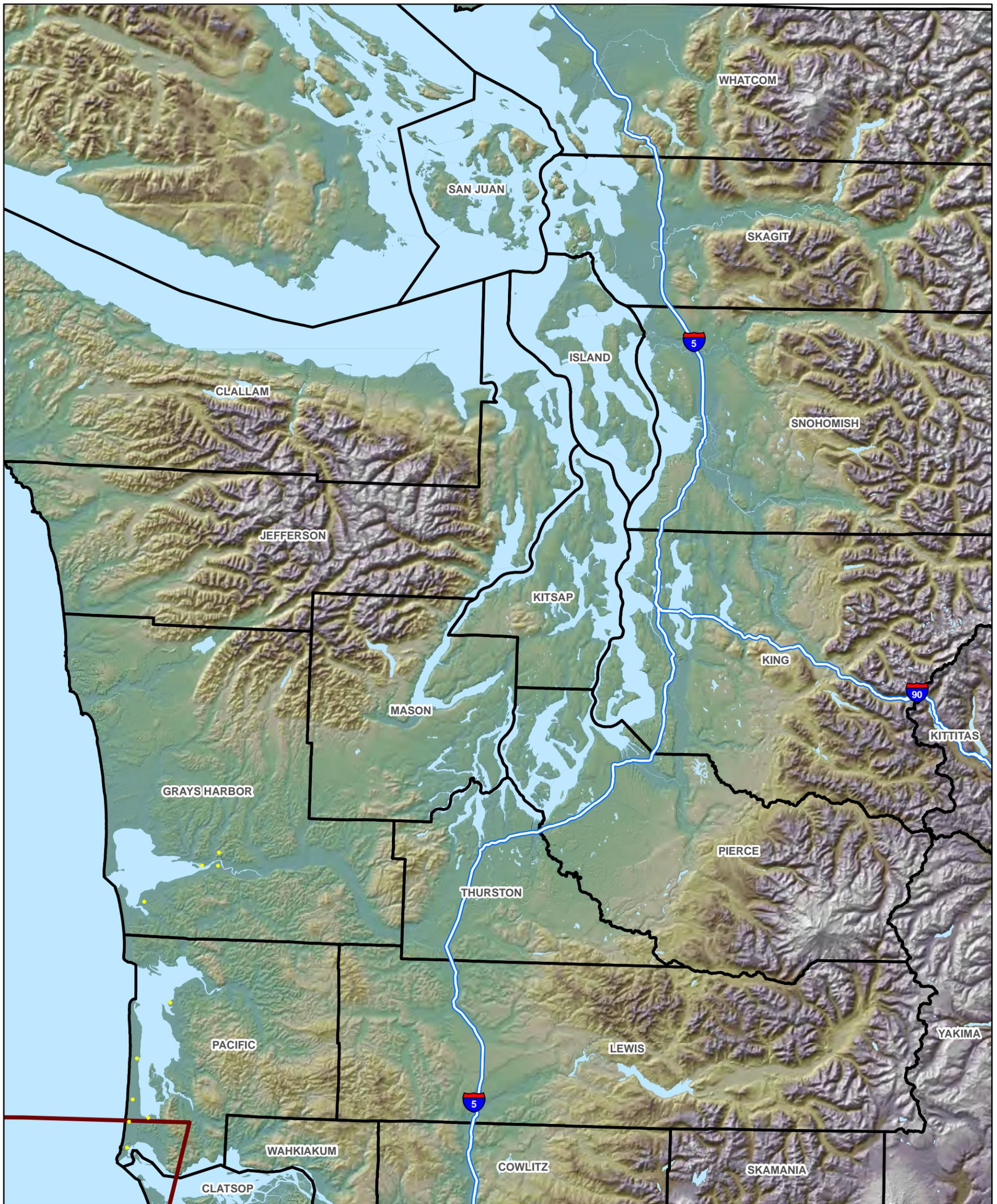
M 8.3 Cascadia Subduction Zone - Northern Section



Sources: 2011 HAZUS runs by URS Corporation, Highways HCIP Gold 2007
 Projection: NAD83 Harn State Plane Washington 4602 (feet)

Figure 5

Injuries 2pm, Collapsed Structures, and Impaired Hospitals - Earthquake Scenario: Washington



Structure Type	Complete Damage	Collapse Rates for Complete Damage	Total Collapse
Wood	147	3%	4
Steel	292	6%	18
Concrete	110	10%	11
Precast	114	13%	15
Reinforced Masonry	110	10%	11
Unreinforced Masonry	56	15%	8
Manufactured Housing	1,112	3%	33
Total	1,941		101

Impaired Hospitals (Day1)

- < 50%
- 50 - 90%
- > 90%

Damage is expressed as the probability that a given hospital will be functional on Day 1.

— Counties — Earthquake rupture

● 1 Dot = 1 Life Threatening Injury (Severity Level 3*)

*Severity Level 3 is defined as injuries that require hospitalization and can become life threatening if not promptly treated.

0 2.5 5 10 15 20 25 30 Miles

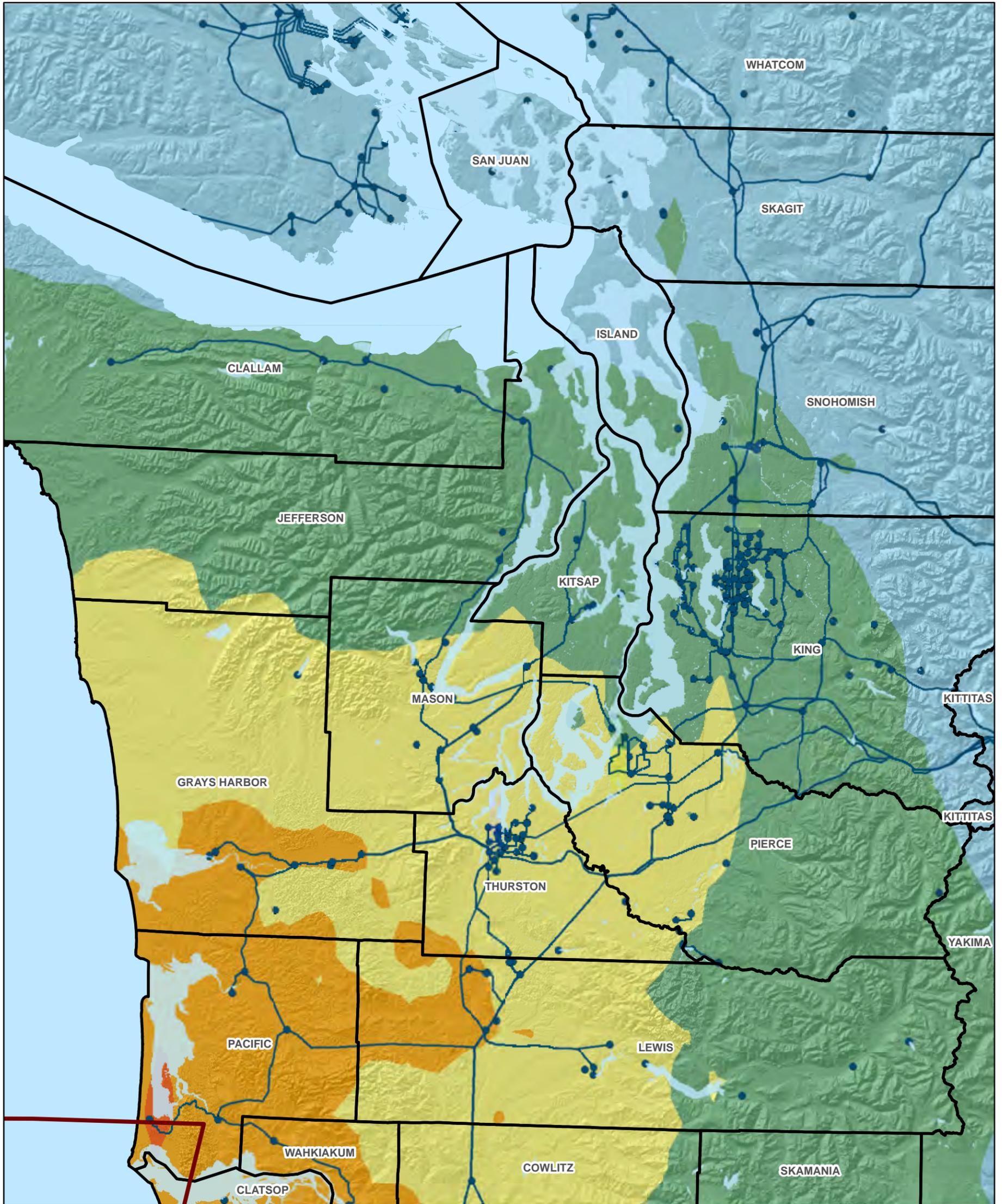
01-19-2011 Fabia Terra, URS Corporation

M 8.3 Cascadia Subduction Zone - Northern Section

Sources: 2011 HAZUS runs by URS Corporation, Highways HCIP Gold 2007
 Projection: NAD83 Harn State Plane Washington 4602 (feet)

Figure 6

Power Lines and Facilities, Households Without Electricity, and Ground Shaking Intensities - Earthquake Scenario: Washington

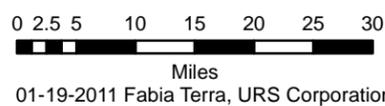


MM Intensity

- IV Light
- V Moderate
- VI Strong
- VII Very Strong
- VIII Severe

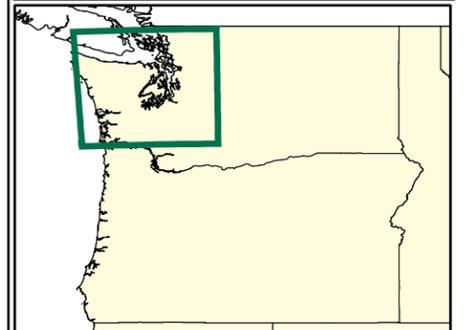
- Power Lines
- Power Facilities
- Counties
- Earthquake rupture

Number of Households without Electricity
 Clallam
 Grays Harbor
 King
 Mason



01-19-2011 Fabia Terra, URS Corporation

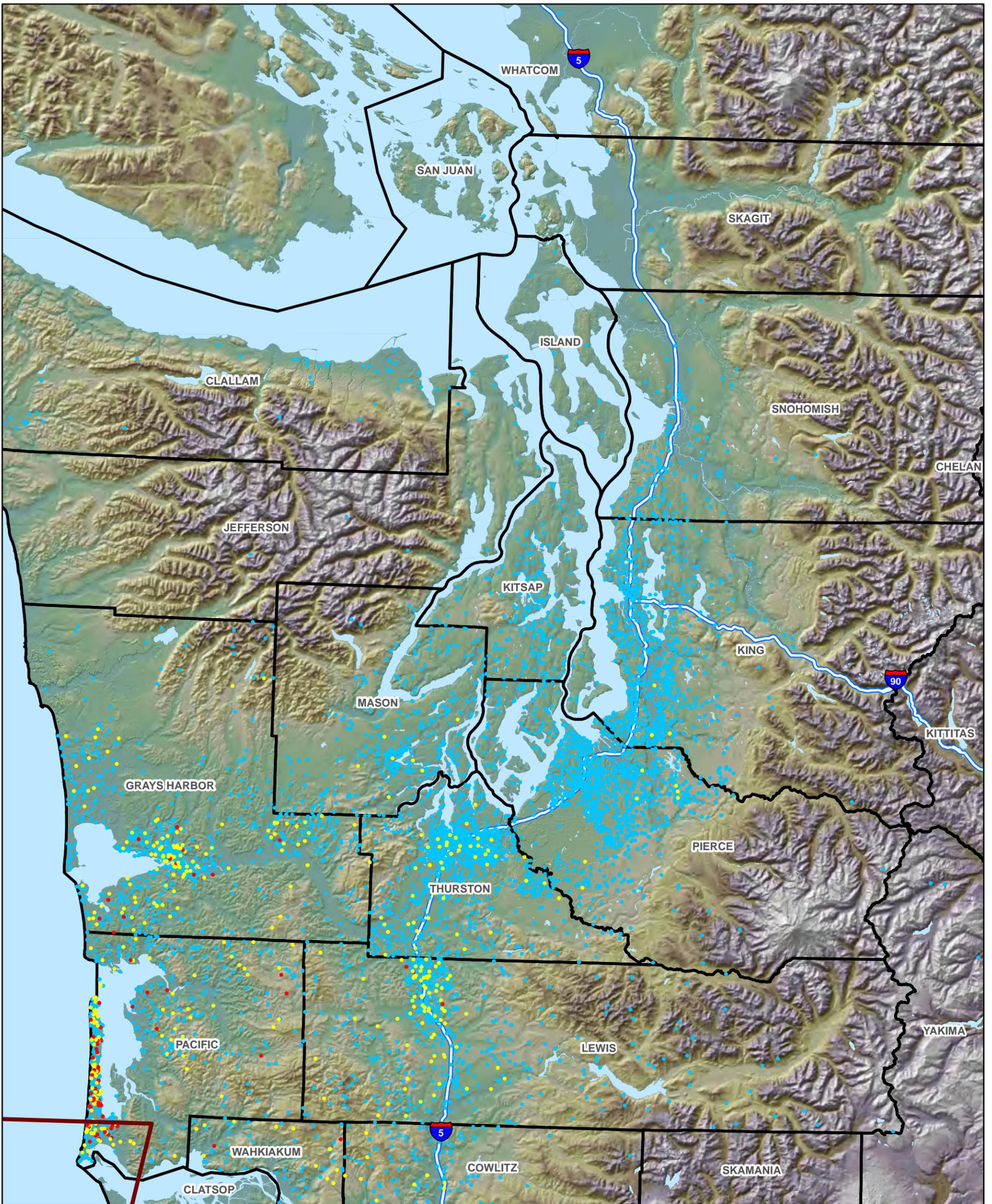
M 8.3 Cascadia Subduction Zone - Northern Section



Sources: 2011 HAZUS runs by URS Corporation, Power lines and facilities HCIP Gold 2007
 Projection: NAD83 Harn State Plane Washington 4602 (feet)

Figure 7

Estimated Building Inspection Needs - Earthquake Scenario: Washington



	Estimated # of Structures	Estimated # of Inspectors Needed
Red (Complete)	1,940	13
Yellow (Extensive)	12,233	163
Light Blue (Slight/Moderate)	140,186	935
Total	154,358	1,111

*Estimated number of inspectors needed to complete inspections in 30 days.

1 Dot = 20 buildings (by census tract)

- Red Tag (Complete Damage)
- Yellow Tag (Extensive Damage)
- Blue Tag (Slight/Moderate Damage)

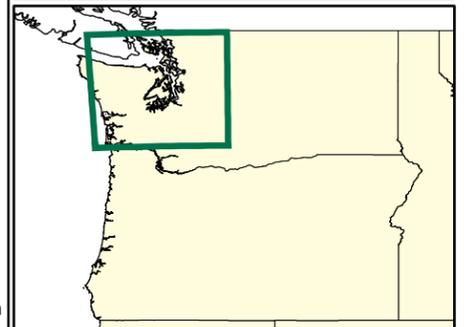
— Counties

— Earthquake rupture

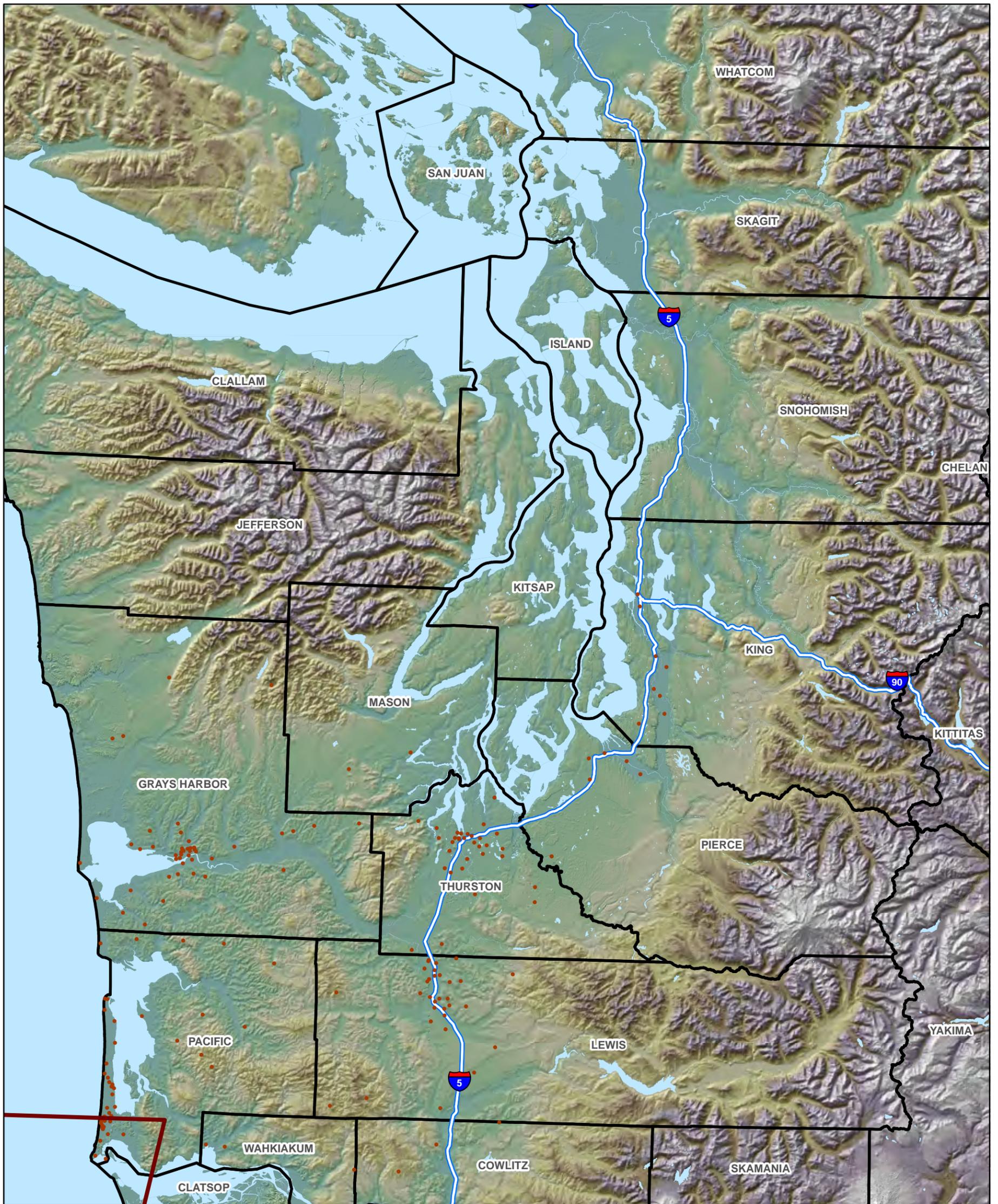


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M 8.3 Cascadia Subduction Zone - Northern Section



Direct Building Economic Loss - Earthquake Scenario: Washington



County	Cost Structural Damage	Cost Non-Structural Damage	Total Loss (Including Contents)
Clallam	\$1 M	\$4 M	\$6 M
Clark	\$128 M	\$314 M	\$561 M
Cowlitz	\$68 M	\$167 M	\$296 M
Grays Harbor	\$67 M	\$170 M	\$297 M
Jefferson	\$0 M	\$1 M	\$2 M
King	\$31 M	\$198 M	\$328 M
Kitsap	\$4 M	\$24 M	\$40 M
Lewis	\$50 M	\$106 M	\$39 M
Mason	\$5 M	\$23 M	\$37 M
Pacific	\$58 M	\$201 M	\$325 M
Pierce	\$30 M	\$161 M	\$266 M
Snohomish	\$3 M	\$28 M	\$45 M
Thurston	\$40 M	\$151 M	\$252 M
Wahkiakum	\$5 M	\$13 M	\$23 M
Total	\$491 M	\$1,562 M	\$2,518 M

1 Dot = \$10,000,000 worth of vulnerable building stock (by census tract)

— Counties

— Earthquake rupture

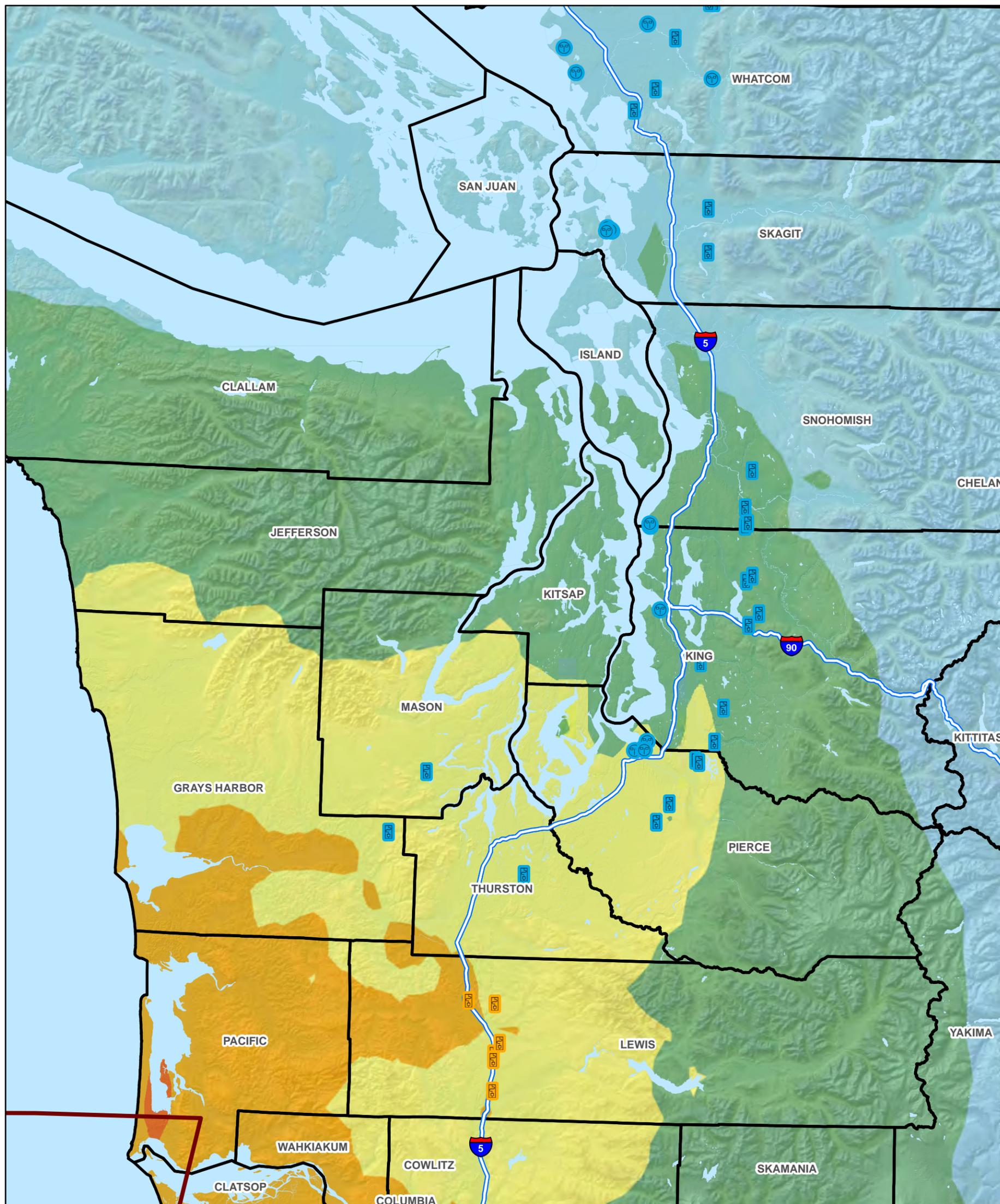
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M 8.3 Cascadia Subduction Zone - Northern Section

Sources: 2011 HAZUS runs by URS Corporation, Highways HCIP Gold 2007
 Projection: NAD83 Harn State Plane Washington 4602 (feet)

Figure 9

Natural Gas, and Oil Facility Damage - Earthquake Scenario: Washington



MM Intensity

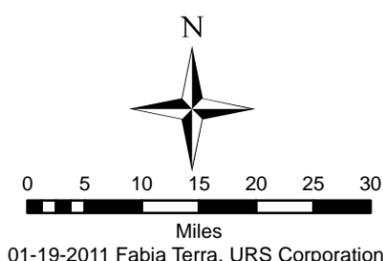
- IV Light
- V Moderate
- VI Strong
- VII Very Strong
- VIII Severe

Utility Damage (at least moderate)

Damage is expressed as the percentage chance that a given Utility System will realize at least moderate damage.

- | | |
|---|---|
| <p>Oil Facility</p> <ul style="list-style-type: none"> < 20% 20% - 60% > 60% | <p>Natural Gas Facility</p> <ul style="list-style-type: none"> < 20% 20% - 60% > 60% |
|---|---|

- Counties
- Earthquake rupture



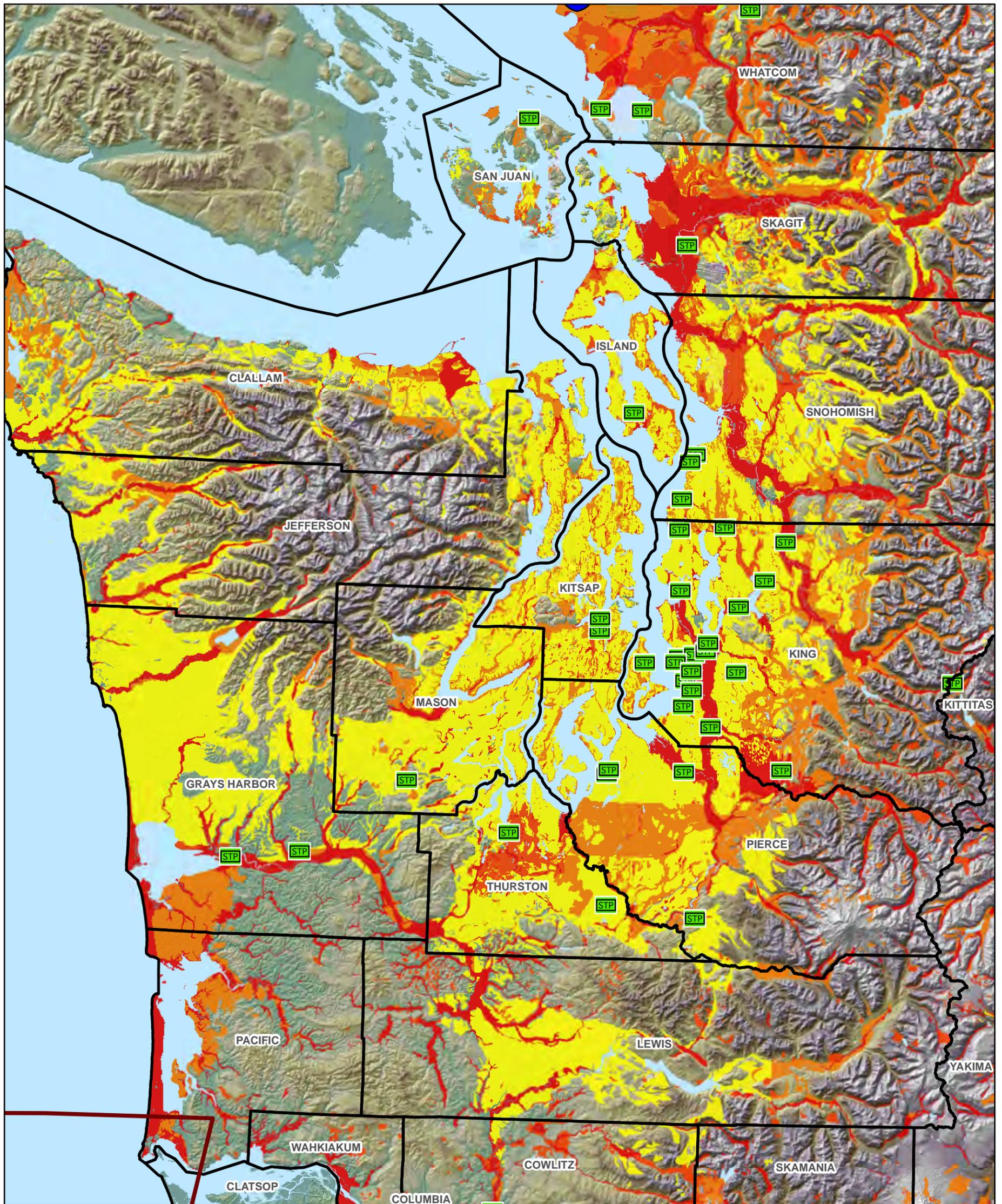
M 8.3 Cascadia Subduction Zone - Northern Section



Sources: 2011 HAZUS runs by URS Corporation, Highways HCIP Gold 2007, MMI Map USGS 2009
Projection: NAD83 Harn State Plane Washington 4602 (feet)

Figure 10

Sewage Treatment Facility Distribution, Households Without Potable Water, and Liquefaction Susceptibility - Earthquake Scenario: Washington



County	# Households without Potable Water (at Day 1)	Daily Potable Water Needs Per Person (Gallons/day)*	Number of Truckloads needed Daily
Cowlitz	75	225	1
Clallam	0	0	0
Grays Harbor	77	231	0
King	0	0	0
Kitsap	0	0	0
Lewis	11	33	1
Mason	0	0	0
Pacific	2,580	7,740	2
Pierce	0	0	0
Thurston	115	345	0

Liquefaction Susceptibility

- Low
- Low-Moderate
- Moderate
- High

Sewage Treatment Facilities

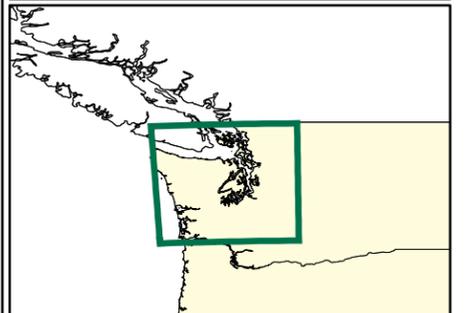
— Counties

— Earthquake rupture



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M 8.3 Cascadia Subduction Zone - Northern Section

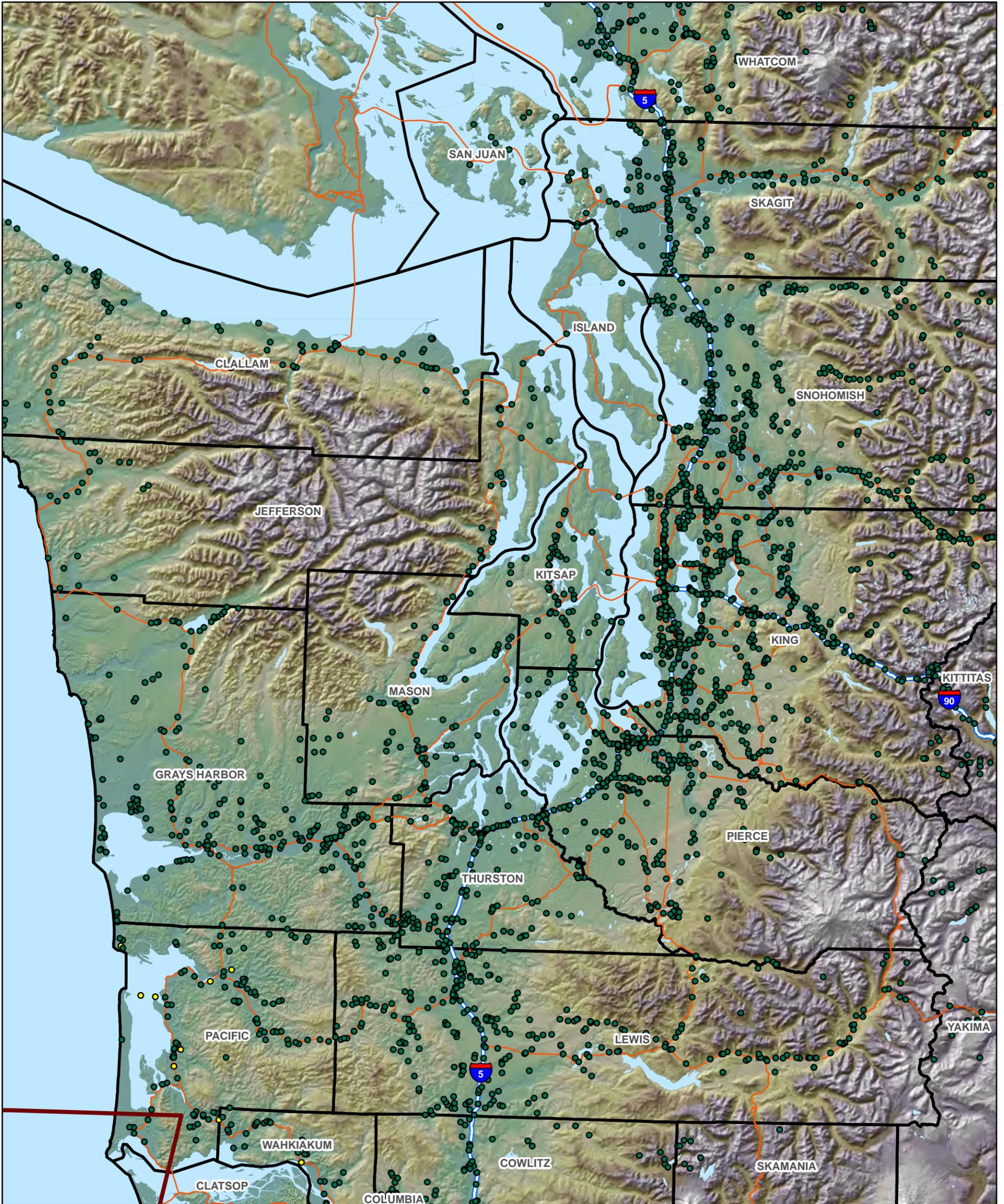


* Based on U.S. Army Corp Mission Guidebook
 (Daily water is based on an estimated 3 people per household.
 One truck can transport an estimated 5000 gallons of water.)

Sources: 2011 HAZUS runs by URS Corporation, Sewage Treatment Facilities HCIP Gold 2007, Liquefaction The Wash State Geological Survey
 Projection: NAD83 Harn State Plane Washington 4602 (feet)

Figure 11

Estimated Highway Bridge Damage - Earthquake Scenario: Washington



County	# of Bridges Needing Inspection	# of Bridge Engineers Needed*
Clallam	95	13
Grays Harbor	269	36
Island	6	1
Jefferson	54	7
King	1,033	138
Kitsap	83	11
Mason	92	12
Pierce	402	54
San Juan	9	1
Snohomish	466	62
Total	2,509	224

Highway Bridge Damage (at least moderate)

Damage is expressed as the probability that a given Bridge will realize at least moderate damage.

- Major Roadway Bridge**
- < 50%
 - 50% - 90%
 - > 90%

- Counties
- Earthquake rupture

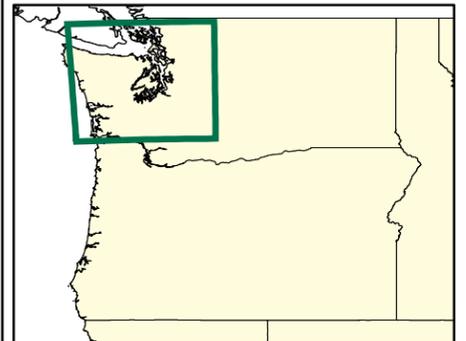
Roads

- Interstate
- Highway



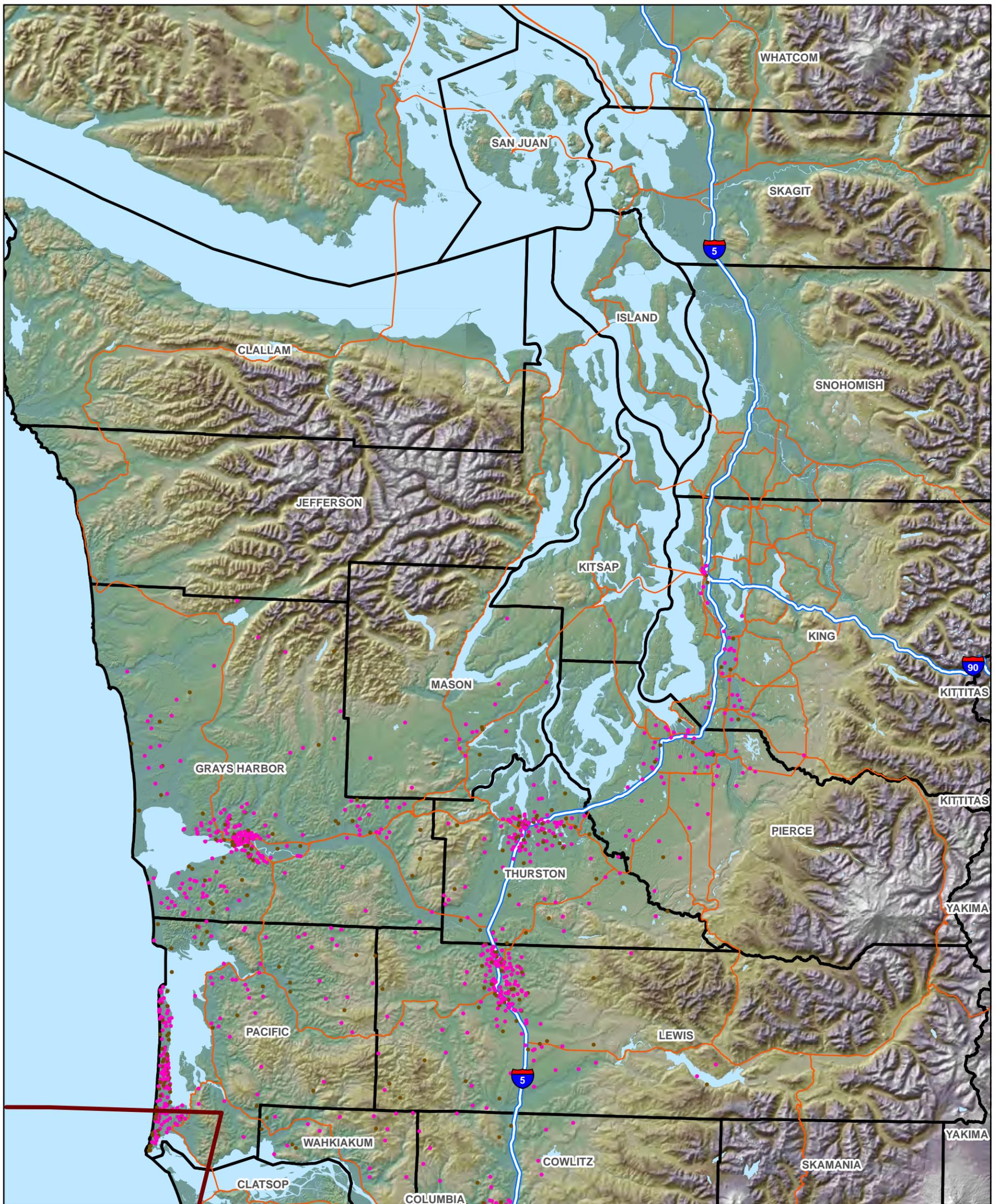
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M 8.3 Cascadia Subduction Zone - Northern Section



* 2 engineers can inspect 5 bridges a day for 3 days

Estimated Brick, Concrete, Steel, and Wood Debris - Earthquake Scenario: Washington



County	Brick and Wood (tons)	Concrete and Steel (tons)	Estimated Truck Loads*
Clallam	1,000	0	40
Cowlitz	49,000	161,000	8,400
Grays Harbor	56,000	154,000	8,400
Jefferson	0	0	0
King	31,000	34,000	2,600
Lewis	38,000	107,000	5,800
Mason	8,000	6,000	560
Pacific	70,000	133,000	8,120
Pierce	31,000	36,000	2,680
Snohomish	4,000	2,000	240
Thurston	45,000	56,000	4,040
Wahkiakum	5,000	12,000	680
Total	338,000	701,000	41,560

● 1 Dot = 1 thousand tons of Concrete and Steel Debris*
● 1 Dot = 1 thousand tons of Brick and Wood Debris*
 *by census tract

* Truck loads estimated at 25 tons per truck

Counties
 — Earthquake rupture
Roads
 — Interstate
 — Highway



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M 8.3 Cascadia Subduction Zone - Northern Section

