HAZUS 99-SR1: Earthquake Event Report

Region Name: smv68_64m

Earthquake Scenario: smv68_val4

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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 4 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 760 square miles and contains 530 census tracts. There are over 789 thousand households in the region and has a total population of 2,214,500 people (1990 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 593 thousand buildings in the region with a total building replacement value (excluding contents) of 120,323 million dollars (1994 dollars). Approximately 96% of the buildings (and 73% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 11,571 and 4,436 million dollars (1994 dollars), respectively.

Building and Lifeline Inventory

Building Inventory

HAZUS estimates that there are 593,000 buildings in the region which have an aggregate total replacement value of 120,323 million dollars (1994 dollars). Figure 1 presents the relative distribution of the value with respect to the general occupancies. Appendix B provides a general distribution of the building value by State and County.

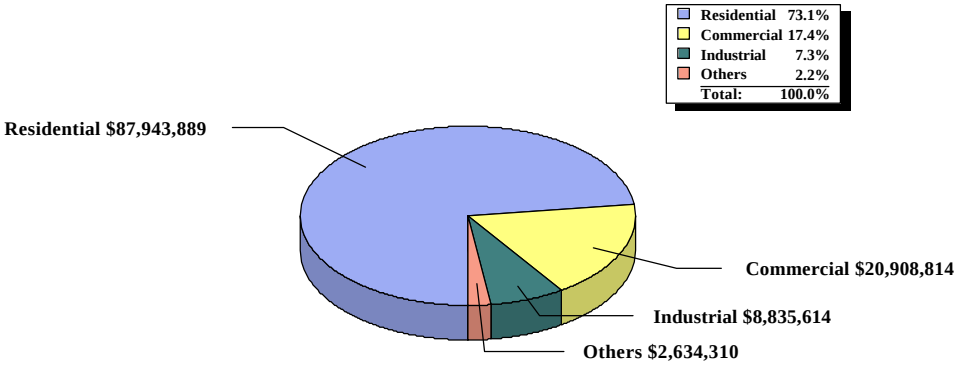

Figure 1: Building Exposure by Occupancy Type
(Thousands of dollars)

In terms of building construction types found in the region, wood frame construction makes up 77% of the building inventory. The remaining percentage is distributed between the other general building types.

Critical Facility Inventory

HAZUS breaks critical facilites 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 22 hospitals in the region with a total bed capacity of 5,846 beds. There are 904 schools, 45 fire stations, 61 police stations and 11 emergency operation facilities. With respect to HPL facilities, there are 40 dams identified within the region. Of these, 25 of the dams are classified as 'high hazard'. The inventory also includes 6,692 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 is provided in Tables 2 and 3.

The total value of the lifeline inventory is over 12,645 million dollars. This inventory includes over 526 kilometers of highways, 1,643 bridges, 0 kilometers of pipes.

Table 2: Transportation System Lifeline Inventory

System	Component	# locations/ # Segments	Replacement value (millions of dollars)
Highway	Major Roads	90	5,255
	Bridges	1,636	5,257
	Tunnels	0	0
		Subtotal	10,512
Railways	Rail Tracks	293	588
	Bridges	7	35
	Tunnels	2	20
	Facilities	2	6
		Subtotal	649
Light Rail	Rail Tracks	0	0
	Bridges	0	0
	Tunnels	0	0
	Facilities	0	0
		Subtotal	0
Bus	Facilities	0	0
Ferry	Facilities	0	0
Port	Facilities	0	0
Airport	Facilities	16	74
	Runways	12	336
		Subtotal	410
		Total	**11,571**

Table 3: Utility System Lifeline inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Pipelines	0	0.0
	Facilities	0	0.0
	Distribution Lines	*NA*	1,653.2
		Subtotal	1,653.2
Waste Water	Pipelines	0	0.0
	Facilities	2	120.0
	Distribution Lines	*NA*	991.9
		Subtotal	1,111.9
Natural Gas	Pipelines	4	19.0
	Facilities	0	0.0
	Distribution Lines	*NA*	661.3
		Subtotal	680.3
Oil Systems	Pipelines	0	0.0
	Facilities	2	4.0
		Subtotal	4.0
Electrical Power	Facilities	0	0.0
	Distribution Lines	*NA*	495.9
		Subtotal	495.9
Communication	Facilities	135	270.0
	Distribution Lines	*NA*	220.4
		Subtotal	490.4
		Total	4,435.7

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	smv68_val4
Type of Earthquake	Arbitrary event
Fault Name	NA
Historical Epicenter ID #	NA
Probabilistic Return Period	NA
Longitude of Epicenter	-122.0
Latitude of Epicenter	37.2997
Earthquake Magnitude	6.8
Depth (Km)	5
Rupture Length (Km)	33.4195
Rupture Orientation (degrees)	126
Attenuation Function	Project 97 West Coast

Building Damage

Building Damage

HAZUS estimates that about 212 thousand buildings will be at least moderately damaged. This is over 36% of the total number of buildings in the region. There are an estimated 17,646 buildings that will be completely destroyed. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the HAZUS technical manual. Table 4 below summaries the expected damage by general occupancy for the buildings in the region. Table 5 summaries the expected damage by general building type.

Table 4: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Residential	180,143	96.49	190,360	98.09	143,293	96.46	43,170	94.37	16,632	94.25
Commercial	4,391	2.35	2,391	1.23	3,286	2.21	1,507	3.29	576	3.26
Industrial	1,584	0.85	1,102	0.57	1,713	1.15	982	2.15	418	2.37
Agriculture	72	0.85	44	0.00	55	0.04	15	0.03	5	0.03
Religion	233	0.12	107	0.00	123	0.08	43	0.09	8	0.05
Government	58	0.03	6	0.00	5	0.00	0	0.00	0	0.00
Education	220	0.12	56	0.03	83	0.06	28	0.06	7	0.04
Total	**186,701**		**194,066**		**148,558**		**45,745**		**17,646**	

Table 5: Expected Building Damage by Building Type (All Design Levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Concrete	1,563	0.8	888	0.5	1,123	0.8	586	1.3	174	1.0
Mobile Homes	2,394	1.3	4,123	2.1	9,081	6.1	7,666	16.8	2,819	16.0
Precast Concrete	1,518	0.8	728	0.4	1,350	0.9	806	1.8	372	2.1
RM*	15,129	8.1	8,770	4.5	12,365	8.3	8,043	17.6	3,127	17.7
Steel	9,644	5.2	7,955	4.1	15,189	10.2	10,690	23.4	4,107	23.3
URM*	605	0.3	863	0.4	1,590	1.1	1,673	3.7	2,077	11.8
Wood	155,848	83.5	170,739	88.0	107,860	72.6	16,281	35.6	4,974	28.2

*Note:
RM Reinforced Masonry
URM Unreiforced Masonry

Essential Facility Damage

Before the earthquake, the region had 5,846 hospital beds available for use. On the day of the earthquake, the model estimates that only 1,174 hospital beds (20%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 37% of the beds will be back in service. By 30 days, 65% will be operational.

Table 6: Expected Damage to Essential Facilities

Classification	Total	# Facilities		
		Least Moderate Damage > 50%	Complete Damage > 50%	Functionality > 50% at dav 1
Hospitals	22	13	0	4
Schools	904	495	0	55
EOCs	11	5	0	0
Police Stations	61	26	0	0
Fire Stations	45	45	0	5

Transportation and Utility Lifeline Damage

Table 7 provides damage estimates for the transportation system.

Table 7: 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	With Functionality > 50 % After Day 7
Highway	Roads	90			90	90
	Bridges	1,636	445	153	1,282	1,513
	Tunnels	0	0	0	0	0
Railways	Tracks	0			293	293
	Bridges	7	1	0	7	7
	Tunnels	2	0	0	2	2
	Facilities	2	1	0	2	2
Light Rail	Tracks	0			0	0
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Bus	Facilities	0	0	0	0	0
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	16	8	1	13	16
	Runways	12	0	0	12	12

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 8-10 provide information on the damage to the utility lifeline systems. Table 8 provides damage to the utility system facilities. Table 9 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 10 provides a summary of the system performance information.

Table 8 : 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	0	0	0	0	0
Waste Water	2	1	0	0	2
Natural Gas	0	1	0	0	0
Oil Systems	2	1	0	2	2
Electrical Power	0	0	0	0	0
Communication	135	86	6	105	135
Total	**145**	**88**	**7**	**107**	**139**

Table 9 : Expected Utility System Pipeline Damage

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	0	0	0
Waste Water	0	0	0
Natural Gas	114	18	16
Oil	0	0	0
Total	114	18	16

Table 10: Expected Potable Water and Electric Power System Performance (Level 1)

	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	789,292	702,157	605,035	481,249	315,909	0
Electric Power	789,292	137,973	19,478	394	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 144 ignitions that will burn about 150 sq. mi (11.8% of the region's total area.) The model also estimates that the fires will displace about 5,800 people and burn about 300 million 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 15.76 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 30% 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 630,000 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.

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 40,793 households to be displaced due to the earthquake. Of these, 23,849 people (out of a total population of 2,214,500) 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 is 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 11: Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
2 AM	Residential	10,276	1,762	150	150
	Non-Residential	888	163	21	21
	Commute	10	13	22	4
	Total	11,174	1,938	194	176
2 PM	Residential	2,245	384	32	32
	Non-Residential	22,781	4,153	529	529
	Commute	50	66	112	22
	Total	25,076	4,602	672	582
5 PM	Residential	2,666	455	38	38
	Non-Residential	9,142	1,669	214	214
	Commute	146	196	330	64
	Total	11,955	2,320	582	316

Economic Loss

The total economic loss estimated for the earthquake is 21,703 million dollars, which represents 16 % of the total replacement value of the region's buildings. 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 21,703 million dollars. 21% 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 60% of the total loss. Table 12 below provides a summary of the losses associated with the building damage.

Table 12: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Residential	Commercial	Industrial	Others	Total
Building Loss	Structural	1,685.8	791.9	285.3	84.3	**2,847.3**
	Non-Structural	7,349.4	2,046.9	746.7	267.8	**10,410.8**
	Content	2,070.3	998.2	559.1	127.0	**3,754.6**
	Inventory	N/A	20.3	78.5	1.4	**100.1**
	Subtotal	11,105.6	3,857.3	1,669.5	480.5	**17,112.8**
Business Interruption Loss	Wage	51.6	678.0	61.5	23.6	**814.7**
	Income	21.9	610.7	37.2	6.9	**676.6**
	Rental	683.2	340.3	46.7	13.1	**1,083.3**
	Relocation	1,263.7	526.3	111.6	114.2	**2,015.8**
	Subtotal	2,020.4	2,155.3	257.0	157.8	**4,590.5**
	Total	13,126.0	6,012.6	1,926.5	638.3	**21,703.4**

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 13 & 14 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 15 presents the results of the region for the given earthquake.

Table 13: Transportation System Economic Losses
(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Roads	5,255.3	2.7	0.1
	Bridges	5,257.0	539.6	10.3
	Tunnels	0.0	0.0	0.0
	Subtotal	10,512.3	542.2	5.2
Railways	Tracks	587.7	1.2	0.2
	Bridges	35.0	3.8	10.9
	Tunnels	20.0	0.1	0.3
	Facilities	6.0	1.4	24.0
	Subtotal	648.7	6.5	1.0
Light Rail	Tracks	0.0	0.0	0.0
	Bridges	0.0	0.0	0.0
	Tunnels	0.0	0.0	0.0
	Facilities	0.0	0.0	0.0
	Subtotal	0.0	0.0	0.0
Bus	Facilities	0.0	0.0	0.0
Ferry	Facilities	0.0	0.0	0.0
Port	Facilities	0.0	0.0	0.0
Airport	Facilities	74.0	22.1	29.8
	Runways	336.0	2.1	0.6
	Subtotal	410.0	24.1	5.9
		11,571.0	**572.9**	**5.0**

Table 14: Utility System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Potable Water	Pipelines	0.0	0.0	0.0
	Facilities	0.0	0.0	0.0
	Distribution Lines	1,653.2	*NA*	*NA*
	Subtotal	1,653.2	0.0	0.0
Waste Water	Pipelines	0.0	0.0	0.0
	Facilities	120.0	34.7	28.9
	Distribution Lines	991.9	*NA*	*NA*
	Subtotal	1,111.9	34.7	3.1
Natural Gas	Pipelines	19.0	0.0	0.1
	Facilities	0.0	0.0	0.0
	Distribution Lines	661.3	*NA*	*NA*
	Subtotal	680.3	0.0	0.0
Oil Systems	Pipelines	0.0	0.0	0.0
	Facilities	4.0	1.1	28.1
	Subtotal	4.0	1.1	28.08
Electrical Power	Facilities	0.0	0.0	0.0
	Distribution Lines	495.9	*NA*	*NA*
	Subtotal	495.9	0.0	0.0
Communication	Facilities	270.0	96.4	35.7
	Distribution Lines	220.4	*NA*	*NA*
	Subtotal	490.4	96.4	35.7
	Total	**4,435.7**	**132.3**	**12.3**

Table 15. Indirect Economic Impact
(with outside aid)

Year(s)	1	2	3	4	5	6-15
Income Impact (millions $	1,931	848	1,531	1,533	1,533	1,533
% Income Impact	4.19	1.84	3.32	3.32	3.32	3.32
Employment Impact (#)	43,465	29,001	51,083	51,117	51,119	51,120
% Employment Impact	3.50	2.33	4.11	4.11	4.11	4.11

Appendix A: County Listing for the Region

California

- Alameda
- San Mateo
- Santa Clara
- Santa Cruz

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
California					
	Alameda	434,700	16,500	6,050	22,560
	San Mateo	360,000	15,780	5,370	21,150
	Santa Clara	1,419,800	55,660	20,960	76,620
	Santa Cruz	0	0	0	0
State Total		*2,214,500*	*87,940*	*32,380*	*120,320*
Region Total		**2,214,500**	**87,940**	**32,380**	**120,320**