Hazus: Earthquake Global Risk Report

Region Name: CascadiaMegathrus

Earthquake Scenario: cascadia_sub0_m9p34_se

Print Date: May 20, 2024

Disclaimer:

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

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-MH is a regional earthquake loss estimation model that was developed by the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences. The primary purpose of Hazus is to provide a methodology and software application to develop multi-hazard 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 multi-hazards and to prepare for emergency response and recovery.

The earthquake loss estimates provided in this report was based on a region that includes 46 county(ies) from the following state(s):

California

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

The geographical size of the region is 94,923.40 square miles and contains 3,502 census tracts. There are over 5,335 thousand households in the region which has a total population of 15,149,716 peopleF. The distribution of population by Total Region and County is provided in Appendix B.

There are an estimated 4,758 thousand buildings in the region with a total building replacement value (excluding contents) of (millions of dollars). Approximately 90.00 % of the buildings (and % of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 265,813 and 214,285 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

Hazus estimates that there are 4,758 thousand buildings in the region which have an aggregate total replacement value of (millions of dollars) . Appendix B provides a general distribution of the building value by Total Region and County.

In terms of building construction types found in the region, wood frame construction makes up 86% 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 facilities (HPL). 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 277 hospitals in the region with a total bed capacity of 38,518 beds. There are 5,840 schools, 1,768 fire stations, 544 police stations and 101 emergency operation facilities. With respect to high potential loss facilities (HPL), there are no dams identified within the inventory. The inventory also includes no hazardous material sites, no military installations and no 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 480,098.00 (millions of dollars). This inventory includes over 13,375.63 miles of highways, 13,671 bridges, 323,910.76 miles of pipes.

Table 1: Transportation System Lifeline Inventory

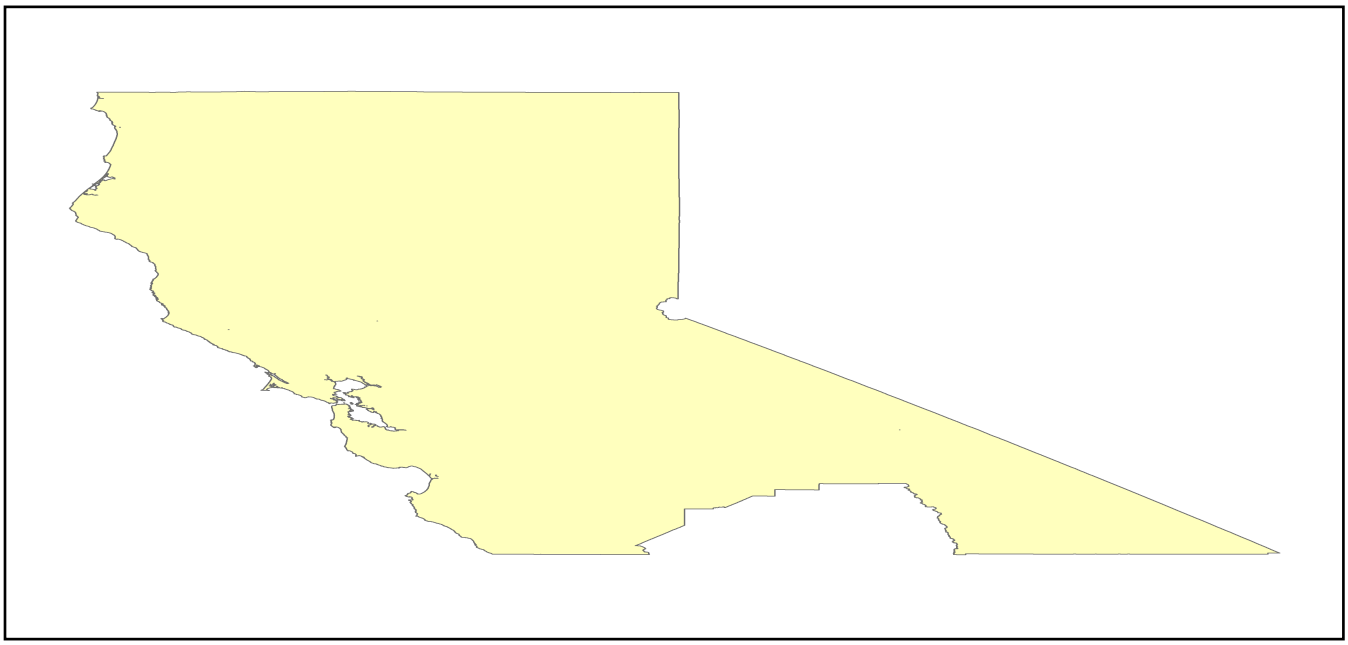
System	Component	# Locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	13,671	62701.4503
	Segments	7,447	109894.3309
	Tunnels	51	1028.6732
		Subtotal	**173624.4544**
Railways	Bridges	2,016	11471.0400
	Facilities	83	221.0290
	Segments	3,539	64551.1864
	Tunnels	3	1.8495
		Subtotal	**76245.1049**
Light Rail	Bridges	112	15.3529
	Facilities	255	4154.0000
	Segments	15	5403.2756
	Tunnels	0	0.0000
		Subtotal	**9572.6285**
Bus	Facilities	52	118.3116
		Subtotal	**118.3116**
Ferry	Facilities	25	33.2750
		Subtotal	**33.2750**
Port	Facilities	385	1467.5602
		Subtotal	**1467.5602**
Airport	Facilities	165	3128.3430
	Runways	211	1623.6748
		Subtotal	**4752.0178**
		Total	**265,813.40**

Table 2: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	6453.1801
	Facilities	25	982.3500
	Pipelines	0	0.0000
		Subtotal	**7435.5301**
Waste Water	Distribution Lines	NA	3871.9081
	Facilities	214	36797.6852
	Pipelines	0	0.0000
		Subtotal	**40669.5933**
Natural Gas	Distribution Lines	NA	2581.2720
	Facilities	5	183.1757
	Pipelines	1,062	17715.2438
		Subtotal	**20479.6915**
Oil Systems	Facilities	17	2.0060
	Pipelines	0	0.0000
		Subtotal	**2.0060**
Electrical Power	Facilities	431	145640.3438
		Subtotal	**145640.3438**
Communication	Facilities	493	58.1740
		Subtotal	**58.1740**
		Total	**214,285.30**

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_sub0_m9p34_se
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	9.34
Depth (km)	NA
Rupture Length (Km)	NA
Rupture Orientation (degrees)	NA
Attenuation Function	NA

Direct Earthquake Damage

Building Damage

Hazus estimates that about 57,981 buildings will be at least moderately damaged. This is over 1.00 % of the buildings in the region. There are an estimated 3,140 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 summarizes the expected damage by general occupancy for the buildings in the region. Table 4 below summarizes the expected damage by general building type.

Damage Categories by General Occupancy Type

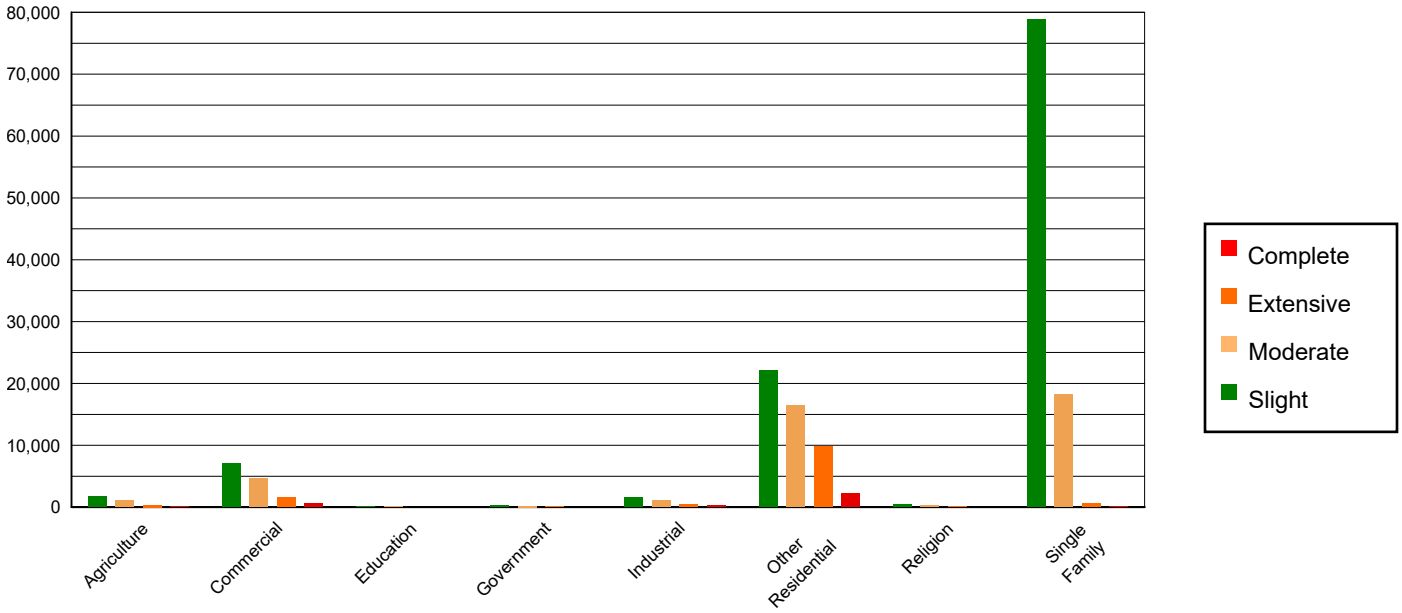


Table 3: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	30415.36	0.66	1711.53	1.53	1079.44	2.58	338.85	2.59	88.83	2.83
Commercial	293771.69	6.40	7025.56	6.27	4572.77	10.94	1622.79	12.43	570.18	18.16
Education	9554.79	0.21	165.14	0.15	69.11	0.17	12.25	0.09	2.71	0.09
Government	22102.58	0.48	309.98	0.28	177.97	0.43	51.83	0.40	12.63	0.40
Industrial	80004.04	1.74	1510.03	1.35	1063.42	2.55	474.02	3.63	206.50	6.58
Other Residential	576430.08	12.56	22052.31	19.69	16440.78	39.35	9836.33	75.32	2170.50	69.11
Religion	16973.70	0.37	367.60	0.33	209.69	0.50	82.23	0.63	17.78	0.57
Single Family	3559741.05	77.57	78828.65	70.40	18168.34	43.48	641.56	4.91	71.40	2.27
Total	**4,588,993**		**111,971**		**41,781**		**13,060**		**3,141**	

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

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	3993373.00	87.02	92309.94	82.44	22523.82	53.91	885.83	6.78	98.61	3.14
Steel	102289.34	2.23	2953.37	2.64	2525.04	6.04	1191.30	9.12	420.94	13.40
Concrete	116292.52	2.53	2415.04	2.16	1891.22	4.53	966.31	7.40	427.85	13.62
Precast	61068.45	1.33	1521.40	1.36	1334.51	3.19	425.26	3.26	87.27	2.78
RM	176919.64	3.86	2251.84	2.01	1736.76	4.16	683.18	5.23	124.26	3.96
URM	43650.23	0.95	1550.95	1.39	381.12	0.91	183.95	1.41	248.12	7.90
MH	95400.13	2.08	8968.27	8.01	11389.03	27.26	8724.02	66.80	1733.50	55.20
Total	**4,588,993**		**111,971**		**41,781**		**13,060**		**3,141**	

*Note:

RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had 38,518 hospital beds available for use. On the day of the earthquake, the model estimates that only 34,344 hospital beds (89.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 92.00% of the beds will be back in service. By 30 days, 96.00% will be operational.

Table 5: Expected Damage to Essential Facilities

Classification	Total	# Facilities		
		At Least Moderate Damage > 50%	Complete Damage > 50%	With Functionality > 50% on day 1
Hospitals	277	20	2	248
Schools	5,840	342	18	5,380
EOCs	101	3	0	95
PoliceStations	544	25	1	499
FireStations	1,768	63	1	1,603

Transportation Lifeline Damage

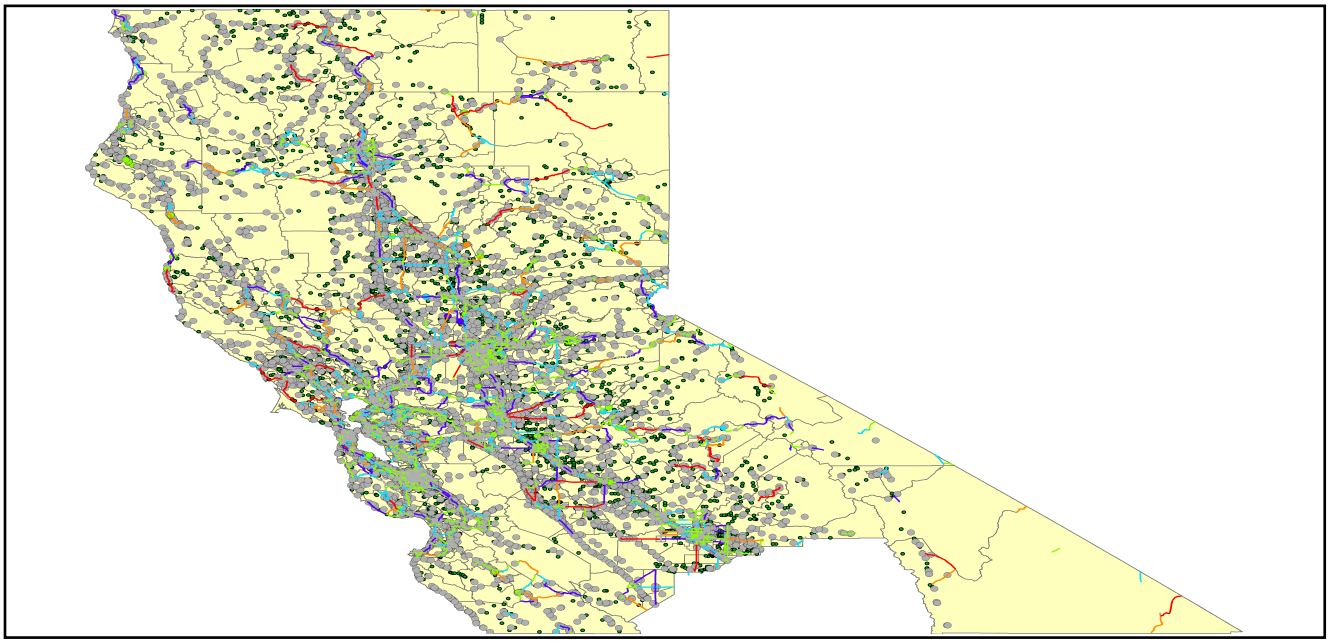


Table 6: Expected Damage to the Transportation Systems

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	7,447	0	0	7,447	7,447
	Bridges	13,671	36	1	13,618	13,663
	Tunnels	51	0	0	51	51
Railways	Segments	3,539	0	0	3,539	3,539
	Bridges	2,016	0	0	2,016	2,016
	Tunnels	3	0	0	3	3
	Facilities	83	0	0	83	83
Light Rail	Segments	15	0	0	15	15
	Bridges	112	0	0	112	112
	Tunnels	0	0	0	0	0
	Facilities	255	0	0	255	255
Bus	Facilities	52	3	0	52	52
Ferry	Facilities	25	0	0	25	25
Port	Facilities	385	23	0	379	385
Airport	Facilities	165	14	0	162	165
	Runways	211	0	0	211	211

Table 6 provides damage estimates for the transportation system.

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	# of Locations				
	Total #	With at Least Moderate Damage	With Complete Damage	with Functionality > 50 %	
				After Day 1	After Day 7
Potable Water	25	1	0	23	25
Waste Water	214	18	0	186	214
Natural Gas	5	1	0	4	5
Oil Systems	17	0	0	17	17
Electrical Power	431	36	0	408	425
Communication	493	50	0	462	493

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

System	Total Pipelines Length (miles)	Number of Leaks	Number of Breaks
Potable Water	200,491	14879	3720
Waste Water	120,295	7474	1868
Natural Gas	3,125	0	0
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	5,335,507	39,256	33,824	25,594	7,084	0
Electric Power		103,993	70,689	32,714	4,208	134

Induced Earthquake Damage

Fire Following Earthquake

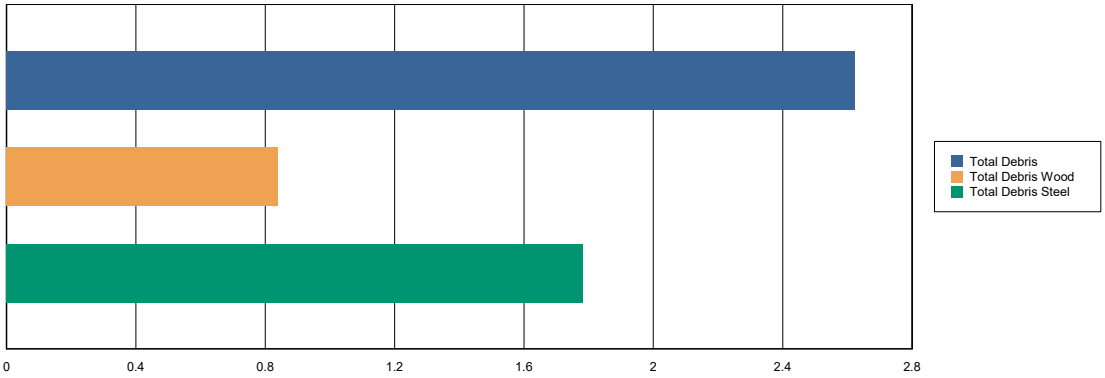
Fires often occur after an earthquake. Because of the number of fires and the lack of water to fight the fires, they can often burn out of control. Hazus uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area. For this scenario, the model estimates that there will be 14 ignitions that will burn about 0.17 sq. mi 0.00 % of the region's total area.) The model also estimates that the fires will displace about 1,468 people and burn about 171 (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 2,623,000 tons of debris will be generated. Of the total amount, Brick/Wood comprises 32.00% 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 104,920 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.

Earthquake Debris (millions of tons)



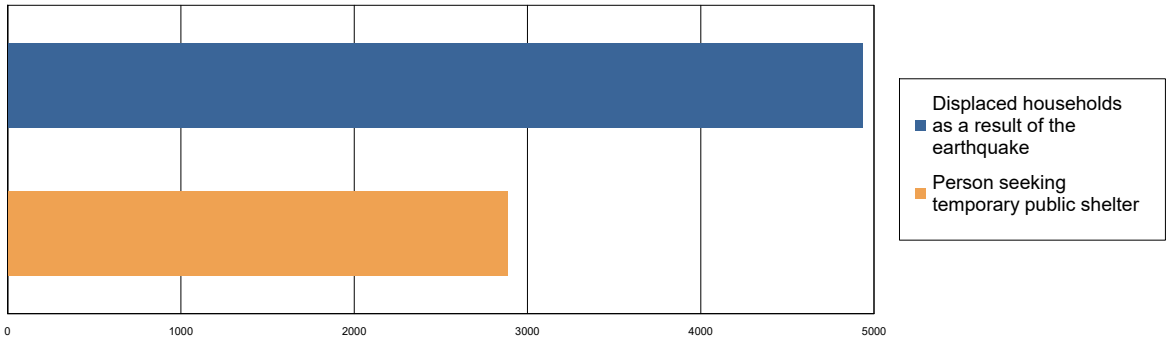
Brick/ Wood	Reinforced Concrete/Steel	Total Debris	Truck Load
0.84	1.78	2.62	104,920 (@25 tons/truck)

Social Impact

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 4,933 households to be displaced due to the earthquake. Of these, 2,886 people (out of a total population of 15,149,716) will seek temporary shelter in public shelters.

Displaced Households/ Persons Seeking Short Term Public Shelter



Displaced households as a result of the earthquake	Persons seeking temporary public shelter
4,933	2,886

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	12.72	2.95	0.42	0.82
	Commuting	0.16	0.21	0.36	0.07
	Educational	0.00	0.00	0.00	0.00
	Hotels	0.66	0.15	0.02	0.04
	Industrial	12.91	3.16	0.45	0.89
	Other-Residential	702.68	135.44	12.60	23.59
	Single Family	236.55	20.19	0.80	1.55
	Total	**966**	**162**	**15**	**27**
2 PM	Commercial	982.17	225.18	31.50	61.29
	Commuting	1.42	1.90	3.21	0.62
	Educational	404.63	90.68	12.44	24.02
	Hotels	0.13	0.03	0.00	0.01
	Industrial	94.87	23.19	3.33	6.47
	Other-Residential	242.22	47.15	4.57	8.37
	Single Family	80.86	7.15	0.31	0.56
	Total	**1,806**	**395**	**55**	**101**
5 PM	Commercial	684.62	156.86	22.00	42.29
	Commuting	24.43	32.48	54.95	10.63
	Educational	104.11	24.55	3.51	6.74
	Hotels	0.20	0.04	0.01	0.01
	Industrial	59.29	14.49	2.08	4.04
	Other-Residential	258.17	50.33	4.88	8.93
	Single Family	88.76	7.88	0.35	0.64
	Total	**1,220**	**287**	**88**	**73**

Economic Loss

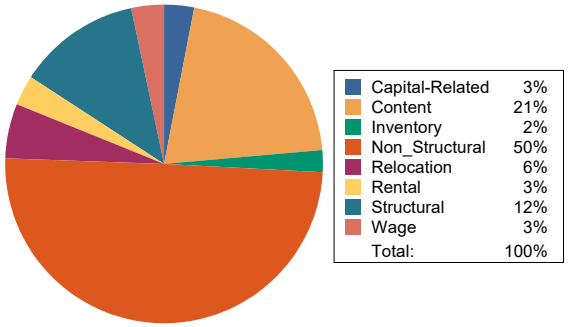
The total economic loss estimated for the earthquake is 25,585.59 (millions of dollars), which includes building and lifeline related losses based on the region's available inventory. The following three sections provide more detailed information about these losses.

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 14,623.14 (millions of dollars); 15 % 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 41 % of the total loss. Table 11 below provides a summary of the losses associated with the building damage.

Earthquake Losses by Loss Type ($ millions)



Earthquake Losses by Occupancy Type ($ millions)

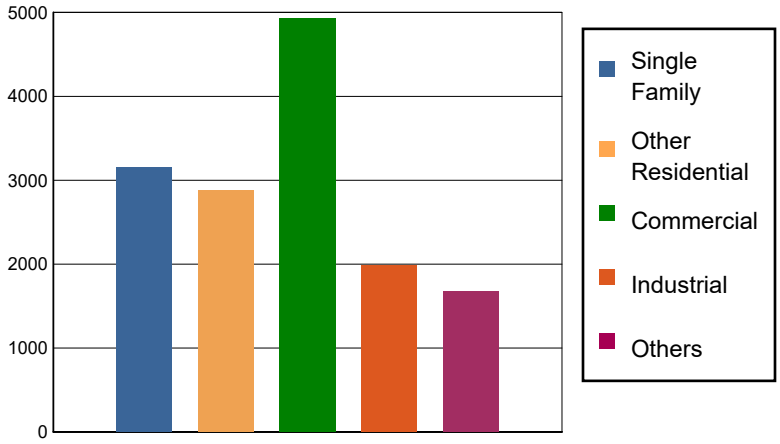


Table 11: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses							
	Wage	0.0000	66.3432	364.1970	26.7905	44.7009	502.0316
	Capital-Related	0.0000	28.2059	374.3411	16.6575	12.0435	431.2480
	Rental	44.9508	140.9783	210.7887	13.6122	22.0198	432.3498
	Relocation	161.8412	149.8002	300.9474	59.9760	155.3764	827.9412
	Subtotal	**206.7920**	**385.3276**	**1250.2742**	**117.0362**	**234.1406**	**2193.5706**
Capital Stock Losses							
	Structural	311.2214	361.8659	609.4858	253.7721	274.3290	1,810.6742
	Non_Structural	1898.5099	1749.8058	1960.7551	914.9405	733.2819	7,257.2932
	Content	738.1842	377.6626	945.8878	617.6377	349.6760	3,029.0483
	Inventory	0.0000	0.0000	159.6543	87.8081	85.0955	332.5579
	Subtotal	**2947.9155**	**2489.3343**	**3675.7830**	**1874.1584**	**1442.3824**	**12429.5736**
	Total	**3154.71**	**2874.66**	**4926.06**	**1991.19**	**1676.52**	**14623.14**

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.

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

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	109894.3309	0.0000	0.00
	Bridges	62701.4503	289.4514	0.46
	Tunnels	1028.6732	2.0189	0.20
	Subtotal	**173624.4544**	**291.4703**	
Railways	Segments	64551.1864	0.0000	0.00
	Bridges	11471.0400	19.5071	0.17
	Tunnels	1.8495	0.0000	0.00
	Facilities	221.0290	4.5810	2.07
	Subtotal	**76245.1049**	**24.0881**	
Light Rail	Segments	5403.2756	0.0000	0.00
	Bridges	15.3529	0.0001	0.00
	Tunnels	0.0000	0.0000	0.00
	Facilities	4154.0000	49.8610	1.20
	Subtotal	**9572.6285**	**49.8611**	
Bus	Facilities	118.3116	6.6369	5.61
	Subtotal	**118.3116**	**6.6369**	
Ferry	Facilities	33.2750	0.7382	2.22
	Subtotal	**33.2750**	**0.7382**	
Port	Facilities	1467.5602	69.0344	4.70
	Subtotal	**1467.5602**	**69.0344**	
Airport	Facilities	3128.3430	112.7181	3.60
	Runways	1623.6748	0.0000	0.00
	Subtotal	**4752.0178**	**112.7181**	
	Total	**265,813.35**	**554.55**	

Table 13: Utility System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Potable Water	Pipelines	0.0000	0.0000	0.00
	Facilities	982.3500	16.4345	1.67
	Distribution Lines	6453.1801	66.9533	1.04
	Subtotal	**7435.5301**	**83.3878**	
Waste Water	Pipelines	0.0000	0.0000	0.00
	Facilities	36797.6852	1254.5337	3.41
	Distribution Lines	3871.9081	33.6324	0.87
	Subtotal	**40669.5933**	**1288.1661**	
Natural Gas	Pipelines	17715.2438	0.0000	0.00
	Facilities	183.1757	11.6866	6.38
	Distribution Lines	2581.2720	11.5222	0.45
	Subtotal	**20479.6915**	**23.2088**	
Oil Systems	Pipelines	0.0000	0.0000	0.00
	Facilities	2.0060	0.0127	0.63
	Subtotal	**2.0060**	**0.0127**	
Electrical Power	Facilities	145640.3438	9008.9482	6.19
	Subtotal	**145640.3438**	**9008.9482**	
Communication	Facilities	58.1740	4.1689	7.17
	Subtotal	**58.1740**	**4.1689**	
	Total	**214,285.34**	**10,407.89**	

Appendix A: County Listing for the Region

Alameda,CA

Alpine,CA

Amador,CA

Butte,CA

Calaveras,CA

Colusa,CA

Contra Costa,CA

Del Norte,CA

El Dorado,CA

Fresno,CA

Glenn,CA

Humboldt,CA

Inyo,CA

Lake,CA

Lassen,CA

Madera,CA

Marin,CA

Mariposa,CA

Mendocino,CA

Merced,CA

Modoc,CA

Mono,CA

Monterey,CA

Napa,CA

Nevada,CA

Placer,CA

Plumas,CA

Sacramento,CA

San Benito,CA

San Francisco,CA

San Joaquin,CA

San Mateo,CA

Santa Clara,CA

Santa Cruz,CA

Shasta,CA

Sierra,CA

Siskiyou,CA

Solano,CA

Sonoma,CA

Stanislaus,CA

Sutter,CA

Tehama,CA

Trinity,CA

Tuolumne,CA

Yolo,CA

Yuba,CA

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
California					
	Alameda	1,682,353	209,951	122,639	332,590
	Alpine	1,204	721	139	861
	Amador	40,474	5,608	2,517	8,125
	Butte	211,632	25,875	16,639	42,514
	Calaveras	45,292	8,305	4,893	13,199
	Colusa	21,839	2,244	2,024	4,268
	Contra Costa	1,165,927	158,118	60,339	218,458
	Del Norte	27,743	5,004	1,876	6,881
	El Dorado	191,185	34,907	9,704	44,611
	Fresno	1,008,654	98,532	61,772	160,304
	Glenn	28,917	2,791	3,717	6,508
	Humboldt	136,463	19,361	8,683	28,044
	Inyo	19,016	2,951	1,970	4,921
	Lake	68,163	9,699	4,530	14,229
	Lassen	32,730	4,033	2,008	6,042
	Madera	156,255	18,025	9,641	27,667
	Marin	262,321	47,738	15,030	62,769
	Mariposa	17,131	3,299	1,141	4,441
	Mendocino	91,601	14,237	8,510	22,748
	Merced	281,202	25,194	26,098	51,292
	Modoc	8,700	1,435	1,468	2,904
	Mono	13,195	3,293	1,083	4,377
	Monterey	439,035	47,655	28,750	76,405
	Napa	138,019	20,517	13,045	33,563
	Nevada	102,241	17,908	6,108	24,016
	Placer	404,739	69,985	24,193	94,179
	Plumas	19,790	6,128	2,276	8,405
	Sacramento	1,585,055	179,811	83,911	263,723
	San Benito	64,209	9,440	3,799	13,239
	San Francisco	873,965	108,848	46,020	154,869
	San Joaquin	779,233	82,706	56,882	139,589
	San Mateo	764,442	110,372	44,995	155,368
	Santa Clara	1,936,259	261,111	120,471	381,582
	Santa Cruz	270,861	36,147	18,805	54,952
	Shasta	182,155	21,572	15,715	37,288
	Sierra	3,236	596	419	1,015
	Siskiyou	44,076	6,856	4,758	11,615
	Solano	453,491	55,802	26,393	82,195
	Sonoma	488,863	68,827	35,781	104,609

	Stanislaus	552,878	62,937	37,511	100,449
	Sutter	99,633	10,618	6,448	17,066
	Tehama	65,829	7,705	5,113	12,818
	Trinity	16,112	2,209	1,485	3,694
	Tuolumne	55,620	8,964	3,507	12,471
	Yolo	216,403	24,130	18,343	42,473
	Yuba	81,575	8,161	4,677	12,839
Total Region		**15,149,716**	**1,930,326**	**975,826**	**2,906,175**