APPENDIX A
REFERENCES

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Appendix A
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APPENDIX B
USEFUL WEB SITES

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Appendix B
USEFUL WEB SITES

Geologic Hazards in General

http://geohazards.cr.usgs.gov/

USGS Hazard Team website. Hazard information on commonly recognized hazards such as earthquakes, landslides, and volcanoes. Contains maps and slide shows.

http://www.usgs.gov/themes/hazard.html

A webpage by the USGS on hazards such as hurricanes, floods, wildland fire, wildlife disease, coastal storms and tsunamis, and earthquakes. Also has information on their Hazard Reduction Program.

http://www.consrv.ca.gov/dmg/index.htm

Homepage for the California Geologic Survey (formerly the Division of Mines and Geology). Information their publications (geologic reports and maps), programs (seismic hazard mapping, Alquist-Priolo Earthquake Fault Study Zone maps); and other brochures (asbestos, natural hazard disclosure).

http://www.oes.ca.gov/

California Governor's Office of Emergency Services website. Contains information on response plans regarding natural disasters (earthquakes), terrorist attacks, and electrical outages, and information on past emergencies.

Geologic Maps

http://wrgis.wr.usgs.gov/wgmt/scamp/scamp.html

Homepage for the Southern California Aerial Mapping Project(SCAMP), which is the USGS' program to update geologic maps of Southern California at a 1:100,000 scale and release these in a digital GIS format.

Seismic Hazards, Faults, and Earthquakes

http://www.consrv.ca.gov/dmg/shezp/schedule.htm

Shows the current list of seismic hazard maps available from the California Geologic Survey. These can be downloaded in a .pdf format.

http://www.scecdc.scec.org.

Southern California Earthquake data center (hosted by SCEC, USGS, and Caltech. Shows maps and data for recent earthquakes in Southern California and worldwide. Catalogs of historic earthquakes.

http://www.consrv.ca.gov/dmg/geohaz/eq_chron.htm

List of California earthquakes (date, magnitude, latitude longitude, description of damage)

http://geohazards.cr.usgs.gov/eq/html/canvmap.html
Website at the USGS Earthquake Hazard's Program that lists seismic acceleration maps available for downloading.

http://www.seismic.ca.gov/
Homepage of the California Seismic Safety Commission. Contains information on California earthquake legislation, safety plans, and programs designed to reduce the hazards from earthquakes. Includes several publications of interest, including "The Homeowner's Guide to Earthquake Safety." Also contains a catalog of recent California earthquakes.

Landslides and Debris Flows

http://landslides.usgs.gov/index.html
USGS Landslide webpage. Links to their publications, recent landslide events, and bibliographic databases.

http://www.consrv.ca.gov/dmg/shezp/index.htm
California Geologic Survey website on Seismic Hazard maps.

http://vulcan.wr.usgs.gov/Glossary/Lahars/framework.html
USGS Volcanic Observatory website list of links regarding mudflows, debris flows, and lahars.

http://www.fema.gov/library/landslif.htm
Federal Emergency Management Agency (FEMA) fact sheet website about landslides and mudflows.

Flooding, Dam Inundation, and Erosion (Note: the information on some of these web sites may no longer be available – data have been removed due to safety concerns).

http://vulcan.wr.usgs.gov/Glossary/Sediment/framework.html
US Geological Survey Volcanic Observatory website list of links regarding sediment and erosion.

http://www.usace.army.mil/public.html#Regulatory
US Army Corps of Engineers website regarding waterway regulations.

http://crunch.tec.army.mil/nid/webpages/nid.cfm
National Inventory of Dams.

http://www.spl.usace.army.mil/resreg/htdocs/Briefing_main.html
US Army Corps of Engineers website about reservoirs in the Los Angeles District.

http://www.fema.gov/fema/nfip.htm
FEMA website about the National Flood Insurance Program.

http://ceres.ca.gov/planning/nhd/dam_inundation.html
Dam inundation information provided by the California Office of Emergency Services

Fire Hazards

http://osfm.fire.ca.gov/FFLaws.html
Site that pertains to California laws about fires and firefighters

http://www.fire.ca.gov/
California Department of Forestry and Fire Protection's Web Site.

http://www.fire.ca.gov/FireEmergencyResponse/FirePlan/FirePlan.asp
California Fire Plan.

http://www.fireplan.gov
National Fire Plan.

http://fire.ci.glendale.ca.us/main.html
City of Glendale Fire Department web site.

http://nfpa.org/
National Fire Protection Association Web Site.

http://firewise.org/
Site dedicated to providing information to homeowners about becoming firewise in the urban/wildland interface.

http://www.fema.gov/
Federal Emergency Management Agency Web Site; includes general information on how to prepare for wildfire season, current fire events, etc.

http://www.usfa.fema.gov/
U.S. Fire Administration Web Site.

http://www.iso.com
Insurance Services Office Web Site.

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APPENDIX C
HAZUS EARTHQUAKE SCENARIO REPORTS

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HAZUS 99-SR2: Earthquake Scenario Report for the City of Glendale

Earthquake Scenario: Magnitude 6.7 Earthquake on the Verdugo Fault

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.

Table of Contents

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 1 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 30 square miles and contains 28 census tracts. There are over 68 thousand households in the region and has a total population of 194,000 people (1990 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 33 thousand buildings in the region with a total building replacement value (excluding contents) of 9,848 million dollars (1994 dollars). Approximately 96% of the buildings (and 76% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 3,258 and 245 million dollars (1994 dollars), respectively.

Building and Lifeline Inventory

Building Inventory

HAZUS estimates that there are 33,000 buildings in the region which have an aggregate total replacement value of 9,848 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.

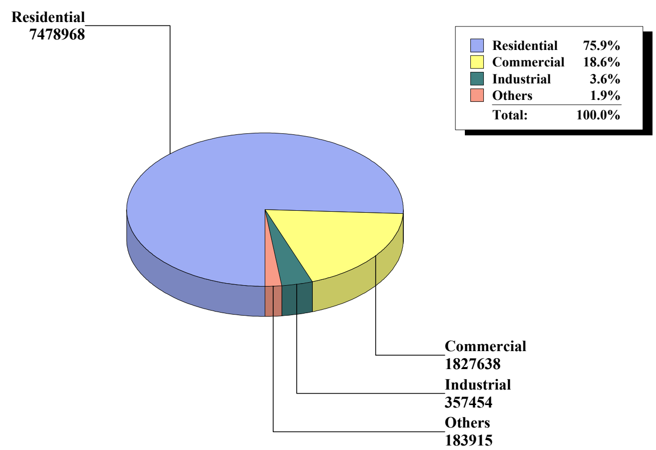

Figure 1: Building Exposure by Occupancy Type
(Thousands of dollars)

In terms of building construction types found in the region, wood frame construction makes up 94% 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 3 hospitals in the region with a total bed capacity of 942 beds. There are 70 schools, 9 fire stations, 2 police stations and 1 emergency operation facilities. With respect to HPL facilities, there are 8 dams identified within the region. Of these, 4 of the dams are classified as 'high hazard'. The inventory also includes 470 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 3,290 million dollars. This inventory includes over 281 kilometers of highways, 143 bridges, 0 kilometers of pipes.

Table 2: Transportation System Lifeline Inventory

System	Component		# locations/ # Segments	Replacement value (millions of dollars)
Highway	Major Roads		5	2,813
	Bridges		143	419
	Tunnels		0	0
		Subtotal		3,232
Railways	Rail Tracks		2	19
	Bridges		0	0
	Tunnels		0	0
	Facilities		0	0
		Subtotal		19
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		4	8
	Runways		0	0
		Subtotal		8
		Total		**3,258**

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*	87.5
	Subtotal		87.5
Waste Water	Pipelines	0	0.0
	Facilities	0	0.0
	Distribution Lines	*NA*	52.5
	Subtotal		52.5
Natural Gas	Pipelines	0	0.0
	Facilities	0	0.0
	Distribution Lines	*NA*	35.0
	Subtotal		35.0
Oil Systems	Pipelines	0	0.0
	Facilities	0	0.0
	Subtotal		0.0
Electrical Power	Facilities	0	0.0
	Distribution Lines	*NA*	26.2
	Subtotal		26.2
Communication	Facilities	16	32.0
	Distribution Lines	*NA*	11.7
	Subtotal		43.7
	Total		**244.9**

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	Verdugo Fault 6.7Mw
Type of Earthquake	Source event
Fault Name	
Historical Epicenter ID #	
	NA
Probabilistic Return Period	NA
Longitude of Epicenter	-118.253
Latitude of Epicenter	34.117
Earthquake Magnitude	6.4
Depth (Km)	0
Rupture Length (Km)	17
Rupture Orientation (degrees)	0
Attenuation Function	Project 97 West Coast

Building Damage

Building Damage

HAZUS estimates that about 7,330 buildings will be at least moderately damaged. This is over 22.254% of the total number of buildings in the region. There are an estimated 165 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	12,411	97.31	12,326	97.13	6,054	93.60	681	79.00	140	84.85
Commercial	259	2.03	274	2.16	312	4.82	138	16.01	20	12.12
Industrial	58	0.45	64	0.50	80	1.24	36	4.18	5	3.03
Agriculture	2	0.45	2	0.00	1	0.02	0	0.00	0	0.00
Religion	18	0.14	18	0.00	18	0.28	7	0.81	0	0.00
Government	1	0.01	1	0.00	1	0.02	0	0.00	0	0.00
Education	5	0.04	5	0.04	2	0.03	0	0.00	0	0.00
Total	**12,754**		**12,690**		**6,468**		**862**		**165**	

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

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Concrete	132	1.0	110	0.9	125	1.9	47	5.5	3	1.9
Mobile Homes	4	0.0	9	0.1	26	0.4	9	1.0	0	0.0
Precast Concrete	87	0.7	48	0.4	104	1.6	49	5.7	6	3.8
RM*	266	2.1	148	1.2	230	3.6	90	10.4	4	2.6
Steel	138	1.1	66	0.5	127	2.0	48	5.6	0	0.0
URM*	15	0.1	32	0.3	62	1.0	28	3.2	6	3.8
Wood	12,112	95.0	12,277	96.7	5,794	89.6	591	68.6	137	87.8

*Note:

RM Reinforced Masonry
URM Unreiforced Masonry

Essential Facility Damage

Before the earthquake, the region had 942 hospital beds available for use. On the day of the earthquake, the model estimates that only 233 hospital beds (25%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 44% of the beds will be back in service. By 30 days, 72% will be operational.

Table 6: Expected Damage to Essential Facilities

		# Facilities		
Classification	Total	Least Moderate Damage > 50%	Complete Damage > 50%	Functionality > 50% at day 1
Hospitals	3	2	0	1
Schools	70	27	0	0
EOCs	1	0	0	0
Police Stations	2	0	0	0
Fire Stations	9	0	0	0

Transportation and Utility Lifeline Damage

Table 7 provides damage estimates for the transportation system.

Table 7: Expected Damage to the Transportation Systems

			Number of Locations			
System	**Component**	**Locations/ Segments**	**With at Least Mod. Damage**	**With Complete Damage**	**With Functionality > 50 % After Day 1**	**After Day 7**
Highway	**Roads**	5			5	5
	Bridges	143	25	6	136	142
	Tunnels	0	0	0	0	0
Railways	**Tracks**	0			2	2
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
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**	4	2	0	3	4
	Runways	0	0	0	0	0

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 through10 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

		# of Locations			
System	**Total #**	**With at Least Moderate Damage**	**With Complete Damage**	**with Functionality > 50 % After Day 1**	**with Functionality > 50 % After Day 7**
Potable Water	0	0	0	0	0
Waste Water	0	0	0	0	0
Natural Gas	0	0	0	0	0
Oil Systems	0	0	0	0	0
Electrical Power	0	0	0	0	0
Communication	16	11	1	16	16
Total	**17**	**11**	**1**	**16**	**16**

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	0	0	0
Oil	0	0	0
Total	**0**	**0**	**0**

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	68,186	15,715	8,193	10	0	0
Electric Power	68,186	57,478	45,336	25,592	3,977	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 20 ignitions that will burn about 10 sq. mi (27.4% of the region's total area.) The model also estimates that the fires will displace about 1,400 people and burn about 60 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 0.70 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 32% 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 28,000 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 2,932 households to be displaced due to the earthquake. Of these, 2,302 people (out of a total population of 194,000) 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 11 provides a summary of the casualties estimated for this earthquake

Table 11: Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
2 AM	**Residential**	345	62	6	11
	Non-Residential	15	4	1	1
	Commute	0	0	0	0
	Total	360	66	7	12
2 PM	**Residential**	93	17	2	3
	Non-Residential	565	134	20	39
	Commute	0	1	1	0
	Total	658	152	22	42
5 PM	**Residential**	111	20	2	4
	Non-Residential	207	49	7	14
	Commute	1	1	2	0
	Total	319	71	11	18

Economic Loss

The total economic loss estimated for the earthquake is 1,456 million dollars, which represents 11 % 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 1,407 million dollars. 18% 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 63% 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
	Structural	76.2	44.6	8.7	3.9	**133.5**
Building	**Non-Structural**	525.9	151.4	28.5	14.5	**720.2**
Loss	**Content**	170.0	89.5	21.8	8.1	**289.4**
	Inventory	N/A	1.3	3.1	0.0	**4.4**
	Subtotal	772.0	286.9	62.1	26.5	**1,147.5**
	Wage	2.3	43.2	1.4	1.1	**48.0**
Business	**Income**	1.1	35.8	0.8	0.3	**38.0**
Interruption	**Rental**	49.7	20.3	1.0	0.7	**71.6**
Loss	**Relocation**	57.0	35.4	4.3	5.5	**102.2**
	Subtotal	110.1	134.7	7.5	7.6	**259.8**
	Total	882.1	421.5	69.6	34.1	**1,407.3**

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.

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

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Roads	2,812.8	0.0	0.0
	Bridges	419.0	33.5	8.0
	Tunnels	0.0	0.0	0.0
	Subtotal	3,231.8	33.5	1.0
Railways	Tracks	18.5	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	18.5	0.0	0.0
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	8.0	2.9	36.6
	Runways	0.0	0.0	0.0
	Subtotal	8.0	2.9	36.6
		3,258.3	**36.4**	**1.1**

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	87.5	*NA*	*NA*
	Subtotal	87.5	0.0	0.0
Waste Water	Pipelines	0.0	0.0	0.0
	Facilities	0.0	0.0	0.0
	Distribution Lines	52.5	*NA*	*NA*
	Subtotal	52.5	0.0	0.0
Natural Gas	Pipelines	0.0	0.0	0.0
	Facilities	0.0	0.0	0.0
	Distribution Lines	35.0	*NA*	*NA*
	Subtotal	35.0	0.0	0.0
Oil Systems	Pipelines	0.0	0.0	0.0
	Facilities	0.0	0.0	0.0
	Subtotal	0.0	0.0	0.00
Electrical Power	Facilities	0.0	0.0	0.0
	Distribution Lines	26.2	*NA*	*NA*
	Subtotal	26.2	0.0	0.0
Communication	Facilities	32.0	11.7	36.4
	Distribution Lines	11.7	*NA*	*NA*
	Subtotal	43.7	11.7	36.4
	Total	**244.9**	**11.7**	**17.4**

Appendix A: County Listing for the Region

California
- Los Angeles

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
California					
	Los Angeles	194,000	7,480	2,370	9,850
State Total		*194,000*	*7,480*	*2,370*	*9,850*
Region Total		**194,000**	**7,480**	**2,370**	**9,850**

HAZUS 99-SR2: Earthquake Scenario Report for the City of Glendale

Earthquake Scenario: Magnitude 7.2 Earthquake on the Sierra Madre Fault

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.

Table of Contents

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 1 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 30 square miles and contains 28 census tracts. There are over 68 thousand households in the region and has a total population of 194,000 people (1990 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 33 thousand buildings in the region with a total building replacement value (excluding contents) of 9,848 million dollars (1994 dollars). Approximately 96% of the buildings (and 76% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 3,258 and 245 million dollars (1994 dollars), respectively.

Building and Lifeline Inventory

Building Inventory

HAZUS estimates that there are 33,000 buildings in the region which have an aggregate total replacement value of 9,848 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.

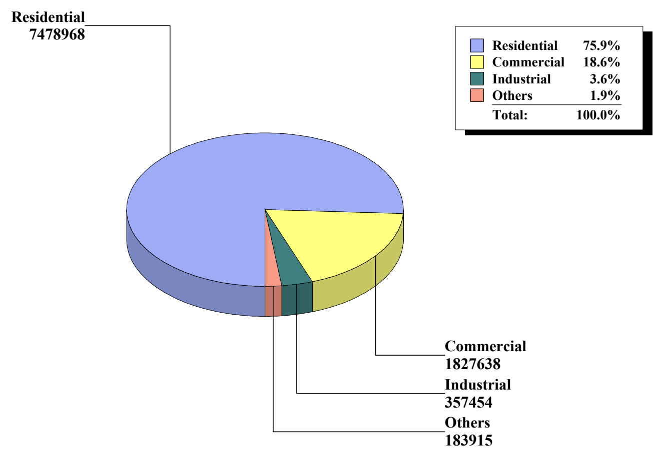

Figure 1: Building Exposure by Occupancy Type
(Thousands of dollars)

In terms of building construction types found in the region, wood frame construction makes up 94% 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 3 hospitals in the region with a total bed capacity of 942 beds. There are 70 schools, 9 fire stations, 2 police stations and 1 emergency operation facilities. With respect to HPL facilities, there are 8 dams identified within the region. Of these, 4 of the dams are classified as 'high hazard'. The inventory also includes 470 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 3,290 million dollars. This inventory includes over 281 kilometers of highways, 143 bridges, 0 kilometers of pipes.

Table 2: Transportation System Lifeline Inventory

System	Component		# locations/ # Segments	Replacement value (millions of dollars)
Highway	Major Roads		5	2,813
	Bridges		143	419
	Tunnels		0	0
		Subtotal		3,232
Railways	Rail Tracks		2	19
	Bridges		0	0
	Tunnels		0	0
	Facilities		0	0
		Subtotal		19
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		4	8
	Runways		0	0
		Subtotal		8
		Total		**3,258**

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*	87.5
	Subtotal		87.5
Waste Water	Pipelines	0	0.0
	Facilities	0	0.0
	Distribution Lines	*NA*	52.5
	Subtotal		52.5
Natural Gas	Pipelines	0	0.0
	Facilities	0	0.0
	Distribution Lines	*NA*	35.0
	Subtotal		35.0
Oil Systems	Pipelines	0	0.0
	Facilities	0	0.0
	Subtotal		0.0
Electrical Power	Facilities	0	0.0
	Distribution Lines	*NA*	26.2
	Subtotal		26.2
Communication	Facilities	16	32.0
	Distribution Lines	*NA*	11.7
	Subtotal		43.7
	Total		**244.9**

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	Sierra Madre Fault 7.2Mw
Type of Earthquake	Source event
Fault Name	
Historical Epicenter ID #	NA
Probabilistic Return Period	NA
Longitude of Epicenter	-118.257
Latitude of Epicenter	34.2373
Earthquake Magnitude	7.2
Depth (Km)	0
Rupture Length (Km)	57
Rupture Orientation (degrees)	0
Attenuation Function	Project 97 West Coast

Building Damage

Building Damage

HAZUS estimates that about 4,993 buildings will be at least moderately damaged. This is over 15.136% of the total number of buildings in the region. There are an estimated 55 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	15,718	96.96	11,362	96.87	4,166	92.33	387	80.46	51	92.73
Commercial	376	2.32	276	2.35	257	5.70	68	14.14	2	3.64
Industrial	78	0.48	65	0.55	71	1.57	24	4.99	2	3.64
Agriculture	2	0.48	2	0.00	2	0.04	0	0.00	0	0.00
Religion	25	0.15	18	0.00	14	0.31	2	0.42	0	0.00
Government	1	0.01	1	0.00	0	0.00	0	0.00	0	0.00
Education	10	0.06	5	0.04	2	0.04	0	0.00	0	0.00
Total		**16,210**		**11,729**		**4,512**		**481**		**55**

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

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Concrete	187	1.2	103	0.9	103	2.3	25	5.3	0	0.0
Mobile Homes	1	0.0	8	0.1	25	0.6	12	2.5	2	4.1
Precast Concrete	126	0.8	59	0.5	83	1.8	22	4.6	2	4.1
RM*	361	2.2	149	1.3	167	3.7	57	12.0	0	0.0
Steel	168	1.0	73	0.6	106	2.3	34	7.1	0	0.0
URM*	43	0.3	39	0.3	50	1.1	11	2.3	1	2.0
Wood	15,324	94.5	11,298	96.3	3,978	88.2	315	66.2	44	89.8

*Note:
RM Reinforced Masonry
URM Unreiforced Masonry

Essential Facility Damage

Before the earthquake, the region had 942 hospital beds available for use. On the day of the earthquake, the model estimates that only 378 hospital beds (40%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 59% of the beds will be back in service. By 30 days, 83% will be operational.

Table 6: Expected Damage to Essential Facilities

		# Facilities		
Classification	Total	Least Moderate Damage > 50%	Complete Damage > 50%	Functionality > 50% at day 1
Hospitals	3	0	0	0
Schools	70	8	0	0
EOCs	1	0	0	0
Police Stations	2	0	0	0
Fire Stations	9	0	0	0

Transportation and Utility Lifeline Damage

Table 7 provides damage estimates for the transportation system.

Table 7: Expected Damage to the Transportation Systems

			Number of Locations			
System	**Component**	**Locations/ Segments**	**With at Least Mod. Damage**	**With Complete Damage**	**With Functionality > 50 % After Day 1**	**After Day 7**
Highway	**Roads**	5			5	5
	Bridges	143	22	5	141	143
	Tunnels	0	0	0	0	0
Railways	**Tracks**	0			2	2
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
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**	4	2	0	4	4
	Runways	0	0	0	0	0

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 through10 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

		# of Locations			
System	**Total #**	**With at Least Moderate Damage**	**With Complete Damage**	**with Functionality > 50 % After Day 1**	**with Functionality > 50 % After Day 7**
Potable Water	0	0	0	0	0
Waste Water	0	0	0	0	0
Natural Gas	0	0	0	0	0
Oil Systems	0	0	0	0	0
Electrical Power	0	0	0	0	0
Communication	16	7	0	16	16
Total	**16**	**7**	**0**	**16**	**16**

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	0	0	0
Oil	0	0	0
Total	**0**	**0**	**0**

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	68,186	16,145	7,933	0	0	0
Electric Power	68,186	45,389	26,431	9,695	376	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 11 ignitions that will burn about 0 sq. mi (3% of the region's total area.) The model also estimates that the fires will displace about 100 people and burn about 10 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 0.70 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 32% 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 16,000 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 1,179 households to be displaced due to the earthquake. Of these, 886 people (out of a total population of 194,000) 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 11 provides a summary of the casualties estimated for this earthquake

Table 11: Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
2 AM	**Residential**	165	24	2	4
	Non-Residential	9	2	0	1
	Commute	0	0	0	0
	Total	175	26	2	4
2 PM	**Residential**	43	6	1	1
	Non-Residential	337	71	9	19
	Commute	0	0	0	0
	Total	380	78	10	20
5 PM	**Residential**	51	7	1	1
	Non-Residential	122	26	3	7
	Commute	0	1	1	0
	Total	173	34	5	8

Economic Loss

The total economic loss estimated for the earthquake is 832 million dollars, which represents 6 % 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 798 million dollars. 20% 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	44.0	28.7	6.2	2.7	**81.5**
	Non-Structural	284.3	88.3	17.6	8.9	**399.1**
	Content	91.4	47.7	12.9	4.5	**156.5**
	Inventory	N/A	0.7	1.8	0.0	**2.6**
	Subtotal	419.6	165.5	38.5	16.1	**639.7**
Business Interruption Loss	Wage	1.2	28.2	1.0	0.8	**31.2**
	Income	0.5	23.9	0.6	0.2	**25.2**
	Rental	24.7	13.5	0.7	0.5	**39.3**
	Relocation	32.2	23.4	3.2	3.7	**62.5**
	Subtotal	58.6	88.9	5.5	5.2	**158.2**
	Total	478.2	254.4	44.1	21.3	**797.8**

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.

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

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Roads	2,812.8	0.0	0.0
	Bridges	419.0	24.4	5.8
	Tunnels	0.0	0.0	0.0
	Subtotal	3,231.8	24.4	0.8
Railways	Tracks	18.5	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	18.5	0.0	0.0
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	8.0	1.8	22.2
	Runways	0.0	0.0	0.0
	Subtotal	8.0	1.8	22.2
		3,258.3	**36.4**	**0.8**

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	87.5	*NA*	*NA*
	Subtotal	87.5	0.0	0.0
Waste Water	Pipelines	0.0	0.0	0.0
	Facilities	0.0	0.0	0.0
	Distribution Lines	52.5	*NA*	*NA*
	Subtotal	52.5	0.0	0.0
Natural Gas	Pipelines	0.0	0.0	0.0
	Facilities	0.0	0.0	0.0
	Distribution Lines	35.0	*NA*	*NA*
	Subtotal	35.0	0.0	0.0
Oil Systems	Pipelines	0.0	0.0	0.0
	Facilities	0.0	0.0	0.0
	Subtotal	0.0	0.0	0.00
Electrical Power	Facilities	0.0	0.0	0.0
	Distribution Lines	26.2	*NA*	*NA*
	Subtotal	26.2	0.0	0.0
Communication	Facilities	32.0	7.2	22.5
	Distribution Lines	11.7	*NA*	*NA*
	Subtotal	43.7	7.2	22.5
	Total	**244.9**	**7.2**	**10.7**

Appendix A: County Listing for the Region

California
- Los Angeles

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
California					
	Los Angeles	194,000	7,480	2,370	9,850
State Total		*194,000*	*7,480*	*2,370*	*9,850*
Region Total		**194,000**	**7,480**	**2,370**	**9,850**

HAZUS 99-SR2: Earthquake Scenario Report for the City of Glendale

Earthquake Scenario: Magnitude 6.4 Earthquake on the Hollywood Fault

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 1 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 30 square miles and contains 28 census tracts. There are over 68 thousand households in the region and has a total population of 194,000 people (1990 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 33 thousand buildings in the region with a total building replacement value (excluding contents) of 9,848 million dollars (1994 dollars). Approximately 96% of the buildings (and 76% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 3,258 and 245 million dollars (1994 dollars), respectively.

Building and Lifeline Inventory

Building Inventory

HAZUS estimates that there are 33,000 buildings in the region which have an aggregate total replacement value of 9,848 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.

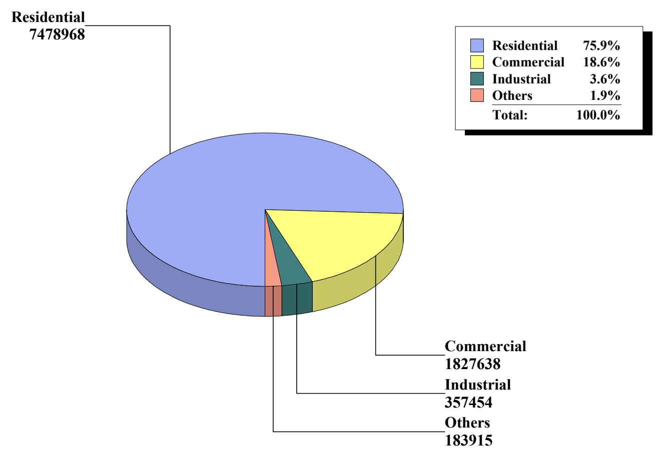

Figure 1: Building Exposure by Occupancy Type
(Thousands of dollars)

In terms of building construction types found in the region, wood frame construction makes up 94% 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 3 hospitals in the region with a total bed capacity of 942 beds. There are 70 schools, 9 fire stations, 2 police stations and 1 emergency operation facilities. With respect to HPL facilities, there are 8 dams identified within the region. Of these, 4 of the dams are classified as ‘high hazard’. The inventory also includes 470 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 3,290 million dollars. This inventory includes over 281 kilometers of highways, 143 bridges, 0 kilometers of pipes.

Table 2: Transportation System Lifeline Inventory

System	Component		# locations/ # Segments	Replacement value (millions of dollars)
Highway	Major Roads		5	2,813
	Bridges		143	419
	Tunnels		0	0
		Subtotal		3,232
Railways	Rail Tracks		2	19
	Bridges		0	0
	Tunnels		0	0
	Facilities		0	0
		Subtotal		19
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		4	8
	Runways		0	0
		Subtotal		8
		Total		**3,258**

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*	87.5
	Subtotal		87.5
Waste Water	Pipelines	0	0.0
	Facilities	0	0.0
	Distribution Lines	*NA*	52.5
	Subtotal		52.5
Natural Gas	Pipelines	0	0.0
	Facilities	0	0.0
	Distribution Lines	*NA*	35.0
	Subtotal		35.0
Oil Systems	Pipelines	0	0.0
	Facilities	0	0.0
	Subtotal		0.0
Electrical Power	Facilities	0	0.0
	Distribution Lines	*NA*	26.2
	Subtotal		26.2
Communication	Facilities	16	32.0
	Distribution Lines	*NA*	11.7
	Subtotal		43.7
	Total		**244.9**

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	Hollywood Fault 6.4Mw
Type of Earthquake	Source event
Fault Name	Hollywood Fault
Historical Epicenter ID #	NA
Probabilistic Return Period	NA
Longitude of Epicenter	-118.253
Latitude of Epicenter	34.117
Earthquake Magnitude	6.4
Depth (Km)	0
Rupture Length (Km)	17
Rupture Orientation (degrees)	0
Attenuation Function	Project 97 West Coast

Building Damage

Building Damage

HAZUS estimates that about 3,120 buildings will be at least moderately damaged. This is over 9.482% of the total number of buildings in the region. There are an estimated 1 building 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	19,344	96.94	9,452	96.45	2,598	90.11	170	71.73	0	0.00
Commercial	461	2.31	264	2.69	215	7.46	49	20.68	0	0.00
Industrial	98	0.49	62	0.63	58	2.01	16	6.75	1	0.00
Agriculture	4	0.49	1	0.00	0	0.00	0	0.00	0	0.00
Religion	32	0.16	17	0.00	11	0.38	2	0.84	0	0.00
Government	4	0.02	1	0.00	0	0.00	0	0.00	0	0.00
Education	12	0.06	3	0.03	1	0.03	0	0.00	0	0.00
Total	**19,985**		**9,800**		**2,883**		**237**		**1**	

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

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Concrete	207	1.0	104	1.1	88	3.1	18	8.1	0	0.0
Mobile Homes	15	0.1	13	0.1	18	0.6	4	1.8	0	0.0
Precast Concrete	142	0.7	61	0.6	70	2.4	18	8.1	0	0.0
RM*	436	2.2	136	1.4	128	4.4	35	15.7	0	0.0
Steel	205	1.0	72	0.7	81	2.8	21	9.4	0	0.0
URM*	57	0.3	42	0.4	39	1.4	6	2.7	0	0.0
Wood	18,923	94.7	9,372	95.6	2,459	85.3	121	54.3	0	0.0

*Note:

RM Reinforced Masonry
URM Unreinforced Masonry

Essential Facility Damage

Before the earthquake, the region had 942 hospital beds available for use. On the day of the earthquake, the model estimates that only 425 hospital beds (45%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 63% of the beds will be back in service. By 30 days, 85% will be operational.

Table 6: Expected Damage to Essential Facilities

Classification	Total	# Facilities: Least Moderate Damage > 50%	Complete Damage > 50%	Functionality > 50% at day 1
Hospitals	3	0	0	1
Schools	70	2	0	8
EOCs	1	0	0	0
Police Stations	2	0	0	0
Fire Stations	9	0	0	3

Transportation and Utility Lifeline Damage

Table 7 provides damage estimates for the transportation system.

Table 7: Expected Damage to the Transportation Systems

System	Component	Locations/ Segments	Number of Locations: With at Least Mod. Damage	With Complete Damage	With Functionality > 50 %: After Day 1	After Day 7
Highway	Roads	5			5	5
	Bridges	143	9	1	143	143
	Tunnels	0	0	0	0	0
Railways	Tracks	0			2	2
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
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	4	1	0	4	4
	Runways	0	0	0	0	0

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 through10 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

		# of Locations			
System	**Total #**	**With at Least Moderate Damage**	**With Complete Damage**	**with Functionality > 50 % After Day 1**	**with Functionality > 50 % After Day 7**
Potable Water	0	0	0	0	0
Waste Water	0	0	0	0	0
Natural Gas	0	0	0	0	0
Oil Systems	0	0	0	0	0
Electrical Power	0	0	0	0	0
Communication	16	5	0	16	16
Total	**16**	**5**	**0**	**16**	**16**

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	0	0	0
Oil	0	0	0
Total	**0**	**0**	**0**

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	68,186	1,562	0	0	0	0
Electric Power	68,186	41,248	22,007	7,295	224	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 10 ignitions that will burn about 0 sq. mi (4.8% of the region's total area.) The model also estimates that the fires will displace about 200 people and burn about 10 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 0.31 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 32% 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 13,000 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 831 households to be displaced due to the earthquake. Of these, 665 people (out of a total population of 194,000) 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 11 provides a summary of the casualties estimated for this earthquake

Table 11: Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
2 AM	**Residential**	119	15	1	2
	Non-Residential	6	1	0	0
	Commute	0	0	0	0
	Total	125	16	1	2
2 PM	**Residential**	32	4	0	1
	Non-Residential	219	41	5	10
	Commute	0	0	0	0
	Total	251	45	5	10
5 PM	**Residential**	38	5	0	1
	Non-Residential	82	16	2	4
	Commute	0	0	0	0
	Total	120	21	3	5

Economic Loss

The total economic loss estimated for the earthquake is 644 million dollars, which represents 5 % 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 628 million dollars. 19% 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 59% 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**	31.4	21.7	4.7	1.8	**59.6**
	Non-Structural	222.7	72.5	15.1	6.8	**317.0**
	Content	73.8	42.7	11.7	3.8	**131.9**
	Inventory	N/A	0.7	1.7	0.0	**2.3**
	Subtotal	327.8	137.5	33.1	12.5	**510.9**
Business Interruption Loss	**Wage**	0.9	20.8	0.8	0.5	**23.0**
	Income	0.4	17.3	0.4	0.1	**18.3**
	Rental	19.1	10.3	0.6	0.3	**30.2**
	Relocation	21.9	18.2	2.6	2.6	**45.3**
	Subtotal	42.3	66.6	4.4	3.6	**116.8**
	Total	370.0	204.1	37.5	16.1	**627.7**

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.

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	Tunnels	0.0	0.0	0.0
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	Subtotal	18.5	0.0	0.0
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
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(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
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	Facilities	0.0	0.0	0.0
	Distribution Lines	87.5	*NA*	*NA*
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HAZUS 99-SR2: Earthquake Scenario Report for the City of Glendale

Earthquake Scenario: Magnitude 6.5 Earthquake on the Raymond Fault

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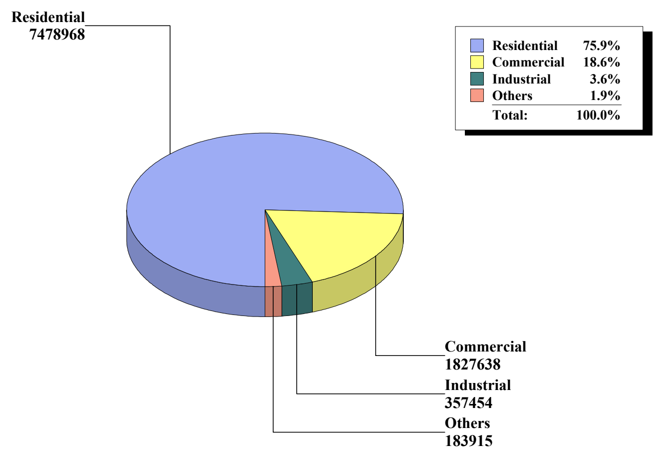

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Table 2: Transportation System Lifeline Inventory

System	Component		# locations/ # Segments	Replacement value (millions of dollars)
Highway	Major Roads		5	2,813
	Bridges		143	419
	Tunnels		0	0
		Subtotal		3,232
Railways	Rail Tracks		2	19
	Bridges		0	0
	Tunnels		0	0
	Facilities		0	0
		Subtotal		19
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		4	8
	Runways		0	0
		Subtotal		8
		Total		**3,258**

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*	87.5
	Subtotal		87.5
Waste Water	Pipelines	0	0.0
	Facilities	0	0.0
	Distribution Lines	*NA*	52.5
	Subtotal		52.5
Natural Gas	Pipelines	0	0.0
	Facilities	0	0.0
	Distribution Lines	*NA*	35.0
	Subtotal		35.0
Oil Systems	Pipelines	0	0.0
	Facilities	0	0.0
	Subtotal		0.0
Electrical Power	Facilities	0	0.0
	Distribution Lines	*NA*	26.2
	Subtotal		26.2
Communication	Facilities	16	32.0
	Distribution Lines	*NA*	11.7
	Subtotal		43.7
	Total		**244.9**

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	Raymond Fault 6.5Mw
Type of Earthquake	Source event
Fault Name	Raymond Fault
Historical Epicenter ID #	NA
Probabilistic Return Period	NA
Longitude of Epicenter	-118.222
Latitude of Epicenter	34.1218
Earthquake Magnitude	6.5
Depth (Km)	0
Rupture Length (Km)	21
Rupture Orientation (degrees)	0
Attenuation Function	Project 97 West Coast

Building Damage

Building Damage

HAZUS estimates that about 3,498 buildings will be at least moderately damaged. This is over 10,642% of the total number of buildings in the region. There are an estimated 6 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	18,397	96.92	10,026	96.56	2,949	90.88	186	73.52	4	66.67
Commercial	439	2.31	271	2.61	224	6.90	50	19.76	0	0.00
Industrial	95	0.50	62	0.60	60	1.85	16	6.32	2	33.33
Agriculture	4	0.50	2	0.00	0	0.00	0	0.00	0	0.00
Religion	32	0.17	17	0.00	11	0.34	1	0.40	0	0.00
Government	4	0.02	1	0.00	0	0.00	0	0.00	0	0.00
Education	11	0.06	4	0.04	1	0.03	0	0.00	0	0.00
Total	**18,982**		**10,383**		**3,245**		**253**		**6**	

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

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Concrete	198	1.0	103	1.0	94	2.9	21	8.5	0	0.0
Mobile Homes	12	0.1	12	0.1	20	0.6	4	1.6	0	0.0
Precast Concrete	140	0.7	60	0.6	72	2.2	20	8.1	0	0.0
RM*	407	2.1	142	1.4	142	4.4	45	18.2	0	0.0
Steel	193	1.0	74	0.7	89	2.7	24	9.7	0	0.0
URM*	51	0.3	43	0.4	43	1.3	7	2.8	0	0.0
Wood	17,981	94.7	9,949	95.8	2,785	85.8	126	51.0	0	0.0

*Note:
RM Reinforced Masonry
URM Unreiforced Masonry

Essential Facility Damage

Before the earthquake, the region had 942 hospital beds available for use. On the day of the earthquake, the model estimates that only 391 hospital beds (42%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 60% of the beds will be back in service. By 30 days, 84% will be operational.

Table 6: Expected Damage to Essential Facilities

		# Facilities		
Classification	Total	Least Moderate Damage > 50%	Complete Damage > 50%	Functionality > 50% at day 1
Hospitals	3	0	0	1
Schools	70	2	0	1
EOCs	1	0	0	0
Police Stations	2	0	0	0
Fire Stations	9	0	0	1

Transportation and Utility Lifeline Damage

Table 7 provides damage estimates for the transportation system.

Table 7: Expected Damage to the Transportation Systems

			Number of Locations			
System	**Component**	**Locations/ Segments**	**With at Least Mod. Damage**	**With Complete Damage**	**With Functionality > 50 % After Day 1**	**After Day 7**
Highway	**Roads**	5			5	5
	Bridges	143	11	2	143	143
	Tunnels	0	0	0	0	0
Railways	**Tracks**	0			2	2
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
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**	4	1	0	4	4
	Runways	0	0	0	0	0

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 through10 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

		# of Locations			
System	Total #	With at Least Moderate Damage	With Complete Damage	with Functionality > 50 % After Day 1	with Functionality > 50 % After Day 7
Potable Water	0	0	0	0	0
Waste Water	0	0	0	0	0
Natural Gas	0	0	0	0	0
Oil Systems	0	0	0	0	0
Electrical Power	0	0	0	0	0
Communication	16	6	0	16	16
Total	**16**	**6**	**0**	**16**	**16**

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	0	0	0
Oil	0	0	0
Total	**0**	**0**	**0**

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	68,186	4,334	52	0	0	0
Electric Power	68,186	43,850	24,845	8,868	322	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 10 ignitions that will burn about 0 sq. mi (6.7% of the region's total area.) The model also estimates that the fires will displace about 400 people and burn about 20 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 0.34 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 32% 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 14,000 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 945 households to be displaced due to the earthquake. Of these, 738 people (out of a total population of 194,000) 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 11 provides a summary of the casualties estimated for this earthquake

Table 11: Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
2 AM	**Residential**	131	17	1	3
	Non-Residential	7	1	0	0
	Commute	0	0	0	0
	Total	138	18	2	3
2 PM	**Residential**	35	5	0	1
	Non-Residential	244	47	6	11
	Commute	0	0	0	0
	Total	279	52	6	12
5 PM	**Residential**	42	5	0	1
	Non-Residential	90	17	2	4
	Commute	0	0	1	0
	Total	132	23	3	5

Economic Loss

The total economic loss estimated for the earthquake is 708 million dollars, which represents 5 % 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 688 million dollars. 19% 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	34.2	23.6	4.9	2.0	**64.6**
	Non-Structural	246.7	78.4	15.8	7.4	**348.4**
	Content	81.9	46.2	12.2	4.2	**144.6**
	Inventory	N/A	0.7	1.7	0.0	**2.5**
	Subtotal	362.8	149.0	34.7	13.6	**560.1**
Business Interruption Loss	Wage	1.0	22.6	0.8	0.6	**25.0**
	Income	0.5	19.0	0.5	0.1	**20.1**
	Rental	20.9	11.1	0.6	0.4	**33.0**
	Relocation	24.2	19.8	2.7	2.8	**49.6**
	Subtotal	46.6	72.6	4.5	3.9	**127.6**
	Total	409.4	221.5	39.2	17.5	**687.7**

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.

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

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Roads	2,812.8	0.0	0.0
	Bridges	419.0	12.1	2.9
	Tunnels	0.0	0.0	0.0
	Subtotal	3,231.8	12.1	0.4
Railways	Tracks	18.5	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	18.5	0.0	0.0
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	8.0	1.5	20.6
	Runways	0.0	0.0	0.0
	Subtotal	8.0	1.6	20.6
		3,258.3	**10.7**	**0.3**

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	87.5	*NA*	*NA*
	Subtotal	87.5	0.0	0.0
Waste Water	Pipelines	0.0	0.0	0.0
	Facilities	0.0	0.0	0.0
	Distribution Lines	52.5	*NA*	*NA*
	Subtotal	52.5	0.0	0.0
Natural Gas	Pipelines	0.0	0.0	0.0
	Facilities	0.0	0.0	0.0
	Distribution Lines	35.0	*NA*	*NA*
	Subtotal	35.0	0.0	0.0
Oil Systems	Pipelines	0.0	0.0	0.0
	Facilities	0.0	0.0	0.0
	Subtotal	0.0	0.0	0.00
Electrical Power	Facilities	0.0	0.0	0.0
	Distribution Lines	26.2	*NA*	*NA*
	Subtotal	26.2	0.0	0.0
Communication	Facilities	32.0	6.2	19.5
	Distribution Lines	11.7	*NA*	*NA*
	Subtotal	43.7	6.2	19.5
	Total	**244.9**	**6.2**	**9.3**

Appendix A: County Listing for the Region

California
- Los Angeles

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
California					
	Los Angeles	194,000	7,480	2,370	9,850
State Total		*194,000*	*7,480*	*2,370*	*9,850*
Region Total		**194,000**	**7,480**	**2,370**	**9,850**

HAZUS 99-SR2: Earthquake Scenario Report for the City of Glendale

Earthquake Scenario: Magnitude 7.1 Earthquake on the San Andreas Fault

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 1 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 30 square miles and contains 28 census tracts. There are over 68 thousand households in the region and has a total population of 194,000 people (1990 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 33 thousand buildings in the region with a total building replacement value (excluding contents) of 9,848 million dollars (1994 dollars). Approximately 96% of the buildings (and 76% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 3,258 and 245 million dollars (1994 dollars), respectively.

Building and Lifeline Inventory

Building Inventory

HAZUS estimates that there are 33,000 buildings in the region which have an aggregate total replacement value of 9,848 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.

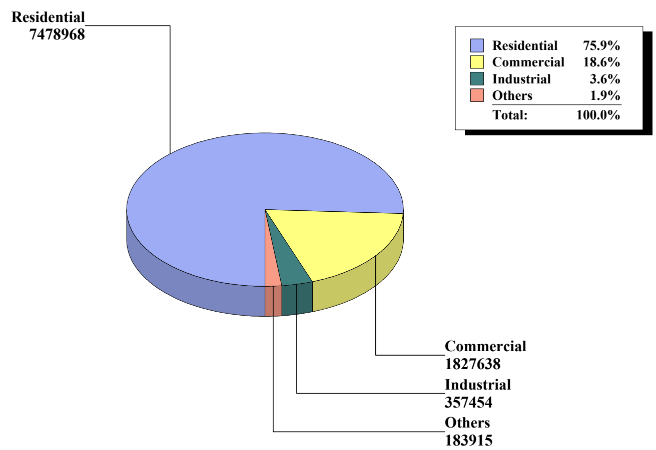

Figure 1: Building Exposure by Occupancy Type
(Thousands of dollars)

In terms of building construction types found in the region, wood frame construction makes up 94% 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 3 hospitals in the region with a total bed capacity of 942 beds. There are 70 schools, 9 fire stations, 2 police stations and 1 emergency operation facilities. With respect to HPL facilities, there are 8 dams identified within the region. Of these, 4 of the dams are classified as 'high hazard'. The inventory also includes 470 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 3,290 million dollars. This inventory includes over 281 kilometers of highways, 143 bridges, 0 kilometers of pipes.

Table 2: Transportation System Lifeline Inventory

System	Component		# locations/ # Segments	Replacement value (millions of dollars)
Highway	Major Roads		5	2,813
	Bridges		143	419
	Tunnels		0	0
		Subtotal		3,232
Railways	Rail Tracks		2	19
	Bridges		0	0
	Tunnels		0	0
	Facilities		0	0
		Subtotal		19
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		4	8
	Runways		0	0
		Subtotal		8
		Total		**3,258**

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*	87.5
	Subtotal		87.5
Waste Water	Pipelines	0	0.0
	Facilities	0	0.0
	Distribution Lines	*NA*	52.5
	Subtotal		52.5
Natural Gas	Pipelines	0	0.0
	Facilities	0	0.0
	Distribution Lines	*NA*	35.0
	Subtotal		35.0
Oil Systems	Pipelines	0	0.0
	Facilities	0	0.0
	Subtotal		0.0
Electrical Power	Facilities	0	0.0
	Distribution Lines	*NA*	26.2
	Subtotal		26.2
Communication	Facilities	16	32.0
	Distribution Lines	*NA*	11.7
	Subtotal		43.7
	Total		**244.9**

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	San Andreas Fault 7.1Mw
Type of Earthquake	Source event
Fault Name	San Andreas
Historical Epicenter ID #	NA
Probabilistic Return Period	NA
Longitude of Epicenter	-118.091
Latitude of Epicenter	34.5428
Earthquake Magnitude	7.1
Depth (Km)	0
Rupture Length (Km)	67.92
Rupture Orientation (degrees)	0
Attenuation Function	Project 97 West Coast

Building Damage

Building Damage

HAZUS estimates that about 344 buildings will be at least moderately damaged. This is over 1.044% of the total number of buildings in the region. There are an estimated 0 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	28,420	95.89	2,859	96.23	308	89.80	0	0.00	0	0.00
Commercial	884	2.98	86	2.89	25	7.29	0	0.00	0	0.00
Industrial	224	0.76	23	0.77	10	2.92	1	0.00	0	0.00
Agriculture	8	0.76	0	0.00	0	0.00	0	0.00	0	0.00
Religion	58	0.20	3	0.00	0	0.00	0	0.00	0	0.00
Government	17	0.06	0	0.00	0	0.00	0	0.00	0	0.00
Education	26	0.09	0	0.00	0	0.00	0	0.00	0	0.00
Total	**29,637**		**2,971**		**343**		**1**		**0**	

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

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Concrete	388	1.3	26	0.9	2	0.6	0	0.0	0	0.0
Mobile Homes	31	0.1	10	0.3	5	1.5	0	0.0	0	0.0
Precast Concrete	266	0.9	18	0.6	7	2.1	0	0.0	0	0.0
RM*	675	2.3	40	1.3	19	5.7	0	0.0	0	0.0
Steel	348	1.2	23	0.8	8	2.4	0	0.0	0	0.0
URM*	115	0.4	23	0.8	5	1.5	0	0.0	0	0.0
Wood	27,814	93.8	2,831	95.3	290	86.3	0	0.0	0	0.0

*Note:
RM Reinforced Masonry
URM Unreiforced Masonry

Essential Facility Damage

Before the earthquake, the region had 942 hospital beds available for use. On the day of the earthquake, the model estimates that only 811 hospital beds (86%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 93% of the beds will be back in service. By 30 days, 98% will be operational.

Table 6: Expected Damage to Essential Facilities

		# Facilities		
Classification	Total	Least Moderate Damage > 50%	Complete Damage > 50%	Functionality > 50% at day 1
Hospitals	3	0	0	3
Schools	70	0	0	70
EOCs	1	0	0	1
Police Stations	2	0	0	2
Fire Stations	9	0	0	9

Transportation and Utility Lifeline Damage

Table 7 provides damage estimates for the transportation system.

Table 7: Expected Damage to the Transportation Systems

			Number of Locations			
System	**Component**	**Locations/ Segments**	**With at Least Mod. Damage**	**With Complete Damage**	**With Functionality > 50 % After Day 1**	**After Day 7**
Highway	**Roads**	5			5	5
	Bridges	143	1	0	143	143
	Tunnels	0	0	0	0	0
Railways	**Tracks**	0			2	2
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
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**	4	0	0	4	4
	Runways	0	0	0	0	0

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 through10 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

		# of Locations			
System	**Total #**	**With at Least Moderate Damage**	**With Complete Damage**	**with Functionality > 50 % After Day 1**	**with Functionality > 50 % After Day 7**
Potable Water	0	0	0	0	0
Waste Water	0	0	0	0	0
Natural Gas	0	0	0	0	0
Oil Systems	0	0	0	0	0
Electrical Power	0	0	0	0	0
Communication	16	1	0	16	16
Total	**16**	**1**	**0**	**16**	**16**

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	0	0	0
Oil	0	0	0
Total	**0**	**0**	**0**

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	68,186	0	0	0	0	0
Electric Power	68,186	10,215	1,440	69	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 3 ignitions that will burn about 0 sq. mi (1.9% of the region's total area.) The model also estimates that the fires will displace about 0 people and burn about 0 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 0.03 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 44% 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 1,000 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 0 households to be displaced due to the earthquake. Of these, 0 people (out of a total population of 194,000) 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 11 provides a summary of the casualties estimated for this earthquake

Table 11: Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
2 AM	**Residential**	15	1	0	0
	Non-Residential	1	0	0	0
	Commute	0	0	0	0
	Total	15	1	0	0
2 PM	**Residential**	4	0	0	0
	Non-Residential	24	2	0	0
	Commute	0	0	0	0
	Total	28	3	0	0
5 PM	**Residential**	4	0	0	0
	Non-Residential	9	1	0	0
	Commute	0	0	0	0
	Total	13	1	0	0

Economic Loss

The total economic loss estimated for the earthquake is 86 million dollars, which represents 1 % 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 83 million dollars. 16% 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 55% 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	4.4	2.9	0.8	0.3	**8.3**
	Non-Structural	28.6	10.4	2.7	1.0	**42.8**
	Content	8.8	6.6	2.2	0.6	**18.3**
	Inventory	N/A	0.1	0.3	0.0	**0.4**
	Subtotal	41.8	20.0	6.1	1.9	**69.8**
Business Interruption Loss	Wage	0.0	2.3	0.1	0.1	**2.6**
	Income	0.0	2.3	0.1	0.0	**2.4**
	Rental	1.7	1.3	0.1	0.0	**3.1**
	Relocation	2.2	2.4	0.5	0.3	**5.4**
	Subtotal	4.0	8.3	0.8	0.4	**13.5**
	Total	45.8	28.3	6.8	2.3	**83.3**

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.

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

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Roads	2,812.8	0.0	0.0
	Bridges	419.0	0.8	0.2
	Tunnels	0.0	0.0	0.0
	Subtotal	3,231.8	0.8	0.0
Railways	Tracks	18.5	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	18.5	0.0	0.0
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	8.0	1.5	3.3
	Runways	0.0	0.0	0.0
	Subtotal	8.0	1.6	3.3
		3,258.3	**1.1**	**0.0**

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	87.5	*NA*	*NA*
	Subtotal	87.5	0.0	0.0
Waste Water	Pipelines	0.0	0.0	0.0
	Facilities	0.0	0.0	0.0
	Distribution Lines	52.5	*NA*	*NA*
	Subtotal	52.5	0.0	0.0
Natural Gas	Pipelines	0.0	0.0	0.0
	Facilities	0.0	0.0	0.0
	Distribution Lines	35.0	*NA*	*NA*
	Subtotal	35.0	0.0	0.0
Oil Systems	Pipelines	0.0	0.0	0.0
	Facilities	0.0	0.0	0.0
	Subtotal	0.0	0.0	0.00
Electrical Power	Facilities	0.0	0.0	0.0
	Distribution Lines	26.2	*NA*	*NA*
	Subtotal	26.2	0.0	0.0
Communication	Facilities	32.0	0.9	2.9
	Distribution Lines	11.7	*NA*	*NA*
	Subtotal	43.7	0.9	2.9
	Total	**244.9**	**0.9**	**1.4**

Appendix A: County Listing for the Region

California
- Los Angeles

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
California					
	Los Angeles	194,000	7,480	2,370	9,850
State Total		*194,000*	*7,480*	*2,370*	*9,850*
Region Total		**194,000**	**7,480**	**2,370**	**9,850**

APPENDIX D
GLOSSARY

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Appendix D
GLOSSARY

Acceleration – The rate of change for a body's magnitude, direction, or both over a given period of time.

Active fault - For implementation of Alquist-Priolo Earthquake Fault Zoning Act (APEFZA) requirements, an active fault is one that shows evidence of, or is suspected of having experienced surface displacement within the last 11,000 years. APEFZA classification is designed for land use management of surface rupture hazards. A more general definition (National Academy of Science, 1988), states "a fault that on the basis of historical, seismological, or geological evidence has the finite probability of producing an earthquake" (see potentially active fault).

Adjacent grade – Elevation of the natural or graded ground surface, or structural fill, abutting the walls of a building. See *highest adjacent grade* and *lowest adjacent grade*.

Aftershocks - Minor earthquakes following a greater one and originating at or near the same place.

Aggradation – The building up of earth's surface by deposition of sediment.

Alluvium - Surficial sediments of poorly consolidated gravels, sand, silts, and clays deposited by flowing water.

Anchor – To secure a structure to its footings or foundation wall in such a way that a continuous load transfer path is created and so that it will not be displaced by flood, wind, or seismic forces.

Aplite – A light-colored igneous rock with a fine-grained texture and free from dark minerals. Aplite forms at great depths beneath the earth's crust.

Appurtenant structure – Under the *National Flood Insurance Program*, a structure which is on the same parcel of property as the principal *structure* to be insured and the use of which is incidental

Argillic – Alteration in which certain minerals of a rock or sediments are converted to clay.

Armor – To protect slopes from *erosion* and *scour* by *flood* waters. Techniques of armoring include the use of riprap, gabions, or concrete.

Artesian – An adjective referring to ground water confined under hydrostatic pressure. The water level in wells drilled into an **artesian** aquifer (also called a confined aquifer) will stand at some height above the top of the aquifer. If the water reaches the ground surface the well is a "flowing" **artesian** well.

Attenuation – The reduction in amplitude of a wave with time or distance traveled.

A zone – Under the *National Flood Insurance Program*, area subject to inundation by the *100-year flood* where wave action does not occur or where waves are less than 3 feet high, designated Zone A, AE, A1-A30, A0, AH, or AR on a *Flood Insurance Rate Map* (FIRM).

Base flood – *Flood* that has as 1-percent probability of being equaled or exceeded in any given year. Also known as the *100-year flood*.

Base Flood Elevation (BFE) – Elevation of the *base flood* in relation to a specified datum, such as the *National Geodetic Vertical Datum* or the *North American Vertical Datum*. The Base Flood Elevation is the basis of the insurance and *floodplain management* requirements of the *National Flood Insurance Program*.

Basement – Under the *National Flood Insurance Program*, any area of a building having its floor subgrade on all sides. (Note: What is typically referred to as a "walkout basement," which has a floor that is at or above grade on at least one side, is not considered a basement under the *National Flood Insurance Program*.)

Bedding - The arrangement of a sedimentary rock in beds or layers of varying thickness and character.

Bedrock - Designates hard rock that is in its natural intact position and underlies soil or other unconsolidated surficial material.

Bench - A grading term that refers to a relatively level step excavated into earth material on which fill is to be placed.

Biotite – A general term to designate all ferromagnesian micas.

Blind thrust fault - A thrust fault is a low-angle reverse fault (top block pushed over bottom block). A "blind" thrust fault refers to one that does not reach the surface.

Breakaway wall – Under the *National Flood Insurance Program*, a wall that is not part of the structural support of the building and is intended through its design and construction to collapse under specific lateral loading forces, without causing damage to the elevated portion of the building or supporting foundation system. Breakaway walls are required by the *National Flood Insurance Program* regulations for any enclosures constructed below the *Base Flood Elevation* beneath elevated buildings in *Coastal High Hazard Areas* (also referred to as *V zones*). In addition, breakaway walls are recommended in areas where *flood* waters flow at high velocities or contain ice or other debris.

Building code – Regulations adopted by local governments that establish standards for construction, modification, and repair of buildings and other structures.

Built-up roof covering – Two or more layers of felt cemented together and surfaced with a cap sheet, mineral aggregate, smooth coating, or similar surfacing material.

Cast-in-place concrete – Concrete that is poured and formed at the construction site.

Cladding – Exterior surface of the building envelope that is directly loaded by the wind.

Clay - A rock or mineral fragment having a diameter less than 1/256 mm (4 microns, or 0.00016 in.). A clay commonly applied to any soft, adhesive, fine-grained deposit.

Claystone - An indurated clay having the texture and composition of shale, but lacking its fine lamination. A massive mudstone in which clay predominates over silt.

Code official – Officer or other designated authority charged with the administration and enforcement of the code, or a duly authorized representative, such as a building, zoning, planning, or *floodplain management* official.

Column foundation – Foundation consisting of vertical support members with a height-to-least-lateral-dimension ratio greater than three. Columns are set in holes and backfilled with compacted material. They are usually made of concrete or masonry and often must be braced. Columns are sometimes known as posts, particularly if the column is made of wood.

Concrete Masonry Unit (CMU) – Building unit or block larger than 12 inches by 4 inches by 4 inches made of cement and suitable aggregates.

Conglomerate - A coarse-grained sedimentary rock composed of rounded to subangular fragments larger than 2 mm in diameter set in a fine-grained matrix of sand or silt, and commonly cemented by calcium carbonate, iron oxide, silica or hardened clay. The consolidated equivalent of gravel.

Connector – Mechanical device for securing two or more pieces, parts, or members together, including anchors, wall ties, and fasteners.

Consolidation - Any process whereby loosely aggregated, soft earth materials become firm and cohesive rock. Also the gradual reduction in volume and increase in density of a soil mass in response to increased load or effective compressive stress, such as the squeezing of fluids from pore spaces.

Contraction joint – Groove that is formed, sawed, or tooled in a concrete structure to create a weakened plane and regulate the location of cracking resulting from the dimensional change of different parts of the structure. See *Isolation joint*.

Corrosion-resistant metal – Any nonferrous metal or any metal having an unbroken surfacing of nonferrous metal, or steel with not less than 10 percent chromium or with not less than 0.20 percent copper.

Coseismic rupture - Ground rupture occurring during an earthquake but not necessarily on the causative fault.

Cretaceous – The final period of the Mesozoic era (before the Tertiary period of the Cenozoic era), thought to have occurred between 136 and 65 million years ago.

Dead load – Weight of all materials of construction incorporated into the building, including but not limited to walls, floors, roofs, ceilings, stairways, built-in partitions, finishes, *cladding*, and other similarly incorporated architectural and structural items and fixed service equipment. See *Loads*.

Debris – (Seismic) The scattered remains of something broken or destroyed; ruins; rubble; fragments. (Flooding, Coastal) Solid objects or masses carried by or floating on the surface of moving water.

Debris impact loads –Loads imposed on a structure by the impact of floodborne debris. These loads are often sudden and large. Though difficult to predict, debris impact loads must be considered when structures are designed and constructed. See *Loads*.

Debris flow - A saturated, rapidly moving saturated earth flow with 50 percent rock fragments coarser than 2 mm in size which can occur on natural and graded slopes.

Debris line – Line left on a structure or on the ground by the deposition of debris. A debris line often indicates the height or inland extent reached by *flood* waters.

Deck – Exterior floor supported on at least two opposing sides by an adjacent structure and/or posts, piers, or other independent supports.

Deflected canyons - A relatively spontaneous diversion in the trend of a stream or canyon caused by any number of processes, including folding and faulting.

Deformation - A general term for the process of folding, faulting, shearing, compression, or extension of rocks.

Design flood – The greater of either (1) the *base flood* or (2) the *flood* associated with the *flood hazard area* depicted on a community's flood hazard map, or otherwise legally designated.

Design Flood Elevation (DFE) – Elevation of the *design flood*, or the flood protection elevation required by a community, including wave effects, relative to the *National Geodetic Vertical Datum*, *North American Vertical Datum*, or other datum.

Development – Under the *National Flood Insurance Program*, any manmade change to improved or unimproved real estate, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation, or drilling operations or storage of equipment or materials.

Differential settlement – Non-uniform settlement; the uneven lowering of different parts of an engineered structure, often resulting in damage to the structure. Sometimes included with liquefaction as ground failure phenomenon.

Dike – A tabular shaped, igneous intrusion that cuts across bedding of the surrounding rock.

Diorite – A group of igneous rocks that form at great depth beneath the earth's crust. These rocks are intermediate in composition between acidic and basic rocks.

Dynamic analysis - A complex earthquake-resistant engineering design technique (UBC - used for critical facilities) capable of modeling the entire frequency spectra, or composition, of ground motion. The method is used to evaluate the stability of a site or structure by considering the motion from any source or mass, such as that dynamic motion produced by machinery or a seismic event.

Earth flow - Imperceptibly slow-moving surficial material in which 80 percent or more of the fragments are smaller than 2 mm, including a range of rock and mineral fragments.

Earthquake - Vibratory motion propagating within the Earth or along its surface caused by the abrupt release of strain from elastically deformed rock by displacement along a fault.

Earth's crust - The outermost layer or shell of the Earth.

Effective Flood Insurance Rate Map (FIRM) – See *Flood Insurance Rate Map*.

Enclosure – That portion of an elevated building below the *Design Flood Elevation (DFE)* that is partially or fully surrounded by solid (including breakaway) walls.

Encroachment – Any physical object placed in a floodplain that hinders the passage of water or otherwise affects the flood flows.

Engineering geologist - A geologist who is certified by the State as qualified to apply geologic data, principles, and interpretation to naturally occurring earth materials so that geologic factors affecting planning, design, construction, and maintenance of civil engineering works are properly recognized and used. An engineering geologist is particularly needed to conduct investigations, often with geotechnical engineers, of sites with potential ground failure hazards.

Epicenter - The point at the Earth's surface directly above where an earthquake originated.

Erodible soil – Soil subject to wearing away and movement due to the effects of wind, water, or other geological processes during a flood or storm or over a period of years.

Erosion – Under the *National Flood Insurance Program*, the process of the gradual wearing away of landmasses. In general, erosion involves the detachment and movement of soil and rock fragments, during a flood or storm or over a period of years, through the action of wind, water, or other geologic processes.

Erosion analysis – Analysis of the short- and long-term *erosion* potential of soil or strata, including the effects of wind action, *flooding* or *storm surge*, moving water, wave action, and the interaction of water and structural components.

Expansive soil - A soil that contains clay minerals that take in water and expand. If a soil contains sufficient amount of these clay minerals, the volume of the soil can change significantly with changes in moisture, with resultant structural damage to structures founded on these materials.

Fault - A fracture (rupture) or a zone of fractures along which there has been displacement of adjacent earth material.

Fault segment - A continuous portion of a fault zone that is likely to rupture along its entire length during an earthquake.

Fault slip rate - The average long-term movement of a fault (measured in cm/year or mm/year) as determined from geologic evidence.

Federal Emergency Management Agency (FEMA) – Independent agency created in 1979 to provide a single point of accountability for all Federal activities related to disaster mitigation and emergency preparedness, response and recovery. FEMA administers the *National Flood Insurance Program*.

Federal Insurance Administration (FIA) – The component of the *Federal Emergency Management Agency* directly responsible for administering the flood insurance aspects of the *National Flood Insurance Program*.

Feldspar – The most widespread of any mineral group; constitutes ~60% of the earth's crust. Feldspars occur as components of all kinds of rocks and, on decomposition, yield a large part of the clay of a soil.

Fill – Material such as soil, gravel, or crushed stone placed in an area to increase ground elevations or change soil properties. See *structural fill*.

Five (500)-year flood – *Flood* that has as 0.2-percent probability of being equaled or exceeded in any given year.

Flood - A rising body of water, as in a stream or lake, which overtops its natural and artificial confines and covers land not normally under water. Under the *National Flood Insurance Program*, either (a) a general and temporary condition or partial or complete inundation of normally dry land areas from:

(1) the overflow of inland or tidal waters,
(2) the unusual and rapid accumulation or runoff of surface waters from any source, or
(3) mudslides (i.e., mudflows) which are proximately caused by flooding as defined in (2) and are akin to a river of liquid and flowing mud on the surfaces of normally dry land areas, as when the earth is carried by a current of water and deposited along the path of the current,

or (b) the collapse or subsidence of land along the shore of a lake or other body of water as a result of erosion or undermining caused by waves or currents of water exceeding anticipated cyclical levels or suddenly caused by an unusually high water level in a natural body of water, accompanied by a severe storm, or by an unanticipated force of nature, such as flash flood or abnormal tidal surge, or by some similarly unusual and unforeseeable event which results in flooding as defined in (1), above.

Flood-damage-resistant material – Any construction material capable of withstanding direct and prolonged contact (i.e., at least 72 hours) with floodwaters without suffering significant damage (i.e., damage that requires more than cleanup or low-cost cosmetic repair, such as painting).

Flood elevation – Height of the water surface above an established elevation datum such as the *National Geodetic Vertical Datum*, *North American Vertical Datum*, or *mean sea level*.

Flood hazard area – The greater of the following: (1) the area of special flood hazard, as defined under the *National Flood Insurance Program*, or (2) the area designated as a flood hazard area on a community's legally adopted flood hazard map, or otherwise legally designated.

Flood insurance – Insurance coverage provided under the National Flood Insurance Program.

Flood Insurance Rate Map (FIRM) – Under the *National Flood Insurance Program*, an official map of a community, on which the *Federal Emergency Management Agency* has delineated both the special hazard areas and the risk premium zones applicable to the community. (Note: The latest FIRM issued for a community is referred to as the *effective FIRM* for that community.)

Flood Insurance Study (FIS) – Under the *National Flood Insurance Program*, an examination, evaluation, and determination of *flood* hazards and, if appropriate, corresponding *water surface elevations*, or an examination, evaluation, and determination of mudslide (i.e., mudflow) and/or flood-related erosion hazards in a community or communities. (Note: The *National Flood Insurance Program* regulations refer to Flood Insurance Studies as "flood elevation studies.")

Flood-related erosion area or flood-related erosion prone area – A land area adjoining the shore of a lake or other body of water, which due to the composition of the shoreline or bank and high water levels or wind-driven currents, is likely to suffer *flood*-related *erosion* damage.

Flooding – See *Flood*.

Floodplain – Under the *National Flood Insurance Program*, any land area susceptible to being inundated by water from any source. See *Flood*.

Floodplain management – Operation of an overall program of corrective and preventive measures for reducing *flood* damage, including but not limited to emergency preparedness plans, flood control works, and *floodplain management regulations*.

Floodplain management regulations – Under the *National Flood Insurance Program*, zoning ordinances, subdivision regulations, building codes, health regulations, special purpose ordinances (such as floodplain ordinance, grading ordinance, and erosion control ordinance), and other applications of police power. The term describes such state or local regulations, in any combination thereof, which provide standards for the purpose of *flood* damage prevention and reduction.

Footing – Enlarged base of a foundation wall, pier, post, or column designed to spread the load of the structure so that it does not exceed the soil bearing capacity.

Footprint – Land area occupied by a structure.

Freeboard – Under the *National Flood Insurance Program*, a factor of safety, usually expressed in feet above a *flood* level, for the purposes of *floodplain management*. Freeboard tends to compensate for the many unknown factors that could contribute to flood heights greater than the heights calculated for a selected size flood and floodway conditions, such as the hydrological effect of urbanization of the watershed.

Geomorphology - The science that treats the general configuration of the Earth's surface. The study of the classification, description, nature, origin and development of landforms, and the history of geologic changes as recorded by these surface features.

Geotechnical engineer - A licensed civil engineer who is also certified by the State as qualified for the investigation and engineering evaluation of earth materials and their interaction with earth retention systems, structural foundations, and other civil engineering works.

Grade beam – Section of a concrete slab that is thicker than the slab and acts as a footing to provide stability, often under load-bearing or critical structural walls. Grade beams are occasionally installed to provide lateral support for vertical foundation members where they enter the ground.

Grading - Any excavating or filling or combination thereof. Generally refers to the modification of the natural landscape into pads suitable as foundations for structures.

Granite – Broadly applied, any completely crystalline, quartz-bearing, plutonic rock.

Ground failure - Permanent ground displacement produced by fault rupture, differential settlement, liquefaction, or slope failure.

Ground rupture - Displacement of the earth's surface as a result of fault movement associated with an earthquake.

Highest adjacent grade – Elevation of the highest natural or regarded ground surface, or structural fill, that abuts the walls of a building.

Holocene – An epoch of the Quaternary period spanning from the end of the Pleistocene to the present time (10,000 years).

Hornblende – The most common mineral of the amphibole group. It is a primary constituent in many intermediate igneous rocks.

Hydrocompaction - Settlement of loose, granular soils that occurs when the loose, dry structure of the sand grains held together by a clay binder or other cementing agent collapses upon the introduction of water.

Hydrodynamic loads – Loads imposed on an object, such as a building, by water flowing against and around it. Among these loads are positive frontal pressure against the structure, drag effect along the sides, and negative pressure on the downstream side.

Hydrostatic loads – Loads imposed on a surface, such as a wall or floor slab, by a standing mass of water. The water pressure increases with the square of the water depth.

Igneous – Type of rock or mineral that formed from molten or partially molten magma.

Intensity - A measure of the effects of an earthquake at a particular place. Intensity depends on the earthquake magnitude, distance from the epicenter, and on the local geology.

Isolation joint – Separation between adjoining parts of a concrete structure, usually a vertical plane, at a designated location such as to interfere least with the performance of the structure, yet such as to allow relative movement in three directions and avoid formation of cracks elsewhere in the concrete and through which all or part of the bonded reinforcement is interrupted. See *Contraction joint*.

Jetting (of piles) – Use of a high-pressure stream of water to embed a pile in sandy soil. See *pile foundation*.

Joist – Any of the parallel structural members of a floor system that support, and are usually immediately beneath, the floor.

ka – thousands of years before present.

Lacustrine flood hazard area – Area subject to inundation by *flooding* from lakes.

Landslide - A general term covering a wide variety of mass-movement landforms and processes involving the downslope transport, under gravitational influence, of soil and rock material en masse.

Lateral force - The force of the horizontal, side-to-side motion on the Earth's surface as measured on a particular mass; either a building or structure.

Lateral spreading - Lateral movements in a fractured mass of rock or soil which result from liquefaction or plastic flow or subjacent materials.

Left-lateral fault – A strike-slip fault across which a viewer would see the block on the opposite side of the fault move to the left.

Lifeline system - Linear conduits or corridors for the delivery of services or movement of people and information (e.g., pipelines, telephones, freeways, railroads)

Lineament – Straight or gently curved, lengthy features of earth's surface, frequently expressed topographically as depressions or lines of depressions, scarps, benches, or change in vegetation.

Liquefaction - Changing of soils (unconsolidated alluvium) from a solid state to weaker state unable to support structures; where the material behaves similar to a liquid as a consequence of earthquake shaking. The transformation of cohesionless soils from a solid or liquid state as a result of increased pore pressure and reduced effective stress.

Live loads – *Loads* produced by the use and occupancy of the building or other structure. Live loads do not include construction or environmental loads such as wind load, snow load, rain load, earthquake load, flood load, or dead load. See *Loads*.

Load-bearing wall – Wall that supports any vertical load in addition to its own weight. See *Non-load-bearing wall*.

Loads – Forces or other actions that result from the weight of all building materials, occupants and their possessions, environmental effects, differential movement, and restrained dimensional changes. Permanent loads are those in which variations over time are rare or of small magnitude. All other loads are variable loads.

Lowest adjacent grade (LAG) – Elevation of the lowest natural or re-graded ground surface, or structural fill, that abuts the walls of a building. See *Highest adjacent grade*.

Lowest floor – Under the *National Flood Insurance Program*, the lowest floor of the lowest enclosed area (including basement) of a structure. An unfinished or *flood*-resistant enclosure, usable solely for parking of vehicles, building access, or storage in an area other than a basement is not considered a building's lowest floor, provided that the enclosure is not built so as to render the structure in violation of *National Flood Insurance Program* regulatory requirements.

Lowest horizontal structural member – In an elevated building, the lowest beam, *joist*, or other horizontal member that supports the building. *Grade beams* installed to support vertical foundation members where they enter the ground are not considered lowest horizontal structural members.

Ma – millions of years before present.

Magnitude - A measure of the size of an earthquake, as determined by measurements from seismograph records.

Major earthquake - Capable of widespread, heavy damage up to 50+ miles from epicenter; generally near Magnitude range 6.5 to 7.0 or greater, but can be less, depending on rupture mechanism, depth of earthquake, location relative to urban centers, etc.

Manufactured home – Under the *National Flood Insurance Program*, a *structure*, transportable in one or more sections, which is built on a permanent chassis and is designed for use with or without a permanent foundation when attached to the required utilities. The term "manufactured home" does not include a "recreational vehicle."

Masonry – Built-up construction of combination of building units or materials of clay, shale, concrete, glass, gypsum, stone, or other approved units bonded together with or without mortar or grout or other accepted methods of joining.

Maximum Magnitude Earthquake (Mmax) - The highest magnitude earthquake a fault is capable of producing based on physical limitations, such as the length of the fault or fault segment.

Maximum Probable Earthquake (MPE) - The design size of the earthquake expected to occur within a time frame of interest, for example within 30 years or 100 years, depending on the purpose, lifetime or importance of the facility. Magnitude/frequency relationships are based on historic seismicity, fault slip rates, or mathematical models. The more critical the facility, the longer the time period considered.

Metamorphic rock – A rock whose original mineralogy, texture, or composition has been changed due to the effects of pressure, temperature, or the gain or loss of chemical components.

Mean sea level (MSL) – Average height of the sea for all stages of the tide, usually determined from hourly height observations over a 19-year period on an open coast or in adjacent waters having free access to the sea. See *National Geodetic Vertical Datum*.

Metal roof panel – Interlocking metal sheet having a minimum installed weather exposure of 3 square feet per sheet.

Metal roof shingle – Interlocking metal sheet having an installed weather exposure less than 3 square feet per sheet.

Mitigation – Any action taken to reduce or permanently eliminate the long-term risk to life and property from natural hazards.

Mitigation Directorate – Component of *Federal Emergency Management Agency* directly responsible for administering the flood hazard identification and *floodplain management* aspects of the *National Flood Insurance Program*.

Moderate earthquake - Capable of causing considerable to severe damage, generally in the range of Magnitude 5.0 to 6.0 (Modified Mercalli Intensity <VI), but highly dependent on rupture mechanism, depth of earthquake, and location relative to urban center, etc.

National Flood Insurance Program (NFIP) – Federal program created by Congress in 1968 that makes *flood* insurance available in communities that enact and enforce satisfactory *floodplain management regulations*.

National Geodetic Vertical Datum (NGVD) – Datum established in 1929 and used as a basis for measuring flood, ground, and structural elevations, previously referred to as Sea Level Datum or *Mean Sea Level*. The *Base Flood Elevations* shown on most of the *Flood Insurance Rate Maps* issued by the *Federal Emergency Management Agency* are referenced to NGVD or, more recently, to the *North American Vertical Datum*.

Naturally decay-resistant wood – Wood whose composition provides it with some measure of resistance to decay and attack by insects, without preservative treatment (e.g., heartwood of cedar, black locust, black walnut, and redwood).

Near-field earthquake - Used to describe a local earthquake within approximately a few fault zone widths of the causative fault which is characterized by high frequency waveforms that are destructive to above-ground utilities and short period structures (less than about two or three stories).

New construction – For the purpose of determining flood insurance rates under the *National Flood Insurance Program*, *structures* for which the start of construction commenced on or after the effective date of the initial *Flood Insurance Rate Map* or after December 31, 1974, whichever is later, including any subsequent improvements to such structures. (See *Post-FIRM structure*.) For *floodplain management* purposes, new construction means *structures* for which the *start of construction* commenced on or after the effective date of a *floodplain management regulation* adopted by a community and includes any subsequent improvements to such structures.

Non-coastal A zone – The portion of the *Special Flood Hazard Area* in which the principal source of *flooding* is runoff from rainfall, snowmelt, or a combination of both. In non-coastal A zones, *flood* waters may move slowly or rapidly, but waves are usually not a significant threat to buildings. See *A zone* and *coastal A zone*. (Note: the *National Flood Insurance Program* regulations do not differentiate between non-coastal A zones and *coastal A zones*.)

Non-load-bearing wall – Wall that does not support vertical loads other than its own weight. See *Load-bearing wall*.

North American Vertical Datum (NAVD) – Datum used as a basis for measuring flood, ground, and structural elevations. NAVD is used in many recent *Flood Insurance Studies* rather than the *National Geodetic Vertical Datum*.

Oblique – reverse fault – A fault that combines some strike-slip motion with some dip-slip motion in which the upper block, above the fault plane, moves up over the lower block.

Offset ridge - A ridge that is discontinuous on account of faulting.

Offset stream - A stream displaced laterally or vertically by faulting.

(One) 100-year flood – See *Base flood*.

Oriented strand board (OSB) – Mat-formed wood structural panel product composed of thin rectangular wood strands or wafers arranged in oriented layers and bonded with waterproof adhesive.

Orthoclase – One of the most common rock-forming minerals; colorless, white, cream-yellow, flesh-reddish, or grayish in color.

Paleoseismic – Pertaining to an earthquake or earth vibration that happened decades, centuries, or millennia ago.

Peak Ground Acceleration (PGA) - The greatest amplitude of acceleration measured for a single frequency on an earthquake accelerogram. The maximum horizontal ground motion generated by an earthquake. The measure of this motion is the acceleration of gravity (equal to 32 feet per second squared, or 980 centimeter per second squared), and generally expressed as a percentage of gravity.

Pedogenic – Pertaining to soil formation.

Pegmatite – An igneous rock with extremely large grains, more than a centimeter in diameter.

Perched ground water - Unconfined ground water separated from an underlying main body of ground water by an unsaturated zone.

Peak flood - The highest discharge or stage value of a flood.

Plagioclase – One of the most common rock forming minerals.

Plutonic – Pertaining to igneous rocks formed at great depth.

Plywood – Wood structural panel composed of plies of wood veneer arranged in cross-aligned layers. The plies are bonded with an adhesive that cures on application of heat and pressure.

Pore pressure - The stress transmitted by the fluid that fills the voids between particles of a soil or rock mass.

Post foundation – Foundation consisting of vertical support members set in holes and backfilled with compacted material. Posts are usually made of wood and usually must be braced. Posts are also known as columns, but columns are usually made of concrete or masonry.

Post-FIRM structure – For purposes of determining insurance rates under the *National Flood Insurance Program*, structures for which the *start of construction* commenced on or after the effective date of an initial *Flood Insurance Rate Map* or after December 31, 1974, whichever is later, including any subsequent improvements to such structures. This term should not be confused with the term *new construction* as it is used in *floodplain management*.

Potentially active fault - A fault showing evidence of movement within the last 1.6 million years (750,000 years according to the U.S. Geological Survey) but before about 11,000 years ago, and that is capable of generating damaging earthquakes.

Precast concrete – Structural concrete element cast elsewhere than its final position in the structure. See *Cast-in-place concrete*.

Pressure-treated wood – Wood impregnated under pressure with compounds that reduce the susceptibility of the wood to flame spread or to deterioration caused by fungi, insects, or marine borers.

Project - A development application involving zone changes, variances, conditional use permits, tentative parcel maps, tentative tract maps, and plan amendments.

Quartzite – A metamorphic rock consisting mostly of quartz.

Quartz monzonite – A plutonic rock containing major plagioclase, orthoclase and quartz; with increased orthoclase it becomes a granite.

Quaternary – The second period of the Cenozoic era, consisting of the Pleistocene and Holocene epochs; covers the last two to three million years.

Resonance - Amplification of ground motion frequencies within bands matching the natural frequency of a structure and often causing partial or complete structural collapse; effects may demonstrate minor damage to single-story residential structures while adjacent 3- or 4-story buildings may collapse because of corresponding frequencies, or vice versa.

Recurrence interval – The time between earthquakes of a given magnitude, or within a given magnitude range, on a specific fault or within a specific area.

Reinforced concrete – *Structural concrete* reinforced with steel bars.

Response spectra - The range of potentially damaging frequencies of a given earthquake applied to a specific site and for a particular building or structure.

Retrofit –Any change made to an existing structure to reduce or eliminate damage to that structure from flooding, *erosion*, high winds, earthquakes, or other hazards.

Revetment – Facing of stone, cement, sandbags, or other materials placed on an earthen wall or embankment to protect it from *erosion* or *scour* caused by *flood* waters or wave action

Right-lateral fault - A strike-slip fault across which a viewer would see the block on the opposite side of the fault move to the right.

Riprap – Broken stone, cut stone blocks, or rubble that is placed on slopes to protect them from *erosion* or *scour* caused by *flood* waters or wave action.

Roof deck – Flat or sloped roof surface not including its supporting members or vertical supports.

Sand boil - An accumulation of sand resembling a miniature volcano or low volcanic mound produced by the expulsion of liquefied sand to the sediment surface. Also called sand blows, and sand volcanoes.

Sandstone - A medium-grained, clastic sedimentary rock composed of abundant rounded or angular fragments of sand size set in a fine-grained matrix and more or less firmly united by a cementing material.

Saturated - Said of the condition in which the interstices of a material are filled with a liquid, usually water.

Scarp – A line of cliffs produced by faulting or by erosion. The term is an abbreviated form of escarpment.

Schist – A metamorphic rock characterized by a preferred orientation in grains resulting in the rock's ability to be split into thin flakes or slabs.

Scour – Removal of soil or fill material by the flow of *flood* waters. The term is frequently used to describe storm-induced, localized conical erosion around pilings and other foundation supports where the obstruction of flow increases turbulence. See *Erosion*.

Sediment - Solid fragmental material that originates from weathering of rocks and is transported or deposited by air, water, ice, or that accumulates by other natural agents, such as chemical precipitation from solution. and that forms in layers on the Earth's surface in a loose, unconsolidated form.

Seiche - A free or standing-wave oscillation of the surface of water in an enclosed or semi-enclosed basin (such as a lake, bay, or harbor), that is initiated chiefly by local changes in atmospheric pressure, aided by winds, tidal currents, and earthquakes, and that continues, pendulum-fashion, for a time after cessation of the originating force.

Seismogenic - Capable of producing earthquake activity.

Seismograph - An instrument that detects, magnifies, and records vibrations of the Earth, especially earthquakes. The resulting record is a seismogram.

Shearwall – *Load-bearing wall* or *non-load-bearing wall* that transfers in-plane lateral forces from lateral *loads* acting on a structure to its foundation.

Shoreline retreat – Progressive movement of the shoreline in a landward direction caused by the

Shutter ridge – That portion of an offset ridge that blocks or "shutters" the adjacent canyon.

Silt - A rock fragment or detrital particle smaller than a very fine sand grain and larger than coarse clay, having a diameter in the range of 1/256 to 1/16 mm (4-62 microns, or 0.00016-0.0025 in.). An indurated silt having the texture and composition of shale but lacking its fine lamination is called a siltstone.

Single-ply membrane – Roofing membrane that is field-applied with one layer of membrane material (either homogeneous or composite) rather than multiple layers.

Slope ratio - Refers to the angle or gradient of a slope as the ratio of horizontal units to vertical units. For example, in a 2:1 slope, for every two horizontal units, there is a vertical rise of one unit (equal to a slope angle, from the horizontal, of 26.6 degrees).

Slump - A landslide characterized by a shearing and rotary movement of a generally independent mass of rock or earth along a curved slip surface.

Soil horizon – A layer of soil that is distinguishable from adjacent layers by characteristic physical properties such as structure, color, or texture.

Special Flood Hazard Area (SFHA) – Under the *National Flood Insurance Program*, an area having special *flood*, mudslide (i.e., mudflow) and/or flood-related erosion hazards, and shown on a Flood Hazard Boundary Map or *Flood Insurance Rate Map* as Zone A, AO, A1-A30, AE, A99, AH, V, V1-V30, VE, M or E.

Storage capacity - Dam storage measured in acre-feet or decameters, including dead storage.

Strike-slip fault - A fault with a vertical to sub-vertical fault surface that displays evidence of horizontal and opposite displacement.

Structural concrete – All concrete used for structural purposes, including *plain concrete* and *reinforced concrete*.

Structural engineer - A licensed civil engineer certified by the State as qualified to design and supervise the construction of engineered structures.

Structural fill – Fill compacted to a specified density to provide structural support or protection to a *structure*. See *Fill*.

Structure – Something constructed, such as a building, or part of one. For *floodplain management* purposes under the *National flood Insurance Program*, a walled and roofed building, including a gas or liquid storage tank, that is principally above ground, as well as a manufactured home. For insurance coverage purposes under the NFIP, structure means a walled and roofed building, other than a gas or liquid storage tank, that is principally above ground and affixed to a permanent site, as well as a *manufactured home* on a permanent foundation. For the latter purpose, the term includes a building while in the course of construction, alteration, or repair, but does not include building materials or supplies intended for use in such construction, alteration, or repair, unless such materials or supplies are within an enclosed building on the premises.

Subsidence - The sudden sinking or gradual downward settling of the Earth's surface with little or no horizontal motion.

Swale – In hillside terrace, a shallow drainage channel, typically with a rounded depression or “hollow” at the head.

Thrust fault – A fault, with a relatively shallow dip, in which the upper block, above the fault plane, moves up over the lower block.

Transform system – A system in which faults of plate-boundary dimensions transform into another plate-boundary structure when it ends.

Transpression – In crustal deformation, an intermediate stage between compression and strike-slip motion; it occurs in zones with oblique compression.

Tsunami – Great sea wave produced by submarine earth movement or volcanic eruption.

Typhoon – Name given to a *hurricane* in the area of the western Pacific Ocean west of 180 degrees longitude.

Unconfined aquifer – Aquifer in which the upper surface of the saturated zone is free to rise and fall.

Unconsolidated sediments - A deposit that is loosely arranged or unstratified, or whose particles are not cemented together, occurring either at the surface or at depth.

Underlayment – One or more layers of felt, sheathing paper, non-bituminous saturated felt, or other approved material over which a steep-sloped roof covering is applied.

Undermining – Process whereby the vertical component of erosion or scour exceeds the depth of the base of a building foundation or the level below which the bearing strength of at the foundation is compromised.

Uplift – Hydrostatic pressure caused by water under a building. It can be strong enough lift a building off its foundation, especially when the building is not properly anchored to its foundation.

Upper bound earthquake – Defined as a 10% chance of exceedance in 100 years, with a statistical return period of 949 years.

Variance – Under the *National Flood Insurance Program*, grant of relief by a community from the terms of a *floodplain management regulation*.

Violation – Under the *National Flood Insurance Program*, the failure of a structure or other development to be fully compliant with the community's *floodplain management regulations*. A *structure* or other *development* without the elevation certificate, other certifications, or other evidence of compliance required in Sections 60.3(b)(5), (c)(4), (c)(10), (d)(3), (e)(2), (e)(4), or (e)(5) of the NFIP regulations is presumed to be in violation until such time as that documentation is provided.

Watershed - A topographically defined region draining into a particular water course.

Water surface elevation – Under the *National Flood Insurance Program*, the height, in relation to the *National Geodetic Vertical Datum* of 1929 (or other datum, where specified), of *floods* of various magnitudes and frequencies in the *floodplains* of coastal or riverine areas.

Water table - The upper surface of groundwater saturation of pores and fractures in rock or surficial earth materials.

X zone – Under the *National Flood Insurance Program*, areas where the *flood* hazard is less than that in the *Special Flood Hazard Area*. Shaded X zones shown on recent *Flood Insurance Rate Maps* (B zones on older maps) designate areas subject to inundation by the *500-year flood*. Un-shaded X zones (C zones on older *Flood Insurance Rate Maps*) designate areas where the annual probability of flooding is less than 0.2 percent.

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